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Dizygostemon riparius (*Plantaginaceae*, *Gratioleae*), a new species from Maranhão, northeastern Brazil

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Abstract: Here we describe and illustrate *Dizygostemon riparius* (*Plantaginaceae*, *Gratioleae*) as a new species from the state of Maranhão, northeastern Brazil. We present morphological and micromorphological descriptions and comparisons, along with illustrations, photographs, and information on its taxonomy, habitat, geographic distribution and conservation status. *Dizygostemon riparius* differs from *D. floribundus*, the only other accepted species of the genus, by having the stems sparsely to densely tomentose, the sepals as long as or slightly longer than the corolla tube, the posterior sepal to 1.5 times as wide as any of the other four, the ovary glandular villous, and the leaves larger. The new species is assessed as Endangered (EN) according to IUCN categories and criteria. Additionally, we provide diagnostic features that help to differentiate *Dizygostemon* from the similar Brazilian genera *Achetaria*, *Stemodia* and *Tetraulacium*.

Key words: aromatic herb, *Beyrichia*, Brazil, Cerrado, conservation, *Dizygostemon*, essential oils, *Gratiolaceae*, *Gratioleae*, Maranhão, micromorphology, Neotropics, new species, *Plantaginaceae*, SEM, taxonomy

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Introduction

Dizygostemon Radlk. ex Wettst. belongs to the *Gratioleae*, a mainly tropical tribe of the *Plantaginaceae* that comprises c. 25 genera and over 300 species (Albach & al. 2005; Estes & Small 2008; Scatigna & al. 2018). The genus, restricted to the northeastern region of Brazil, is currently composed of a single accepted species and is characterized by the herbaceous habit, the short-pedicellate and bibracteolate flowers, and the androecium composed of four fertile stamens, the anterior pair being monothecous and the posterior pair being bithecous with a bi-brachiate connective separating the thecae (Souza & Giulietti 2009).

Dizygostemon was described by Bentham (1846) as a monotypic section of *Beyrichia* Cham. & Schltdl., represented only by *Beyrichia floribunda* Benth., and was placed within the tribe *Gratioleae*. According to Bentham

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(1846) and Bentham & Hooker (1876), *Dizygostemon* differs from *Achetaria* Cham. & Schltdl., the other section of *Beyrichia* sensu Bentham (1846), by the posterior pair of stamens being fertile (vs sterile) and by the loculicidal capsule (vs septicidal). Subsequently, Wettstein (1891) elevated *Dizygostemon* to the generic level based on these differences and proposed the combination *D. floribundus* (Benth.) Radlk. ex Wettst. Later, Giulietti (1973) recognized *D. angustifolius* Giul. as a new species characterized by narrower leaf blades and a more restricted geographic distribution (Giulietti & Wanderley 1973; Souza & Giulietti 1990). More recently, Souza & Giulietti (2009) adopted a broader concept of *D. floribundus*, including *D. angustifolius* in its synonymy, and this circumscription is currently followed (BFG 2015, 2018).

The phylogenetic placement of *Dizygostemon* within the *Gratioleae* has not been tested, but the anthers with the thecae separated by a bi-brachiate connective was used by Bentham & Hooker (1876) to include *Achetaria* and *Dizygostemon* (then under *Beyrichia*) in the subtribe *Stemodiineae* (*Stemodieae* sensu Bentham & Hooker 1876) along with *Adenosma* Nees, *Hydrotriche* Zucc., *Limnophila* R. Br. (these three exclusive to the Old World), *Lindenbergia* Lehm. (currently in *Orobanchaceae*; Young 1999; Olmstead & al. 2001), *Morgania* (= *Stemodia* L.; Barker 1990), *Stemodia* and *Tetraulacium* Turcz. Moreover, Souza & Giullieti (2009) suggested a close relationship between *Achetaria* (currently at the generic level; Pennell 1940), *Dizygostemon* and *Tetraulacium* based on the calyx having the posterior sepal much larger than the other four, and the anterior pair of stamens being monothecous. In a recent phylogenetic study of tribe *Gratioleae*, Scatigna & al. (2018) recovered *Achetaria* as closely related to *Stemodia* in part, but not to *Tetraulacium*.

In Brazil, the only genera of *Stemodiineae* (sensu Bentham & Hooker 1876) with native representatives are *Achetaria*, *Dizygostemon*, *Stemodia* and *Tetraulacium* (Souza & Giulietti 2009; BFG 2015, 2018). In the consulted herbaria, some specimens of *Achetaria*, *Dizygostemon* and *Tetraulacium* were identified as *Stemodia*, probably due to their resemblance and the fact that the last is the largest genus of the group.

In 2011, one of the authors (R.M.T.) while on a trip back to his birthland, São Benedito do Rio Preto, Maranhão, Brazil, was attracted by the pleasant fragrance of a riparian herb, locally called "melosa", on the bank of the Rio Preto River. This pleasant aroma aroused interest in plant identification and investigation of its essential oil composition. Specimens were sent for identification to the MAR herbarium, identified there as *Stemodia foliosa* Benth., and to SLUI herbarium, identified there as *S. arizonica* Pennell (= *S. durantifolia* [L.] Sw.). However, preliminary analysis of its essential oils revealed chemotypes that differ substantially from those known in some *Stemodia* species (Arriaga & al. 2007; Silva & al. 2009); therefore, the plant identity remained uncertain. In 2017, specimens were sent for identification to other two authors (A.V.S. and G.D.C.), both of whom are working on the systematics of *Gratioleae*, and they concluded that the "melosas" from the Rio Preto River represented an undescribed species of *Dizygostemon*.

Here we describe this new species of *Dizygostemon* from the State of Maranhão, northeastern Brazil. We include morphological and micromorphological evidence, along with illustrations, photographs, and information on its taxonomy, habitat, geographic distribution and conservation status. Additionally, we provide diagnostic features that help in differentiating *Dizygostemon* from *Achetaria*, *Stemodia* and *Tetraulacium*.

