European Journal of Taxonomy 733: 72–86
https://doi.org/10.5852/ejt.2021.733.1223
ISSN 2118-9773
www.europeanjournaloftaxonomy.eu
2021 · Silva O.L.M. *et al.*

Research article

Three new species of *Euphorbia* subgenus *Chamaesyce* (Euphorbiaceae) endemic to Brazil

Otávio Luis Marques da SILVA[1,*], Pierre BRAUN[2], Ricarda RIINA[3] & Inês CORDEIRO[4]

[1,4] Instituto de Botânica, Secretaria de Infraestrutura e Meio Ambiente, Cx. Postal 3005, 01061-970, São Paulo, SP, Brazil.
[2] Im Fusstal 37, D-50171 Kerpen, Germany.
[3] Real Jardín Botánico, RJB-CSIC, Plaza de Murillo 2, Madrid, 28014, Spain.

[*] Corresponding author: otaviolmarques@gmail.com
[2] Email: pbraunger@aol.com
[3] Email: rgriina@gmail.com
[4] Email: isandona@uol.com.br

[1] https://orcid.org/0000-0002-4561-5936
[2] https://orcid.org/0000-0002-2558-284X
[3] https://orcid.org/0000-0002-7423-899X
[4] https://orcid.org/0000-0002-2626-5280

Abstract. We describe and illustrate three new species of *Euphorbia* subgenus *Chamaesyce* from Brazil: *E. blepharadena* O.L.M.Silva & Cordeiro sp. nov., *E. longipedunculata* O.L.M.Silva & Riina sp. nov. and *E. sobolifera* O.L.M.Silva & P.J.Braun sp. nov. Based on morphological characteristics, *E. blepharadena* sp. nov. and *E. longipedunculata* sp. nov. are placed in the subcosmopolitan section *Anisophyllum*, whereas *E. sobolifera* sp. nov. is placed in the more geographically restricted section *Crossadenia*. The three new species are compared with their most similar species in each section, and accompanied by comments on habitat and distribution, illustrations, photographs, and proposed conservation status.

Keywords. *Euphorbia* section *Crossadenia*, *Euphorbia* section *Anisophyllum*, caatinga, cerrado, Neotropics, taxonomy.

Silva O.L.M., Braun P., Riina R. & Cordeiro I. 2021. Three new species of *Euphorbia* subgenus *Chamaesyce* (Euphorbiaceae) endemic to Brazil. *European Journal of Taxonomy* 733: 72–86.
https://doi.org/10.5852/ejt.2021.733.1223

Introduction

Euphorbia L. includes more than 2000 species, which makes it the most diverse genus of Euphorbiaceae Juss., and one of the largest within the angiosperms (Govaerts *et al.* 2000; Horn *et al.* 2012; Webster 2014). Despite its great variation in morphology, ranging from small annual plants to large and long-lived trees, the genus is characterized by a synapomorphy, unique among angiosperms, the cyathium

(Horn *et al.* 2012). This pseudanthial inflorescence consists of a cup-like involucre with glands along its rim (sometimes with appendages of several types) enclosing a single, central pistillate flower surrounded by four or five staminate cymules with reduced axes. Both the pistillate and staminate flowers are highly reduced to a single pistil and a single stamen, respectively (Radcliffe-Smith 2001; Prenner & Rudall 2007; Horn *et al.* 2012; Webster 2014), and in some species with unisexual cyathia, pistillate or staminate flowers may be reduced to a pistillode or staminodes (Rizzini 1989; Silva *et al.* 2020).

Phylogenetic studies have confirmed the monophyly of *Euphorbia* and recognized four subgenera: *E.* subg. *Athymalus* Neck. ex Rchb., restricted to the Old World (Peirson *et al.* 2013); *E.* subg. *Esula* Pers., mostly centered in temperate regions of the northern hemisphere (Riina *et al.* 2013); *E.* subg. *Euphorbia*, the most morphologically diverse, found mainly in the tropics and subtropics (Dorsey *et al.* 2013); and *E.* subg. *Chamaesyce* Raf., distributed primarily in the New World but also represented in the Old World (Yang *et al.* 2012).

