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A new species of *Tocoyena* (Rubiaceae, Gardenieae) from the Brazilian Atlantic Forest

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Abstract

Tocoyena atlantica, a new species endemic to southern Bahia and northern Espírito Santo states, Brazil, is here described and illustrated. The species consists of trees 5−8 m tall; with petioles 2−5 cm long, and leaf blades 7.4−24.5 × 2.5−9.1 cm, elliptic, adaxially glabrous; calyces cup-shaped with triangular lobes; corolla yellow during anthesis, with tube gradually wider towards the mouth; and laterally compressed hypanthia. Based on IUCN criteria, we consider *T. atlantica* endangered, with three collection localities within the Atlantic Forest domain. An identification key for species of *Tocoyena* occurring in the Brazilian Atlantic Forest is also provided.

Keywords: Atlantic rainforest, endangered species, Bahia, *mussununga*

Introduction

Tocoyena Aublet (1775: 131) (Rubiaceae) is a Neotropical genus composed of trees, shrubs, and subshrubs, with corolla tubes 3−35 cm long, green in bud, passing from white to yellow at anthesis and generally pollinated by hawkmoths (Delprete 2008). *Tocoyena* fruits have multiple discoid seeds surrounded by a mesocarp that turns dark when exposed to air (Borges 2020, Prado 1987).

According to Borges (2020), 12 species of *Tocoyena* occur in Brazil, five of which are found in the Atlantic Forest domain and its associated phytophysiognomies: *Tocoyena formosa* (Chamisso & Schlechtendal 1829: 200) Schumann (in Martius 1889: 347), *T. brasiliensis* Martius (1841: 82), *T. bullata* (Vellozo 1829 ["1825"]: 103; 1831 ["1827"]: tab. 12) Martius (1841: 80), *T. sellowiana* (Chamisso & Schlechtendal 1829: 197) Schumann (in Martius 1889: 349), and *T. longiflora* Aublet (1775: 131). The first four species are common in *restinga* vegetation and seasonal phytophysiognomies, while *T. longiflora* occurs in the Atlantic rainforest (pers. obs.). During recent field expeditions and herbaria surveys, we identified specimens from the Atlantic Forest whose traits differ greatly from any other species of *Tocoyena*. Here, we describe the new species as a taxon endemic to the Atlantic Forest of southern Bahia and northern Espírito Santo states, an area recognized by its high level of endemism and species richness (Thomas *et al.* 1998, Martini *et al.* 2007, Amorim *et al.* 2009). The new species is described, illustrated, and compared with similar species, and its geographical distribution, habitat, and conservation status are discussed. Additionally, we present an identification key to the species of *Tocoyena* that occur in the Brazilian Atlantic Forest.

Material and methods

Specimens at ALCB, B, BM, CEPEC, GB, HUEFS, HURB, INPA, K, LE, M, P, R, RB, S, SPF and UEC herbaria (acronyms following Thiers, continuously updated) were examined. The morphological description is based on

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herbarium specimens and collections from the municipalities of Nova Viçosa, Teixeira de Freitas (southern Bahia) and Linhares (Espirito Santo). Morphological terminology follows specialized bibliography (Radford *et al.* 1974, Beentje 2016, Weberling 1989) and Rubiaceae works (Robbrecht & Puff 1986, Robbrecht 1988, Weberling 1977).

The distribution map was produced with QGIS (QGIS Development Team 2019) using geospatial data obtained from herbaria specimens labels or estimated from locality descriptions (Fig. 1). Shape files with the current distribution of the Atlantic Forest were retrieved from the SOS Mata Atlântica website (http://mapas.sosma.org.br/dados/). The assessment of the Conservation status is based on IUCN criteria (IUCN 2019). Area of occupancy (AOO) and extent of occurrence (EOO) were estimated using GeoCAT (Bachman *et al.* 2011).