Material and methods

Morphological comparisons and the key in this work are based on field observation, direct examination of specimens of *Dizygostemon* housed in CEPEC, EAC, ESA, HUEFS, K, SLUI and UEC (herbarium codes according to Thiers 2018+), and consultation of digital images of specimens housed in G, IPA, MG, MO, NY and P, complemented with information available in the literature (Bentham 1846; Schmidt 1862; Bentham & Hooker 1876; Wettstein 1891; Pennell 1940; Giulietti 1973; Giulietti & Wanderley 1973; Ronse 2001; Souza & Giulietti 1990, 2009). All cited specimens were directly observed, except where otherwise stated. Additional records of the new species were obtained from the following herbaria: ALCB, BHCB, BHZB, CEN, CGMS, COR, CPAP, CTES, CVRD, DIAM, HCJS, HRB, HRCB, IAC, IAN, ICN, MBM, MBML, OUPR, PACA, R, RB, SP, SPF, UB and UPCB. Line drawings were made by Klei Sousa from fresh, fixed and herbarium specimen material under an Olympus SZH10 stereomicroscope with a drawing attachment, and also digital photographs of specimens in vivo. The distribution map was generated with ArcGIS, a product of the Environmental Systems Research Institute (ESRI; Redlands, California).

Micromorphological study — Fresh samples from stems, leaves, flowers and seeds of the new species were fixed and stored in 70% ethanol, whereas samples from dried material of *Dizygostemon floribundus* (*Melo 3449* [ESA]) were rehydrated with boiling water and stored in 70% ethanol. The material was critical-point dried, mounted on aluminium stubs with double-sided adhesive tape and covered with c. 40 nm of gold in a SCD 050 sputter coater (Bal-Tec). Images were observed in a JSM 5800LV scanning electron microscope (Jeol, Japan), at 10kV, and captured with the software SemAfore 5.21.

Conservation status assessment — The conservation status evaluation was based on field observations and followed the IUCN Red List categories and criteria (IUCN 2012) and subsequent guidelines (IUCN 2017); we estimated the extent of occurrence (EOO) and area of occupancy

(AOO) using the Geospatial Conservation Assessment Tool (Bachman & al. 2011) with a cell width of 2 km and based on the coordinates provided on specimen labels.

Results and Discussion

Defining the genus

Dizygostemon is one of the four genera of the subtribe *Stemodiineae* (sensu Bentham & Hooker 1876) that occur in Brazil (BFG 2018). It is similar to *Achetaria* in having the posterior sepal usually much wider than the other four, which are uniformly narrower, the corolla with a papillate lower lip (Fig. 4H), the corolla tube occluded by the inflated palate of the lower lip, touching the upper lip (Fig. 1D, E, 2A, B, C), and the anterior pair of stamens monothecous (Fig.1H left, 3J; Pennel 1940; Ronse 2001; Souza & Giullieti 2009). *Dizygostemon* can be confused with *Stemodia* in general aspect and is similar to this genus in the posterior pair of stamens being fertile. It is also similar to *Tetraulacium* in the four stamens being fertile and in the unequal sepals.

Dizygostemon differs from *Achetaria* in having the anterior pair of anthers free (Fig. 1G, 4L; vs adherent) and the posterior pair of the anthers fertile with unequal thecae (Fig. 1H right, 4I, J, L; vs sterile with equal thecae) (Giulietti & Wanderley 1973; Souza & Giulietti 2009). It differs from *Stemodia* in having the corolla tube occluded by the palate (vs not occluded), the anterior pair of stamens monothecous (vs bithecous) and the posterior pair of anthers with unequal thecae (vs equal). It also differs from *Tetraulacium* in having the corolla tube occluded (vs not occluded), bracteoles present (vs absent) and the posterior pair of stamens bithecous (vs monothecous).

Identification key to the species of *Dizygostemon* from northeastern Brazil

1. Sepals as long as or slightly longer than corolla tube; posterior sepal to 1.5 times as wide as any of other four; ovary glandular villous; leaves larger, 1.5–8 × 0.5–4 cm; stems sparsely to densely tomentose; corolla tube 5.2–6.2 mm long . . . . . ***D. riparius***
– Sepals shorter than half of corolla tube; posterior sepal more than 2 times as wide as any of other four; ovary glabrous to glandular puberulent; leaves smaller, 0.6–1.6 × 0.2–0.7 cm; stems glabrous to strigillose; corolla tube 2.5–6 mm long . . . . . ***D. floribundus***

Dizygostemon riparius Scatigna & Colletta, **sp. nov.** – Fig. 1, 2, 3, 4B, D, F, H, J, L, N, P.

Holotype: Brazil, Maranhão, São Benedito do Rio Preto, margem do Rio Preto, 03°19'28"S, 43º31'02"W, 28 m, planta com flor roxa, 30 Sep 2017, *Teles s.n.* (UEC[accession number]202426; isotypes: B, K, MAR).

Diagnosis — Dizygostemon riparius is characterized by its glandular villous ovary. It differs from *D. floribundus* in having stems sparsely to densely tomentose (vs glabrous to strigillose); sepals as long as or slightly longer than corolla tube (vs shorter than half of corolla tube); posterior sepal to 1.5 times as wide as any of other four (vs more than 2 times); ovary glandular villous (vs. glabrous to glandular puberulent); and leaves larger, 1.5–8 × 0.5–4 cm (vs 0.6–1.6 × 0.2–0.7 cm).

Morphological description — Subshrubs, to c. 50 cm tall, aromatic, viscid. *Stems* crawling to erect, subquadrangular to clearly quadrangular, canaliculate, branched, frequently presenting adventitious roots, sparsely to densely tomentose, densely covered with non-capitate, flexuous trichomes, interspersed with short, capitate trichomes and sessile glands, denser towards apex. *Leaves* opposite or rarely 3-whorled, sessile or petiole to 1.5 cm long; *blade* narrowly ovate to elliptic, 1.5–8 × 0.5–4 cm, base attenuate, margin crenate-serrate, apex acute to obtuse; abaxial surface covered with short, capitate trichomes, sessile glands and more abundant, longer, curved, non-capitate trichomes, these concentrated on veins; adaxial surface covered with short, capitate trichomes and sessile glands interspersed with longer, non-capitate, curved trichomes scattered over surface. *Flowers* axillary, single or geminate, bracteolate; *pedicel* 1–3 mm long, densely covered with short, capitate trichomes, sessile glands and abundant, longer, curved, non-capitate trichomes; *bracteoles* 2, opposite, narrowly elliptic to lanceolate, 2.9–7 × 1.5–1.7 mm, indumentum similar to leaves; *sepals* subequal, connate at base, lanceolate, 5.9–7.7 × 2–2.8 mm, posterior one slightly longer and wider than others, apex acute, all five slightly curved outwards, external surface indumentum similar to leaves, internal surface covered exclusively with sessile glands; *corolla* bilabiate, personate, entirely white or lilac with a pair of white patches on throat, tube 5.2–6.2 mm long, occluded by palate of lower lip, base slightly inflated, externally sparsely tomentose, covered with short, capitate trichomes, sessile glands and longer, curved, non-capitate trichomes, internally tomentose, upper lip 2-lobed, 5–6.2 × 4–4.5 mm, apex truncate to slightly emarginate, externally sparsely tomentose, covered with short, capitate trichomes, sessile glands and more abundant, longer, curved, non-capitate trichomes, lower lip 3-lobed, palate inflated, 3.5–5 × 4–6.5 mm, covered with short, non-capitate trichomes on throat, papillate, lobes 1.8–2.5 × 2–2.5 mm, apex emarginate. *Stamens* 4, all fertile, didynamous, reaching throat, *filaments* filiform, apex capitate, anterior pair 3.3–3.7 mm long, posterior pair 4.4–4.6 mm long, both with rare, short, capitate trichomes; *anthers* of anterior stamens with only one theca, 1–1.1 mm long, glabrous or with rare, sessile glands, anthers of posterior stamens with two thecae, slightly subequal, separated by bi-brachiate connective, 0.7–1 mm long, glabrous or with rare, ses-