Brazil is the most *Euphorbia* species-rich country in South America (Steinmann 2013). Currently, 64 native species of *Euphorbia* are recorded for Brazil, half of them endemic to the country (Flora do Brasil 2020, in construction). Since the last complete treatment of the genus for Brazil (the monograph in *Flora Brasiliensis* by Müller Argoviensis 1874), additional new species and new occurrences have been published, even in the past few years (Carrillo-Reyes & Steinmann 2011; Carneiro-Torres *et al.* 2012; Silva & Cordeiro 2015; Hurbath *et al.* 2018; Küllkamp *et al.* 2018; Silva *et al.* 2020).

Euphorbia subg. *Chamaesyce* is the most species-rich lineage of *Euphorbia* in Brazil, with two thirds of the species belonging to this subgenus. Within the subgenus, *E.* sect. *Anisophyllum* Roep. and *E.* sect. *Crossadenia* Boiss. are the most diverse sections, with 27 and 11 species, respectively (Flora do Brasil 2020, in construction; Silva *et al.* 2020). Based on extensive herbarium studies, we present and describe three new Brazilian species of *Euphorbia* subg. *Chamaesyce*, and, based on morphological evidence, we place two of them in *E.* sect. *Anisophyllum* and the third one in *E.* sect. *Crossadenia*.

Material and methods

We examined the collections of *Euphorbia* deposited in SP, SPF, HUEFS, MBM and RB; acronyms of herbaria follow Index Herbariorum (Thiers, continuously updated). Protologues and type specimens of related species were also analyzed through JSTOR Global Plants website (https://plants.jstor.org/). Morphological descriptions were based on observations using a 10−60 × magnification stereo microscope. We followed Beentje (2010) for general terminology, and for cyathial features we applied the specific terms from the *Euphorbia* Planetary Biodiversity Inventory group (www.euphorbiaceae.org) and relevant systematic treatments for *Euphorbia* (Horn *et al.* 2012; Yang *et al.* 2012). The distribution map was generated in QGIS ver. 3.14 (QGIS Development Team 2020), and the conservation status was proposed based on the International Union for the Conservation of Nature guidelines (IUCN 2019), adopting area of occupancy with a cell width of 2 km in GeoCAT (available from geocat.kew.org/).

Results

Class Magnoliopsida Brongn.
Order Malpighiales Mart.
Family Euphorbiaceae Juss.
Genus *Euphorbia* L.

Euphorbia blepharadena O.L.M.Silva & Cordeiro sp. nov.
urn:lsid:ipni.org:names:77214813-1
Figs 1–2

Diagnosis

Euphorbia blepharadena O.L.M.Silva & Cordeiro sp. nov. is similar to *Euphorbia foliolosa* Boiss. but differs in its smaller leaves with a denser indumentum composed of long (ca 1 mm) trichomes, cyathial glands with digitate appendages and pubescent ovary / fruit.

Type

BRAZIL • Minas Gerais, Jaíba, Furados, "lado direito da Estrada Jaíba – Mocambinho" [right side of the road Jaíba – Mocambinho]; 15°12′37″ S, 43°51′33″ W; 19 Oct. 2001; *J.A. Lombardi et al. 4433*; holotype: UEC[018613]; isotype: BHCB[64825].

Etymology

The epithet is a reference to the cyathial gland appendages, which look like eyelashes on these glands (Fig. 1G).