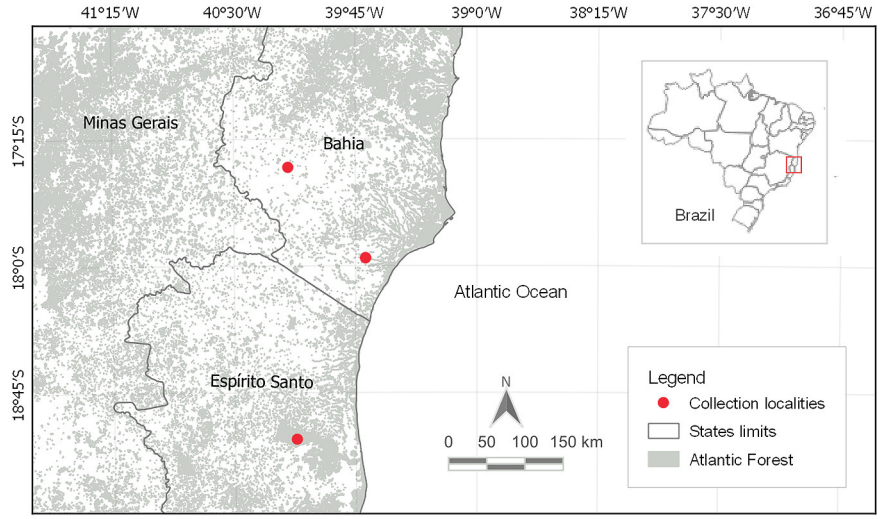

FIGURE 1. Distribution of *Tocoyena atlantica* in Bahia and Espírito Santo states, Brazil.

Taxonomy

Tocoyena atlantica R. Borges & Gaem, ***sp. nov.***

Type:—BRAZIL. Bahia: Teixeira de Freitas, mata higrófila, terreno aberto, 17°26'27"S, 40°10'15"W, 764 m, 26 November 2009 (fl.), *V.F. Mansano 670* (holotype RB! [barcode RB00578075] isotypes NY! [barcode NY01182630] (image), UEC! [barcode UEC054114]). (Figures 2–3).

Diagnosis:—*Tocoyena atlantica* differs from the other species of the genus by the leaves clustered on tip of branches and disposed between reduced internodes (2–3 mm long); with petioles 2–5 cm long; calyx distinctly lobed (*vs.* minutely lobed or truncate in *T. formosa*, *T. sellowiana* and *T. bullata*); and a corolla green in bud passing to yellow during and after anthesis (*vs.* most of the species having a greenish-white corolla during anthesis, passing to cream-yellow after anthesis). It resembles *T. longiflora* by the triangular calyx lobes, but differs from it by having a corolla ca. 10 cm long (*vs.* ca. 30 cm in *T. longiflora*), dichasial or thyrsiform inflorescences (*vs.* fasciculate), and a laterally compressed hypantium (*vs.* not compressed).

Description:—*Trees* 5−8 m tall; branches terete, sometimes exfoliating in small pieces; bark irregularly fissurate with the most distal parts bearing lenticels and showing scars of the fallen leaves, glabrous; branchlets laterally compressed with reduced internodes (2–3 mm long), smooth or longitudinally sulcate, densely strigose, sometimes bearing lenticels. *Stipules* persistent, triangular, 5.0−11.0 × 6.0−9.0 mm, apex acute, chartaceous, margins entire, glabrous outside, tomentose inside, with regular-shaped colleters on the inner surface. *Leaves* opposite, clustered at branches tips, appearing whorled due to the reduced internodes, long-petiolate; petioles 2−5 cm long, canaliculate, moderately strigose; blades elliptic, 7.4−24.5 × 2.5−9.1 cm, base attenuate, apex acute, margin undulated, discolorous, glabrous adaxially, moderately sericeous abaxially; secondary veins 11–15 on each side of midrib; tertiary venation reticulate. *Inflorescence* terminal, peduncles 2.2−4.8 mm long, dichasium, sometimes with 2–3 dichasia organized on a truncated thyrse (with main and lateral paraclades shortened), 2−9 flowered; bracts triangular, ca. 1.0 × 1.5 mm, glabrous outside, sericeous inside. *Flowers* subsessile, fragrant; pedicels 1.0−3.0 mm long. *Hypanthium* obconical,

ca. 2 mm long, laterally compressed, sericeous at base. *Calyx* cup-shaped, 5-merous, lobes triangular, ca. 6 mm long, glabrous on both sides. *Corolla* hypocrateriform, 7.2–9.7 cm long, green in bud, yellow during and after anthesis, expanded towards the mouth, ca. 1 cm wide at the level of the anthers, tube cylindrical, 5.7–7.8 cm long, glabrous, tomentose close to the mouth; lobes ovate, 11−20.5 × 7.0−11.5 mm, round to retuse at the tip, glabrous. *Anthers* dorsifixed, sessile, ellipsoid-oblong, 8.5−11.5 × 1−2 mm, base cordate, apex mucronate, yellow, smooth, glabrous. *Style* exserted, terete, yellow, glabrous, with sparse short trichomes; lobes 2, elliptic to obovate, flat, yellow, smooth, glabrous. *Fruit* unknown.