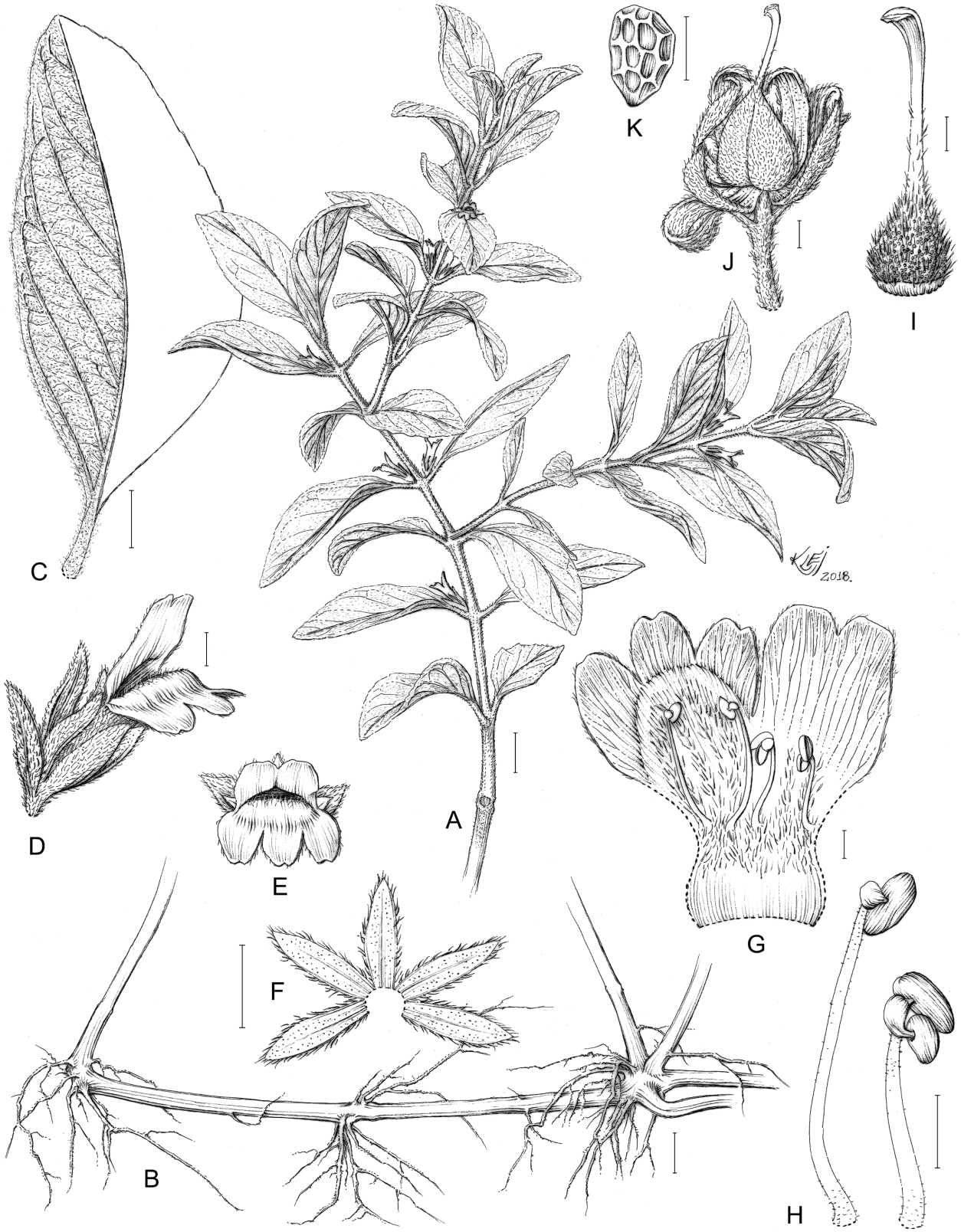

Fig. 1. *Dizygostemon riparius* – A: flowering branch; B: prostrate branch with adventitious roots; C: leaf abaxial surface, showing indumentum; D: flower in lateral view subtended by a pair of bracteoles; E: flower in frontal view, showing personate shape; F: calyx with subequal sepals; G: dissected corolla showing androecium; H: types of stamens, anterior on left, posterior on right; I: ovary covered by glandular villous indumentum; J: immature fruit and persistent calyx; K: seed with reticulate surface. – Drawn by Klei Sousa from the holotype (*Teles s.n.* UEC[accession number]202426). – Scale bars: K = 0.25 mm; G, H, I, J = 1 mm; D, E = 2 mm; C, F = 5 mm; A, B = 1 cm.