Description

Erect monoecious herbs, up to 30 cm tall; underground system not seen; latex white. Stems terete, irregularly branched, brown when dried, pubescent, with short (< 0.25 mm) curved and longer (ca 1 mm) erect simple trichomes. Leaves opposite, persistent, subsessile (petioles reaching up to 1 mm long); stipules interpetiolar, deltoid, inconspicuous (up to 1 mm long), apex fimbriate, indumentum of erect, long (ca 1 mm), simple trichomes; leaf blade membranaceous, pilose on the adaxial surface and densely pilose on the abaxial surface, both surfaces with erect, long (ca 1 mm), simple trichomes, discolorous (abaxial surface slightly lighter), elliptic to oblong, 0.5–0.8(–1) × 0.15–0.2 cm, base asymmetric, margin serrate with a colleter at the apex of each tooth, apex acute, venation hyphodromous. Cyathia solitary, axillary, subsessile; peduncle up to 1.5 mm long, with a few scattered erect, long (ca 1 mm), simple trichomes; involucre turbinate, 1.5–2.5 × 0.8–1.3 mm, actinomorphic, pilose on the outer surface, with erect, long (ca 1 mm), simple trichomes; involucral lobes triangular, pale to greenish when dried, margin fimbriate; cyathial glands 4(5), dark when dried, transversely elliptic and slightly concave, smooth, glabrous, 0.2–0.3 × 0.2–0.3 mm; cyathial gland appendages 6–8-digitate, lobes linear, 1.5–1.8(–2) mm long, white when dried, glabrous. Staminate flowers 25–35, arranged in (4)5 cincinni with 6–7 flowers each; bracteoles lanceolate, ciliate; pedicels up to 2 mm long, filaments up to 1 mm long, anthers ca 0.5 mm wide, dorsifixed, extrorse, transversely dehiscent. Pistillate flowers ca 7 mm long; pedicel up to 2.5 mm long; ovary globose, ca 1.5 × 1.5 mm, densely pubescent, with erect, long (ca 1 mm), simple trichomes; styles 3, 3.5–4 mm long, united only at the base, entire and slightly revolute at the apex, glabrous. Capsules 3-lobed, subglobose, 3.0–3.5 × 3.5–4 mm, pubescent, with erect, long (ca 1 mm) simple trichomes, green; pedicel shortly accrescent, reaching up to 4 mm long; columella 2–2.5 mm long; seeds brown, ovoid, ca 2 × 1 mm, tetragonous in cross section, testa shallowly tuberculate.