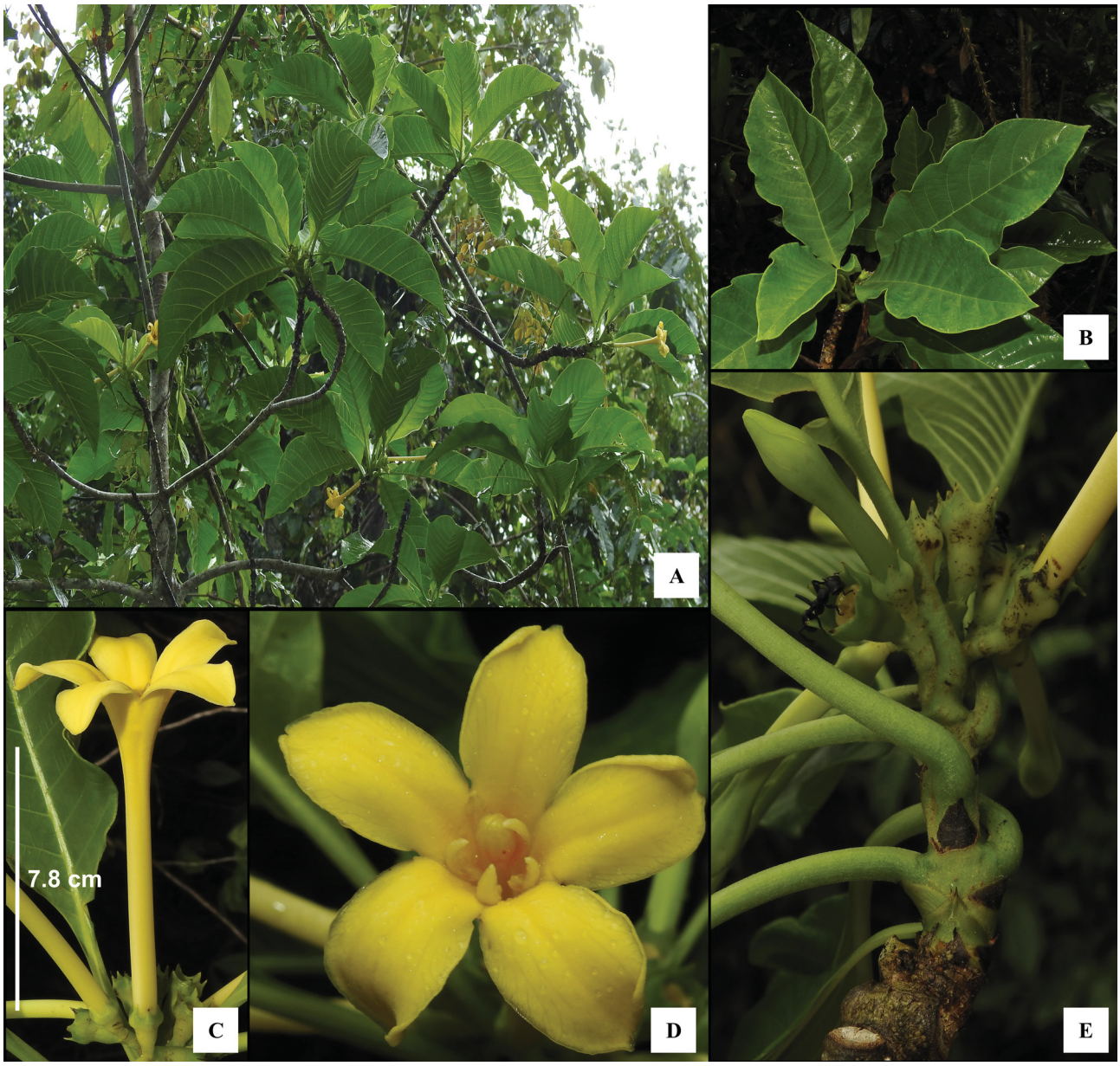

FIGURE 2. *Tocoyena atlantica*. **A.** Habit, with flowering branches; **B.** Leaves; **C.** Flower, side view; **D.** Flower, top view; detail of anthers and style; **E.** Terminal portion of branch, showing internodes, stipule, and calyx. (*P.H. Gaem & H.T.A. Morais 212*). Photo by P. H. Gaem.