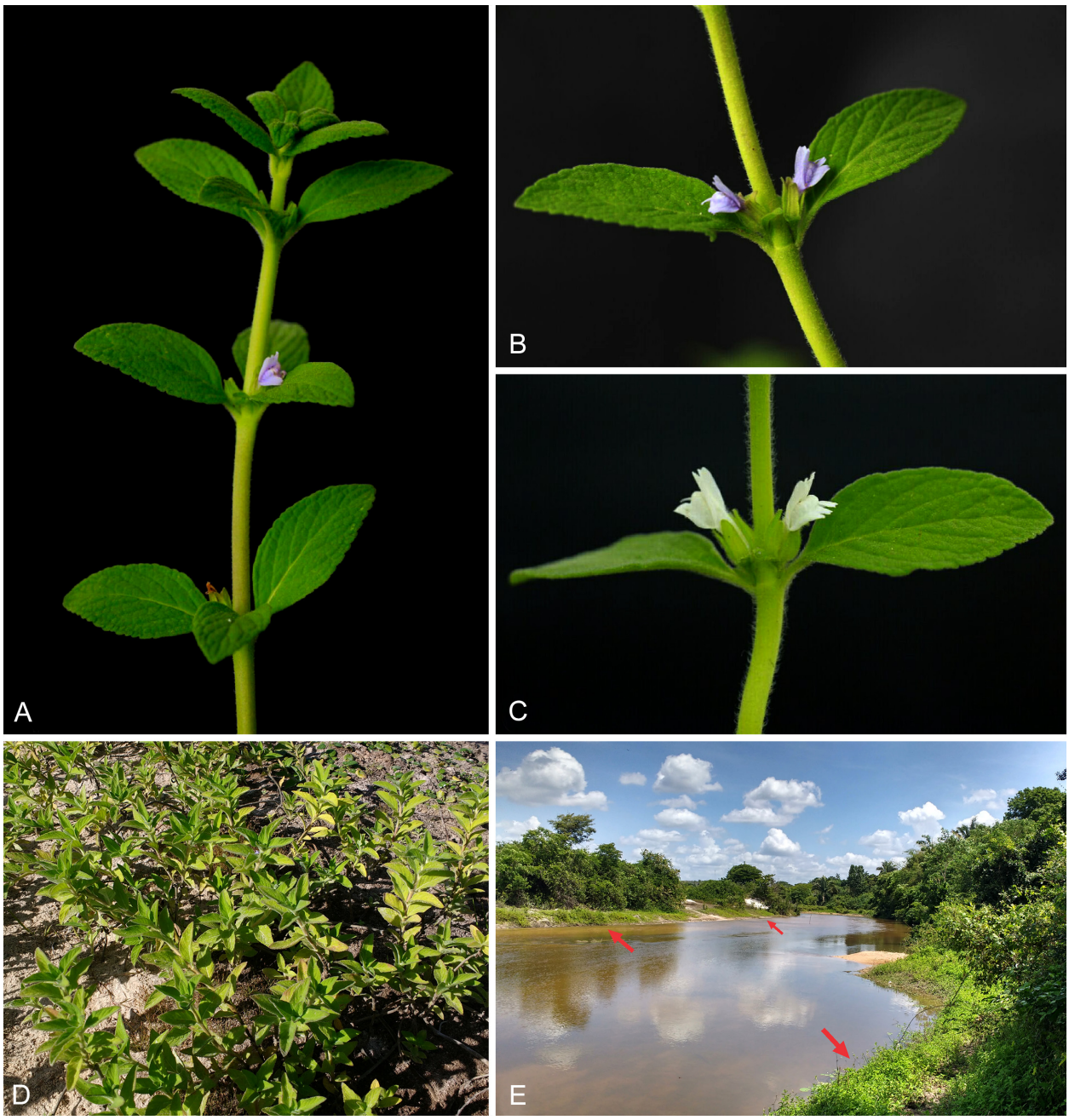

Fig. 2. *Dizygostemon riparius* – A: flowering branch with 3-whorled leaves; B: flower insertion of lilac-flowered specimen; C: flower insertion of white-flowered specimen; D: habit; E: habitat in Rio Preto River. – Red arrows indicate patches of *D. riparius*. – Photographs: A, B, C: Ermenson Martins; D, E: Rogério Teles.

sile glands; *staminode* 1, much reduced. *Ovary* superior, 2-carpellate, 2-locular, ovoid, 2.8–3 × 1.9–2.1 mm, glandular villous, densely covered with long, glandular trichomes and sessile glands; placentation axillary, ovules numerous; *style* terminal, solitary, filiform, 4.3–4.6 mm long, sparsely glandular puberulent, persistent; *stigma* obdeltoid, 0.7–0.8 mm long, curved, glabrous. *Capsule* ovoid, 5.8–6 × 3.3–3.5 mm, with a deep, longitudinal groove on septum line, sparsely covered with long, glandular trichomes and sessile glands, dehiscence not observed; *seeds* ovoid, 0.45–0.5 × 0.3–0.31 mm, surface reticulate.

Micromorphological study — We observed non-glandular trichomes (type NG) and glandular trichomes (types G1, G2, G3 and G4). The NG type consists of a multicellular, uniseriate trichome with an acute head cell and tiny cuticular granules on the surface (Fig. 3A); its length is variable, reaching 2 mm in *Dizygostemon riparius*, but scarcely exceeding 0.5 mm in *D. floribundus*. Type G1 has a broad base, a uniseriate, 2- or 3-celled pedicel, and an apparently 1-celled, round head (Fig. 3B); this type is referred to as capitate throughout the text. Type G2 consists of an obscure, 1-celled pedicel and a wide (60–80 µm in diam.), multicellular head covered with a cuticle layer