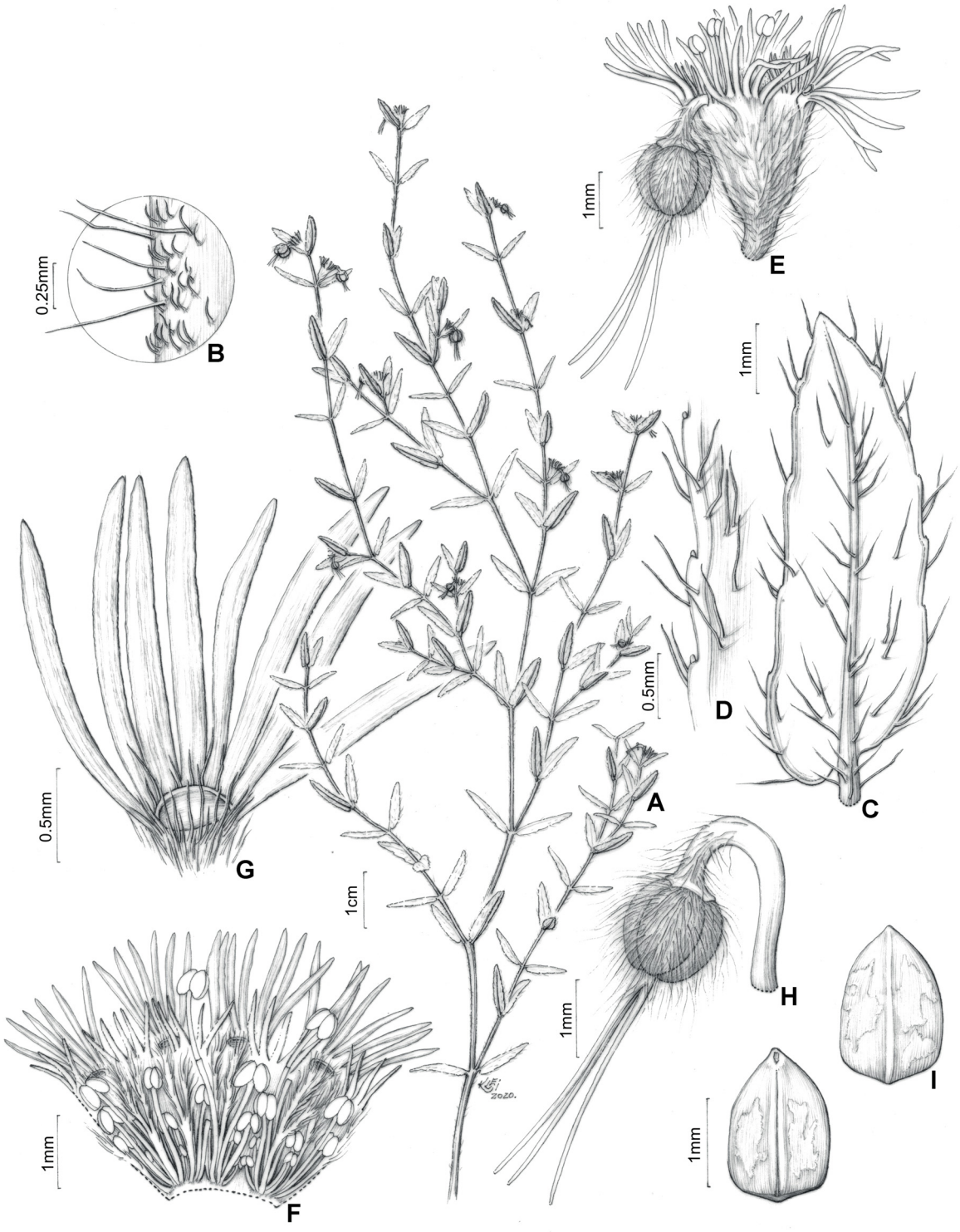

Fig. 1. *Euphorbia blepharadena* O.L.M.Silva & Cordeiro sp. nov. **A**. Habit. **B**. Detail of indumentum on branches, with curved short and longer erect trichomes. **C**. Leaf. **D**. Detail of leaf blade margin, showing a colleter at the apex of each tooth. **E**. Cyathium. **F**. Opened cyathium, showing staminate cymules and bracteoles. **G**. Isolated cyathial gland, with its fimbriate appendage. **H**. Young fruit. **I**. Seeds in ventral (left) and dorsal (right) views. Illustration of the holotype, *J.A. Lombardi et al. 4433* (UEC), by Klei Souza.

Distribution, ecology, and phenology

Euphorbia blepharadena sp. nov. occurs in clay soils in flat rocky outcrops ('lageado') in northeast Minas Gerais, within the Cerrado domain (Fig. 2). The only specimen found so far was collected in October with both flowers and fruits.

Provisional conservation status

Euphorbia blepharadena sp. nov. is only known from a single locality (Fig. 2), with AOO < 10 km² and EOO < 100 km². Its habitat is subjected to continuing decline in area, extent and quality. In the light of this, our evaluation suggests it to be classified as Critically Endangered (CR; B2ab[iii]).

Fig. 2. Geographical distribution of *Euphorbia blepharadena* O.L.M.Silva & Cordeiro sp. nov. (triangle), *E. longipedunculata* O.L.M.Silva & Riina sp. nov. (star) and *E. sobolifera* O.L.M.Silva & P.J.Braun sp. nov. (square).

Euphorbia longipedunculata O.L.M.Silva & Riina sp. nov.
http://www.ipni.org/urn:lsid:ipni.org:names:77214814-1
Figs 2–3

Diagnosis

Euphorbia longipenduculata O.L.M.Silva & Riina sp. nov. is most closely related to *Euphorbia potentilloides* Boiss., but differs in its orbicular leaves, long-pedunculate cyathia (5–10 mm long, reaching up to 45 mm long when the cyathium is fully developed) and longer cyathial gland appendages (ca 3 × 4 mm).