Distribution and Ecology:—*Tocoyena atlantica* occurs in the fragmented Atlantic Forest of southern Bahia and northern Espírito Santo states (Fig. 1). It was found in the rainforest and *mussununga*, a vegetation exclusive to Bahia and Espírito Santo states associated with sandy soils surrounded by tropical forests (Meira Neto *et al.* 2005). This region is known by its high levels of endemism and the constant discovery of new taxa, therefore being considered a biodiversity refuge and one of the focal points for conservation in Brazil (Thomas *et al.* 1998, Martini *et al.* 2007, Amorim 2009). *Tocoyena* is pollinated by hawkmoths, which are attracted by the fragrant scent produced by its large flowers (Fig 2E) (Camargo *et al.* 2018), and its baccate fruits are eaten by small mammals (Kuhlmann & Ribeiro 2016).

FIGURE 3. Holotype of *Tocoyena atlantica* at RB.

Conservation status:—Endangered (EN). This species has an EOO of approximately 3,176 km² and is restricted to a region that faces deforestation due to logging and agricultural activities (Fig. 1). Therefore, according to criteria B1ab[iii] of the IUCN (2019) it is considered Endangered (EN).

Phenology:—Flowering specimens were collected in October and November.

Etymology:—The specific epithet refers to the Atlantic Forest domain, to which the species is endemic.

Additional specimens examined (paratypes):—BRAZIL. **Bahia:** Nova Viçosa, Fazenda Bloco 34 da Suzano S.A. (Project BAMGES), 17°57'11"S, 39°41'21"W, 764 m, 3 November 2019 (fl.), *P.H. Gaem & H.T.A. Morais 212* (ALCB, CASA, ESA, HUEFS, RB, SORO). **Espírito Santo:** Linhares, Reserva Natural Vale, estrada Aceiro–Aracruz, borda da estrada, mata de tabuleiro, 26 October 2010 (fl.), *T.B. Flores 949* (RB, SPF, VIES); estrada Aceiro–João Pedro, mussununga, 9 November 2005 (fl.), *G. Siqueira 198* (VIES).

Comments:—*Tocoyena atlantica* has a cup-shaped calyx with triangular lobes (*vs.* minutely lobed or truncate in *T. formosa*, *T. brasiliensis* and *T. sellowiana*) and an obconical, laterally compressed hypanthium (*vs.* oblong or ellipsoid, not laterally compressed in *T. formosa*, *T. brasiliensis*, and *T. sellowiana*).

Tocoyena atlantica also differs from *Tocoyena formosa* and *T. brasiliensis*, two similar species (Prado 1987; Borges *et al. in prep.*), in aspects such as habit (*T. atlantica* is always a tree 5–8 m tall, while *T. formosa* and *T. brasiliensis* are trees or shrubs 0.5–12 m tall), corolla glabrous outside (*vs.* puberulent outside in *T. formosa* and *T. brasiliensis*), and leaves blades adaxially glabrous (*vs.* tomentose or strigose on both sides in *Tocoyena formosa*, and glabrous or occasionally with puberulous vestiture on abaxial vein in *T. brasiliensis*). *Tocoyena sellowiana* has leaf blades completely glabrous, with domatia at the axils of secondary veins on the abaxial surface (as observed in the type material *Sellow 1758*), a feature not found in *T. atlantica*.

Delprete (2008) reported that *Tocoyena formosa* is mainly associated with savannas (*cerrado sensu stricto* and the vegetation on *campo rupestre*) or mesophytic forests (*cerradão*), which are formations on which *T. atlantica* does not occur. We consider the ecological and morphological differences between these two taxa, as an important set of characters to recognize *T. atlantica* as a distinct species.

Key to the species of *Tocoyena* occurring in the Brazilian Atlantic Forest

1. Leaf blades widely elliptic, 34−46.4 cm long; corollas 24−28 cm long ..... *T. longiflora*
- Leaf blades elliptic, oblong, or obovate, 5.5−24.5 cm long; corollas 8.5−14 cm long 2
2. Leaves clustered at branch tips, separated by internodes 2−3 mm long; calyx lobed, lobes triangular, ca. 6 mm long; hypanthium obconic, laterally compressed ..... *T. atlantica*
- Leaves separated by internodes 8−22 mm long; calyx truncate or minutely lobed; hypanthium ellipsoid to oblong, not laterally compressed 3
3. Stipules 12 × 5 mm, apex acuminate; leaf blades bullate, pilose ..... *T. bullata*
- Stipules 4−6 × 4.2−5.4 mm, apex acute; leaf blades planar (i.e. not bullate), glabrous, pubescent, sericeous, or tomentose 4
4. Leaves completely glabrous, brownish to black when dry, with domatia at axils of secondary veins; corolla tube glabrous externally ..... *T. sellowiana*
- Leaves pubescent, sericeous, or tomentose, yellowish, or olive green when dry; domatia absent; corolla tube puberulent externally ..... *T. formosa*

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