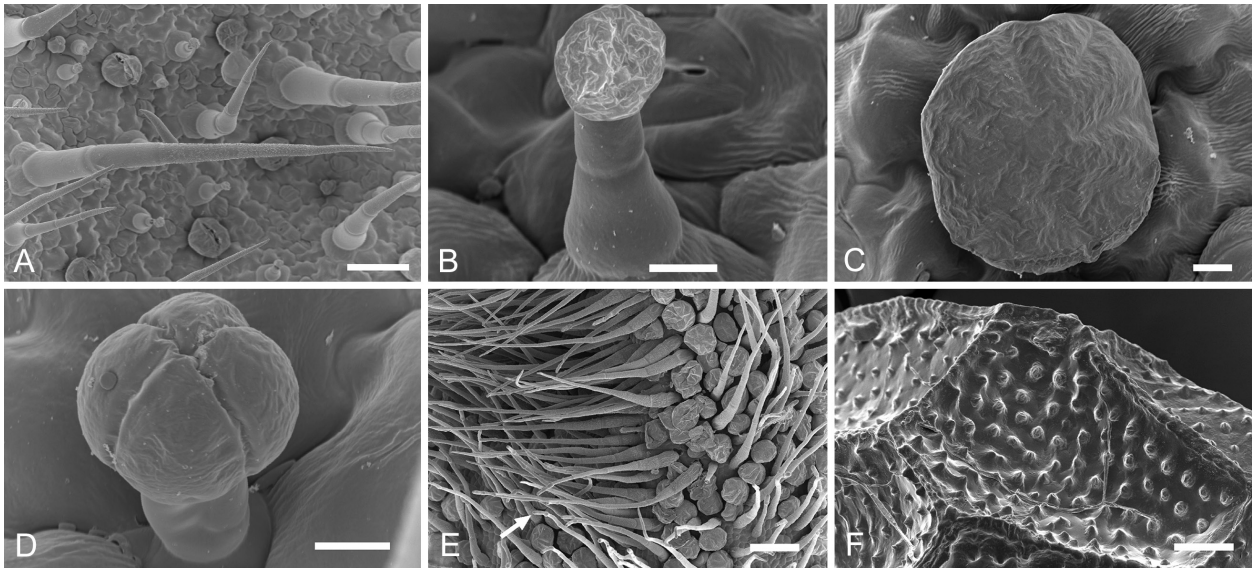

Fig. 3. Scanning electron micrographs of trichomes and seed surface of *Dizygostemon riparius*. – A: type NG; B: type G1; C: type G2; D: type G3; E: types G2 and G4 (white arrow); F: detail of reticulate seed surface, showing periclinal wall ornamentation. – All from the holotype (*Teles s.n.* UEC[accession number]202426). – Scale bars: B, C, D = 10 µm; F = 20 µm; A, E = 100 µm.

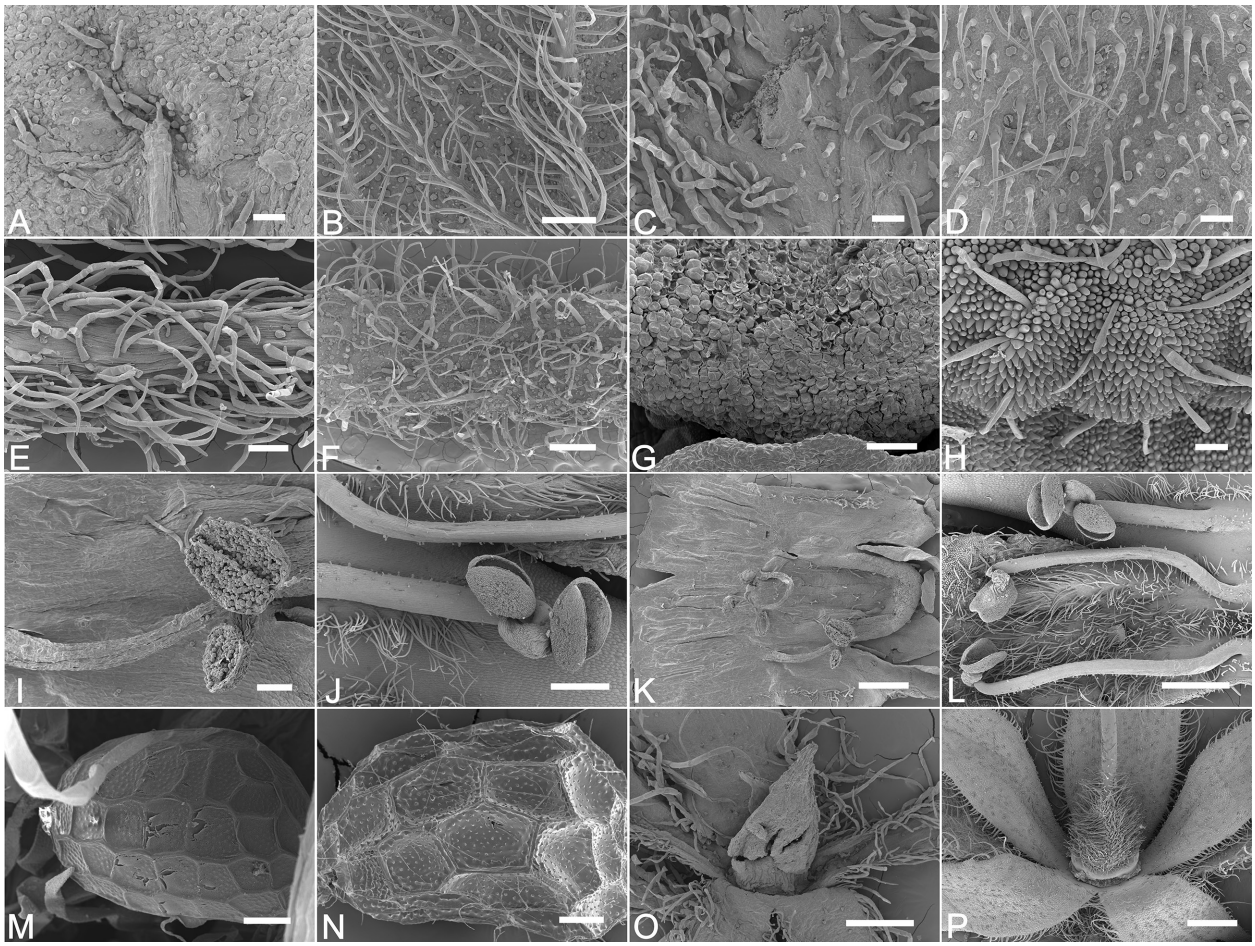

Fig. 4. Comparative scanning electron micrographs of micromorphological characters of *Dizygostemon floribundus* (A, C, E, G, I, K, M, O) versus *D. riparius* (B, D, F, H, J, L, N, P). – A, B: abaxial leaf surface; C, D: adaxial leaf surface; E, F: stem; G, H: corolla lower lip surface; I, J: posterior stamen; K, L: dissected corolla; M, N: seed; O, P: ovary. – *Dizygostemon floribundus*, from *Melo 3449* (ESA); *D. riparius*, from the holotype (*Teles s.n.* UEC[accession number]202426). – Scale bars: G, M, N = 50 µm; H, I = 100 µm; A, C, D, E = 200 µm; B, F, J, K, O = 500 µm; L, P = 1 mm.