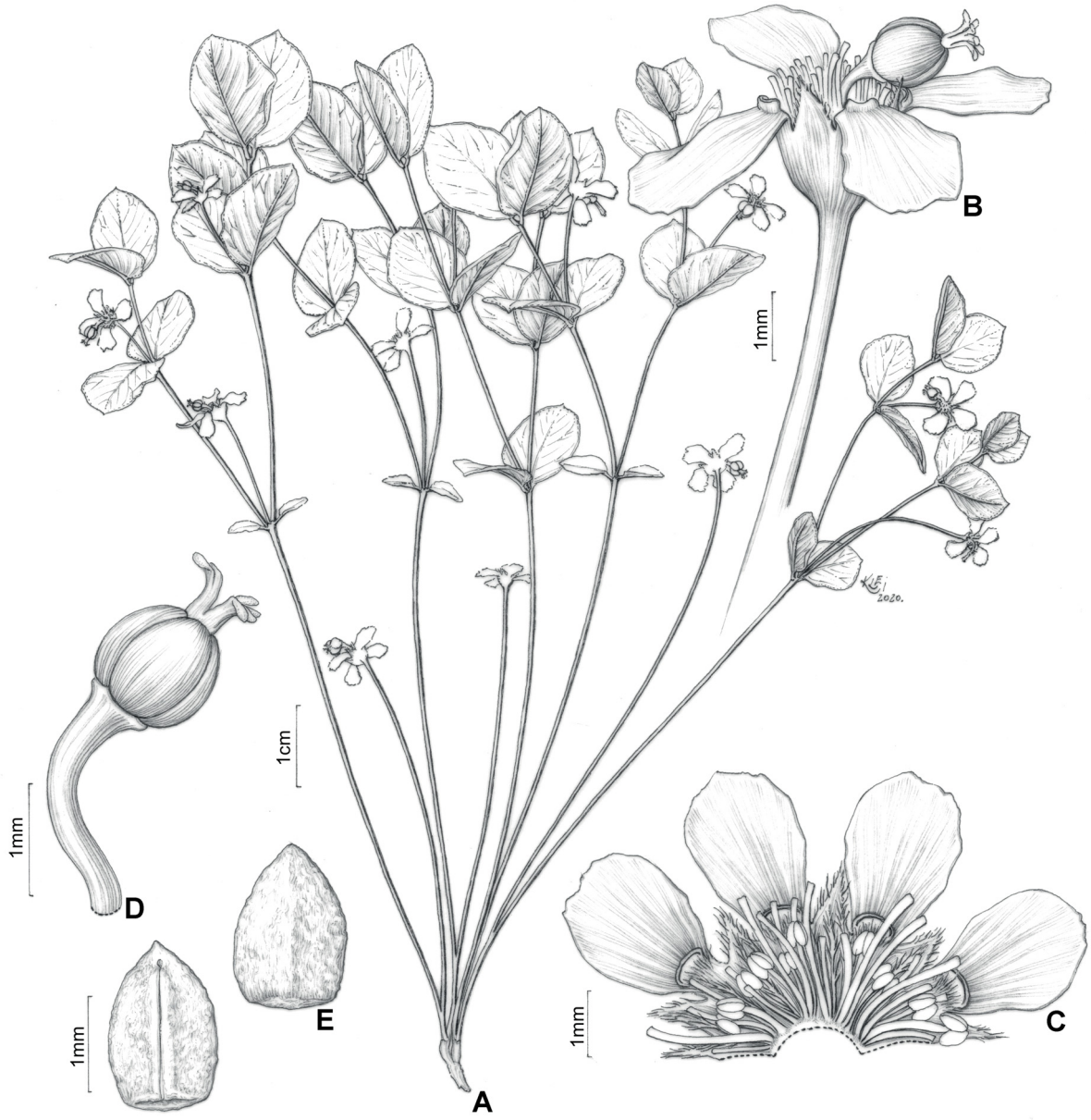

Fig. 3. *Euphorbia longipedunculata* O.L.M.Silva & Riina sp. nov. **A**. Habit. **B**. Cyathium, **C**. Opened cyathium, showing staminate cymules and bracteoles, **D**. Young fruit. **E**. Seeds in ventral (left) and dorsal (right) views. Illustrations of the holotype, *B.M.T. Walter et al. 4688* (SP), by Klei Souza.