Table 1. Occurrence and frequency of each type of trichome on aerial parts of *Dizygostemon riparius* and *D. floribundus*. Trichomes: – absent, ± rare, + present, ++ abundant.

	Trichome type	Stem	Leaf		Sepal		Corolla		Ovary
			abaxial	adaxial	abaxial	adaxial	external	internal	
D. riparius	NG	++	++	++	++	–	++	++	±
	G1	++	++	++	++	±	±	±	–
	G2	++	++	+	++	±	++	±	++
	G3	+	+	+	+	+	+	+	+
	G4	–	–	–	±	–	+	+	++
D. floribundus	NG	++	±	++	++	–	+	–	–
	G1	–	±	–	–	–	–	–	–
	G2	+	++	+	+	+	+	±	–
	G3	–	–	±	–	–	±	–	–
	G4	–	–	–	–	–	–	–	–

Table 2. Diagnostic characters between *Dizygostemon riparius* and *D. floribundus.*

Character	*D. riparius*	*D. floribundus*
Habit	robust, prostrate to erect subshrubs	delicate, erect herbs
Height	up to 50 cm	(5–)10–30 cm
Stem indumentum	sparsely to densely tomentose	glabrous to strigillose
Leaf shape	narrowly ovate to elliptic	linear, lanceolate, oblanceolate, ovate or obovate
Leaf size	1.5–8 × 0.5–4 cm	0.6–1.6 × 0.2–0.7 cm
Sepal length relative to corolla tube	equal or slightly longer	shorter than half
Width of posterior sepal relative to 4 remnants	up to 1.5 ×	more than 2 ×
Corolla tube length	5.2–6.2 mm	2.5–6 mm
Ovary surface	glandular villous	glabrous to glandular puberulent

(Fig. 3C); this type is referred to as sessile glands in the key, diagnosis and descriptions, because this is how it appears under the stereo microscope. Type G3 has a short, 1-celled pedicel and a wide (10–30 µm in diam.), usually clearly 4-celled (sometimes 8- or 16-celled) head (Fig. 3D); this type is also referred to as capitate throughout the text. Type G4 is a variation of the NG type except for the slightly inflated head cell (Fig. 3E). All types of trichomes were found in both compared specimens, but with relatively different distribution and abundance among plant parts.

The indumentum and micromorphological aspects of trichomes have been useful for recognizing species within some genera of *Gratioleae* such as *Achetaria* (including *Otacanthus* Lindl.), *Philcoxia* P. Taylor & V. C. Souza and *Stemodia* (Ronse 2001; Souza & Giulietti 2009; Scatigna & al. 2017a, 2017b). In this study, these characters were useful in distinguishing *Dizygostemon riparius* from *D. floribundus* (Table 1; Fig. 4A–F, O, P).

Both studied specimens were found to possess a reticulate seed surface with smooth to slightly cristate anticlinal walls and more or less papillate external periclinal walls. In *Dizygostemon riparius* (Fig. 3F, 4N), anticlinal walls are slightly cristate and relatively higher and the periclinal wall is more markedly papillate. In *D. floribundus* (Fig. 4M), anticlinal walls are smooth and relatively lower and the external periclinal wall is less markedly papillate. In addition, the cells delimited by anticlinal walls are larger and more angulate in *D. riparius*.

Phenology — Specimens were observed with flowers and fruits from May to December, especially during the dry season. In São Benedito do Rio Preto, the population was found submerged in the waters of the Rio Preto River from January to June, during the rainy season.

Distribution and ecology — *Dizygostemon riparius* was recorded in three municipalities of the northeastern portion of Maranhão, Brazil (Fig. 5). Populations grow in periodically waterlogged habitats such as banks and margins of rivers and marshes (Fig. 2E); this riparian life-form is present in some species of *Achetaria* and *Stemodia*, which are not described as typical macrophytes (Souza & Giulietti 2009).

Conservation status — Although one of the recorded populations of *Dizygostemon riparius* is at least partly encompassed by a protected area (Parque Nacional dos Lençóis Maranhenses), we observed strong threats to the quality and extent of its habitat. Threats include inappropriate waste disposal, sand removal, and deforestation

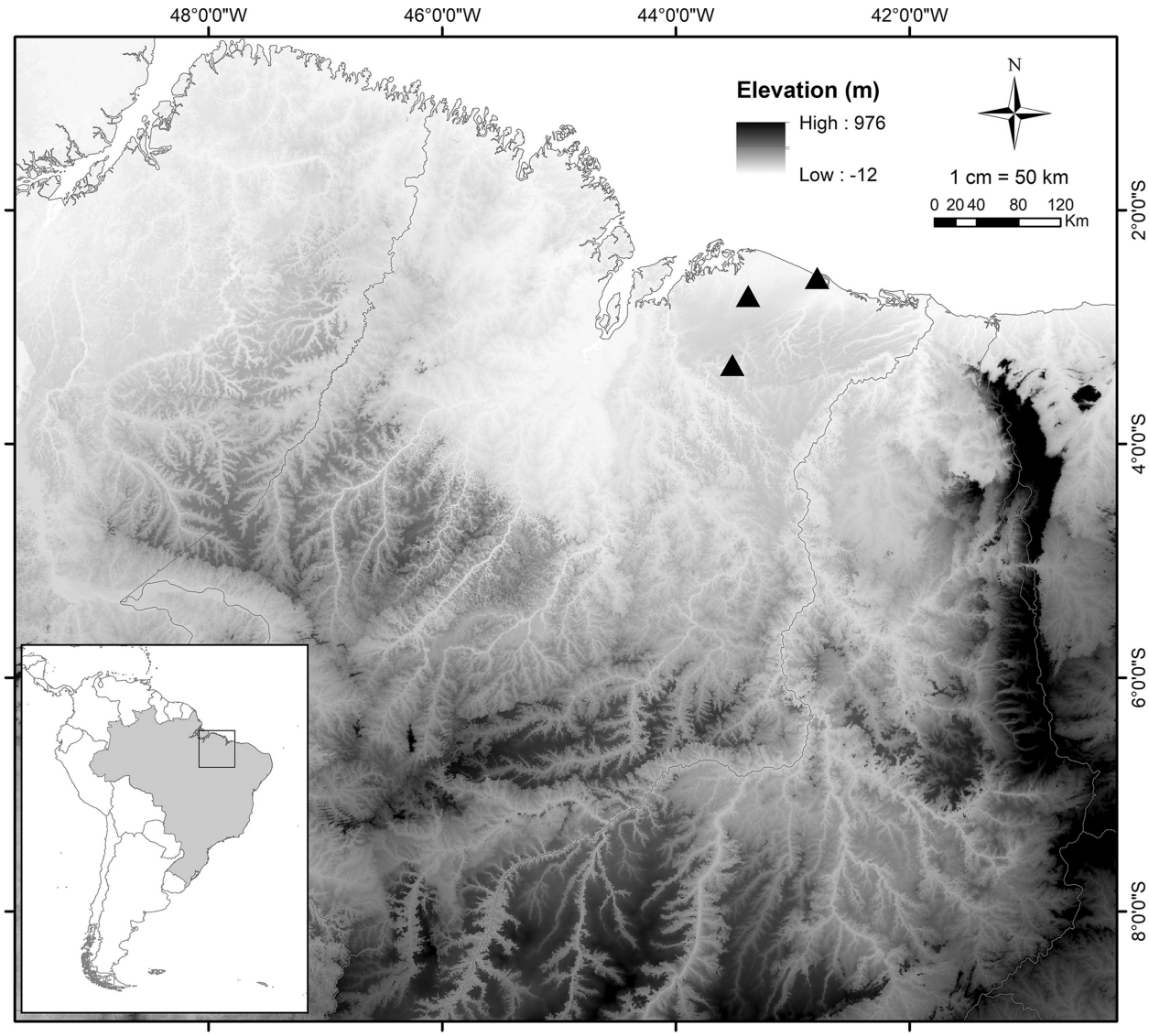

Fig. 5. Distribution map of *Dizygostemon riparius* in northeastern Brazil. Black triangles represent recorded populations.

of riparian forest, leading to riverbed silting. The species is known from only three locations, with an EOO of 2027 km^2 and an AOO of 12 km^2. As based on the IUCN (2012, 2017) criteria, *D. riparius* should be considered Endangered [EN, B1ab(i,ii,iii)+2ab(i,ii,iii)]. New efforts to track populations of the new species along the river basin may provide additional information for a more accurate evaluation.

Etymology — The specific epithet refers to the riparian habit of the new species, which is found in dense patches along watercourse margins (Fig. 2D, E)

Vernacular name — *Dizygostemon riparius* is known as "melosa" by local people of São Benedito do Rio Preto because of its viscid aspect when rubbed between fingers. Its leaves, stems and roots release a sharp, refreshing and pleasant aroma and are used to scent clothes and in domestic animals' hygiene.

Remarks — The originally neuter terminations of the epithets of *Dizygostemon angustifolius* and *D. floribundus* have been corrected to agree with the masculine gender of *Dizygostemon* (Art. 23.5, 32.2 and 62.2(a) of the *Shenzhen Code*; Turland & al. 2018).

Based on the description of *Dizygostemon floribundus* provided by Schmidt (1862) and an examination of photographs of type specimens, Giulietti & Wanderley (1973) differentiated it from *D. angustifolius* by leaf blade dimensions, shape and margin. Souza & Giulietti (2009) considered these characters to be highly variable, even among type specimens of *D. floribundus*, and therefore included *D. angustifolius* under its synonymy. *Dizygostemon floribundus*, as currently circumscribed (sensu Souza & Giulietti 2009), has a wide range of morphological variation, especially regarding general indumentum (from glabrous to strigillose), leaf shape (linear, linear-lanceolate, ovate, obovate, oblanceolate), ovary surface (glabrous to glandular puberulent) and corolla dimen-

sions. It occurs in the Caatinga domain in four states of the northeastern region of Brazil, namely Bahia, Ceará, Pernambuco and Piauí. Nevertheless, *D. riparius* has a unique set of morphological traits not encompassed by this variation; it has sparsely to densely tomentose indumentum (Fig. 4B, D, F), much larger leaves (Fig. 1C, 2A), a glandular villous ovary surface (Fig. 1I, 3E, 4P), and is restricted to the state of Maranhão, within the Cerrado domain. We observed two morphotypes in the population of *D. riparius* from São Benedito do Rio Preto, one with a lilac corolla with white patches on the lower lip (Fig. 1A, B) and the other with an entirely white corolla (Fig. 2C); in *D. floribundus*, the corolla is reportedly pale lilac (Souza & Giulietti 2009). For additional diagnostic characters, see Table 2.

Giulietti (1973) and Giulietti & Wanderley (1973) used only a few characters to recognize *Dizygostemon angustifolius* as a distinct species. Conversely, Souza & Giulietti (2009) examined a limited number of specimens when proposing its synonymization. It is possible that the broad concept of *D. floribundus* covers even more undescribed species. To properly assess this issue, we recommend thorough examination of several specimens, considering both morphological and geographic ranges, and the use of additional characters such as the types of trichomes and their distribution in the plants, as has proven useful within *Achetaria*, *Philcoxia* and *Stemodia* (Ronse 2001; Souza & Giulietti 2009; Scatigna & al. 2017a, 2017b).

Additional specimens examined — Brazil: Maranhão: Barreirinhas, PARNA dos Lençóis Maranhenses, Povoado de Santo Inácio, campos brejosos abertos, 02°34'49"S, 42°47'32"W, 7 m, 16 May 2015, *Mota & al. 3099* (MG[digital image]); Primeira Cruz, Rodovia MA-402 margem direita (Barreirinhas-São Luís), zona rural, margem de lagoa temporária, 02°44'04"S, 43°22'57"W, 25 Sep 2014, *Mota & Viana 2776* (MG[digital image]); São Benedito do Rio Preto, 10 Aug 2016, *Brandão & Soeiro s.n.* (SLUI[accession number]4587); idem, margem do Rio Preto, 03°19'28"S, 43°31'02"W, 1 Oct 2017, Planta com flor branca, *Teles s.n.* (ESA, HUEFS, UEC[accession number]202423); idem, margem do Rio Preto, 03°19'28"S, 43°31'02"W, planta com flor roxa, 1 Oct 2017, *Teles s.n.* (UEC[accession number]202425); idem, planta com flor branca, amostra de material cultivado, 21 Oct 2017, *Brandão s.n.* (UEC[accession number]202422); idem, planta com flor roxa, amostra de material cultivado, 21 Oct 2017, *Brandão s.n*. (UEC[accession number]202424).

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References

Albach D. C., Meudt H. M. & Oxelman B. 2005: Piecing together the "new" *Plantaginaceae*. – Amer. J. Bot. **92:** 297–315.