Type

BRAZIL • Goiás, Cavalcante, Estrada Minaçu – Cavalcante, "passando pela balsa Serra Branca, a cerca de 126 km do rio Tocantins" [after Serra Branca ferry, around 120 km from Tocantins river]; 13°35′35″ S, 47°31′24″ W; 1120 m a.s.l.; 10 Nov. 2000; *B.M.T. Walter et al. 4688*; holotype: SP[360090]; isotypes: CEN[CEN00041136], HUEFS[HUEFS000199840], SP[468419].

Etymology

The epithet is a reference to the long peduncle of the cyathium (Fig. 3A), which is remarkable among all species of *Euphorbia* in Brazil.

Description

Erect monoecious herbs, up to 20 cm tall; underground system probably xylopodiferous, unbranched; latex white. Stems terete, dichotomously branched from the base, slightly reddish when dried, glabrous. Leaves opposite, persistent, subsessile (petioles reaching up to 1.5 mm long); stipules interpetiolar, deltoid, inconspicuous (up to 1 mm long), apex with stiff short (up to 0.25 mm long) simple trichomes; leaf blade membranaceous, glabrous on both surfaces, discolorous (abaxial surface glaucous), orbicular, (0.8–)1–1.5(–1.7) × (0.8–)1–1.5(–1.7) cm, base obtuse to slightly truncate, margin entire, thickened, apex cuspidate, venation brochidodromous. Cyathia solitary at the axils of dichotomous branches, long-pedunculate; peduncle 5–10 mm long (reaching up to 45 mm long when cyathium is fully developed), glabrous; cyathophylls similar to the leaves; involucre campanulate, 3–5 × 3–5 mm, actinomorphic, glabrous on the outer surface; involucral lobes triangular, pale when dried, apex partite, glabrous; cyathial glands 4 or 5, yellowish when dried, transversely elliptic, slightly concave, glabrous on both surfaces, 0.2–0.3 × 0.5–1 mm; cyathial gland appendages petaloid, wide-obovate, ca 3 × 4 mm, white when dried, glabrous on both surfaces, margin crenate, veins conspicuous. Staminate flowers 25(30), arranged in 5 cincinni with 5(6) flowers each; bracteoles lanceolate, ciliate; pedicels up to 2 mm long, filaments up to 1 mm long, anthers ca 1 mm wide, dorsifixed, extrorse, transversely dehiscent. Pistillate flowers ca 3.5 mm long; pedicel up to 2 mm long; ovary globose, ca 1 × 1 mm, glabrous; styles 3, up to 0.5–0.8 mm long when fully developed, united only at the base, shortly bifid at the apex. Capsule 3-lobed, subglobose, 3–4.5 × 4–5 mm, glabrous, pale when dried; pedicel shortly accrescent, reaching up to 5 mm long; columella ca 3 mm long; seeds brown, ovoid, 1.8–2.3 × 1–1.2 mm, rounded in cross section, testa slightly tuberculate; caruncle absent.

Distribution, ecology, and phenology

Euphorbia longipedunculata sp. nov. grows in open cerrado vegetation ('campo limpo') near the Chapada dos Veadeiros in northern Goiás, within the Cerrado domain (Fig. 2).

Provisional conservation status

Euphorbia longipedunculata sp. nov. is only known from a single location (Fig. 2), it has AOO < 10 km² and EOO < 100 km². As this location is close to roadsides, it is subject to continuing decline in area, extent and quality due to the always growing anthropic pressure in Central Brazil. In the light of this, we suggest that this new species be classified as Critically Endangered (CR; B2ab[iii]).

Euphorbia sobolifera O.L.M.Silva & P.J.Braun sp. nov.
urn:lsid:ipni.org:names:77214815-1
Figs 2, 4

Diagnosis

Euphorbia sobolifera O.L.M.Silva & P.J.Braun sp. nov. is similar to *E. appariciana* Rizzini, but differs in being dioecious, decumbent and having soboliferous growth, with stems reaching up to 2 m long.