Arriaga A. M. C., Rodrigues F. E. A., Lemos T. L. G., Oliveira M. D. C. F., Lima J. Q. & Santiago G. 2007: Composition and larvicidal activity of essential oil from *Stemodia maritima* L. – Nat. Prod. Commun. **2:** 1237–1239.

Bachman S., Moat J., Hill A. W., de la Torre J. & Scott B. 2011: Supporting Red List threat assessments with GeoCAT: geospatial conservation assessment tool. – ZooKeys **150:** 117–126.

Barker W. R. 1990: New taxa, names and combinations in *Lindernia*, *Peplidium*, *Stemodia* and *Striga* (*Scrophulariaceae*) mainly of the Kimberley Region, Western Australia. – J. Adelaide Bot. Gard. **13**: 79–93.

Bentham G. 1846: *Scrophulariaceae*. – Pp. 186–586 in: Candolle A. de (ed.), Prodromus systematis naturalis regni vegetabilis **10.** – Parisiis: Sumptibus Victoris Masson.

Bentham G. & Hooker J. D. 1876: *Scrophulariaceae*. – In: Bentham G. & Hooker J. D. (ed.). Genera plantarum **2(2).** – London: Lovell Reeve & Co.

BFG – The Brazil Flora Group 2015: Growing knowledge: an overview of seed plant diversity in Brazil. – Rodriguésia **66:** 1085–1113.

BFG – The Brazil Flora Group 2018: Brazilian Flora 2020: innovation and collaboration to meet Target 1 of the Global Strategy for Plant Conservation (GSPC). – Rodriguésia **69:** 1513–1527.

Estes D. & Small R. L. 2008: Phylogenetic relationships of the monotypic genus *Amphianthus* (*Plantaginaceae* tribe *Gratioleae*) inferred from chloroplast DNA sequences. – Syst. Bot. **33:** 176–182.

Giulietti A. M. 1973: *Dizygostemon angustifolium* [sic] nova espécie de *Scrophulariaceae* de Pernambuco. – Anais Congr. Soc. Bot. Brasil. **23:** 77–78.

Giulietti A. M. & Wanderley, M. B. 1973: O gênero *Dizygostemon* (Benth.) Radlk. (*Scrophulariaceae*). – Anais Congr. Soc. Bot. Brasil. **23:** 77–81.

IUCN 2012: IUCN Red List categories and criteria: version 3.1, ed. 2. – Gland & Cambridge: IUCN.

IUCN 2017: Guidelines for using the IUCN Red List categories and criteria. Version 13. Prepared by the Standards and Petitions Subcommittee of the IUCN Species Survival Commission. – Published at http://cmsdocs.s3.amazonaws.com/RedListGuidelines.pdf

Olmstead R. G., dePamphilis C. W., Wolfe A. D., Young N. D., Elisons W. J. & Reeves P. A. 2001: Disintegration of the *Scrophulariaceae*. – Amer. J. Bot. **88:** 348–361.

Pennell F. W. 1940: Some new species of *Scrophulariaceae* from Guiana. – Notul. Nat. Acad. Nat. Sci. Philadelphia **46:** 1–6.

Ronse A. 2001: A revision of *Otacanthus* Lindl. (*Scrophulariaceae*). – Brittonia **53:** 137–153.

Scatigna A. V., Fritsch P. W., Souza V. C. & Simões A. O. 2018: Phylogenetic relationships and morphological evolution in the carnivorous genus *Philcoxia* (*Plantaginaceae*, *Gratioleae*). – Syst. Bot. **43:** 910–919.

Scatigna A. V., Silva N. G., Alves R. J. V., Souza V. C. & Simões A. O. 2017a: Two new species of the carnivorous genus *Philcoxia* (*Plantaginaceae*) from the Brazilian Cerrado. – Syst. Bot. **42:** 351–357.

Scatigna A. V., Souza V. C. & Simões A. O. 2017b: *Stemodia cipoensis* (*Plantaginaceae*): A new species from Serra do Cipó, Minas Gerais, Brazil. – Syst. Bot. **42:** 371–377.

Schmidt J. A. 1862: *Scrophularinae*. – Pp. 229–330, t. 39–57 in: Martius C. F. P., Eichler A. W. & Urban I. (ed.), Flora brasiliensis **8(1).** – Lipsiae: apud Frid. Fleischer in comm.

Silva W. M. B., Assunção J. C. C., Araújo R. M., Silveira E. R., Pessoa O. D. L. 2009: New volatile constituents from leaves of *Stemodia trifoliata* (Link.) Reichb. (*Scrophulariaceae*). – J. Braz. Chem. Soc. **20:** 37–41.

Souza V. C. & Giulietti A. M. 1990: *Scrophulariaceae* from Pernambuco. – Bol. Bot. Univ. São Paulo. **12:** 185–209.

Souza V. C. & Giulietti A. M. 2009: Levantamento das espécies de *Scrophulariaceae* sensu lato nativas do Brasil. – Pesquisas, Bot. **60:** 7–288.

Thiers B. 2018+ [continuously updated]: Index herbariorum: a global directory of public herbaria and associated staff. New York Botanical Garden's virtual herbarium. – Published at http://sweetgum.nybg.org/science/ih/ [accessed Nov 2018].

Turland N. J., Wiersema J. H., Barrie F. R., Greuter W., Hawksworth D. L., Herendeen P. S., Knapp S., Kusber W.-H., Li D.-Z., Marhold K., May T. W., McNeill J., Monro A. M., Prado J., Price M. J. & Smith G. F. (ed.) 2018: International Code of Nomenclature for algae, fungi, and plants (Shenzhen Code) adopted by the Nineteenth International Botanical Congress Shenzhen, China, July 2017. – Glashütten: Koeltz Botanical Books. – [Regnum Veg. **159**].

Wettstein R. v. 1891. *Scrophulariaceae*. – Pp. 39–107 in: Engler A. & Prantl K. (ed.), Die natürlichen Pflanzenfamilien **IV(3b).** – Leipzig: Wilhelm Engelmann.

Young N. D., Steiner K. E. & dePamphilis C. W. 1999: The evolution of parasitism in *Scrophulariaceae*/*Orobanchaceae*: plastid gene sequences refute an evolutionary transition series. – Ann. Missouri Bot. Gard. **86:** 876–893.

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