Type

BRAZIL • Bahia, Serra do Tombador; 11°3′4.5″ S, 40°39′22.8″ W; 911 m a.s.l.; 11 Aug. 2019; *B.G. Brito 11;* holotype: SP; isotypes: HUEFS, SPF, RB.

Etymology

The epithet refers to the soboliferous growth form of the species: when a stem becomes decumbent and reaches the soil, it starts branching and eventually roots. This allows *E. sobolifera* sp. nov. to form dense colonies in the rocky outcrops where it grows (Fig. 4B).

Description

Decumbent dioecious shrubs, branches reaching up to 2 m long; underground system much branched; latex white. Stems slightly 6-costate, whorled branched, green to slightly reddish at the apex, glabrous, soboliferous. Leaves opposite, deciduous, subsessile (petioles reaching up to 1 mm long); stipules lateral and glanduliform, globose, inconspicuous (up to 1 mm long); leaf blade membranaceous, glabrous on both surfaces, concolorous, elliptic, narrow-elliptic or oblong, (0.5–)1–1.5(–2) × 0.1–0.5 cm, base attenuate, margin entire, apex cuspidate, venation hyphodromous. Cyathia solitary and sessile (pistillate) or glomerulate and subsessile (staminate), terminal; peduncle up to 1 mm long, glabrous; cyathophylls opposite, sessile, wide-elliptic to triangular, 1.0–1.5 × 0.5–0.8 mm, with 2(3) pairs of lateral colleters at the base, chartaceous, glabrous on both surfaces, persistent, base truncate, margin entire, apex cuspidate, venation hyphodromous; involucre campanulate, 1.5–2.5 × 1.5–2.5 mm, actinomorphic, glabrous on the outer surface; involucral lobes triangular, pale to greenish, margin fimbriate, with simple trichomes; cyathial glands 5(6), yellow, transversely elliptic, punctate, glabrous, 0.5–1.0 × 1.5–2.0(–2.5) mm; short crenulate white appendages. Staminate cyathia: staminate flowers 20–30, arranged in 5 cincinni with 4–6 flowers each; bracteoles lanceolate, ciliate; pedicels up to 1.0 mm long, filaments up to 0.5 mm long, anthers ca 1 mm wide, dorsifixed, extrorse, transversely dehiscent; pistillate flowers reduced to a pistillode, ca 0.5 mm long, with three inconspicuous styles that never exceed the involucre rim of the cyathia. Pistillate cyathia: staminate flowers atrophied and not exceeding involucre rim of the cyathia; pistillate flowers ca 2 mm long; pedicel up to 0.5 mm long; ovary globose, ca 0.5 × 0.5 mm, glabrous; styles 3, up to 1 mm long when fully developed, free at the base, bifid for half their length and revolute at the apex. Capsules 3-lobed, subglobose, 2–3 × 3–4 mm (immature), glabrous, green; pedicel shortly accrescent, reaching up to 2 mm long (immature fruit); columella and seeds not seen.

Distribution, ecology and phenology

Euphorbia sobolifera sp. nov. grows in open vegetation on sandstone outcrops (Fig. 4A) in the Serra do Tombador, near the Jacobina Municipality, in the northern portion of the Chapada Diamantina complex in Bahia State, within the Caatinga domain (Fig. 2). The species was collected during the dry season (August) with immature fruits, but individuals cultivated in the São Paulo Botanical Garden have been producing cyathia throughout the year, although we could not make them produce viable fruits.

Provisional conservation status

Euphorbia sobolifera sp. nov. is only known from a single locality (Fig. 2), with AOO < 10 km² and EOO < 100 km², and its habitat is subjected to continuing decline in area, extent and quality. We suggest that it should be classified as Critically Endangered (CR; B2ab[iii]).

Discussion

Both *Euphorbia blepharadena* sp. nov. and *E. longipedunculata* sp. nov. are here placed in *E.* sect. *Anisophyllum* based on morphological characters, such as the presence of interpetiolar stipules and opposite leaves with the base asymmetrical (Yang *et al.* 2012). *Euphorbia sobolifera* sp. nov., in turn,

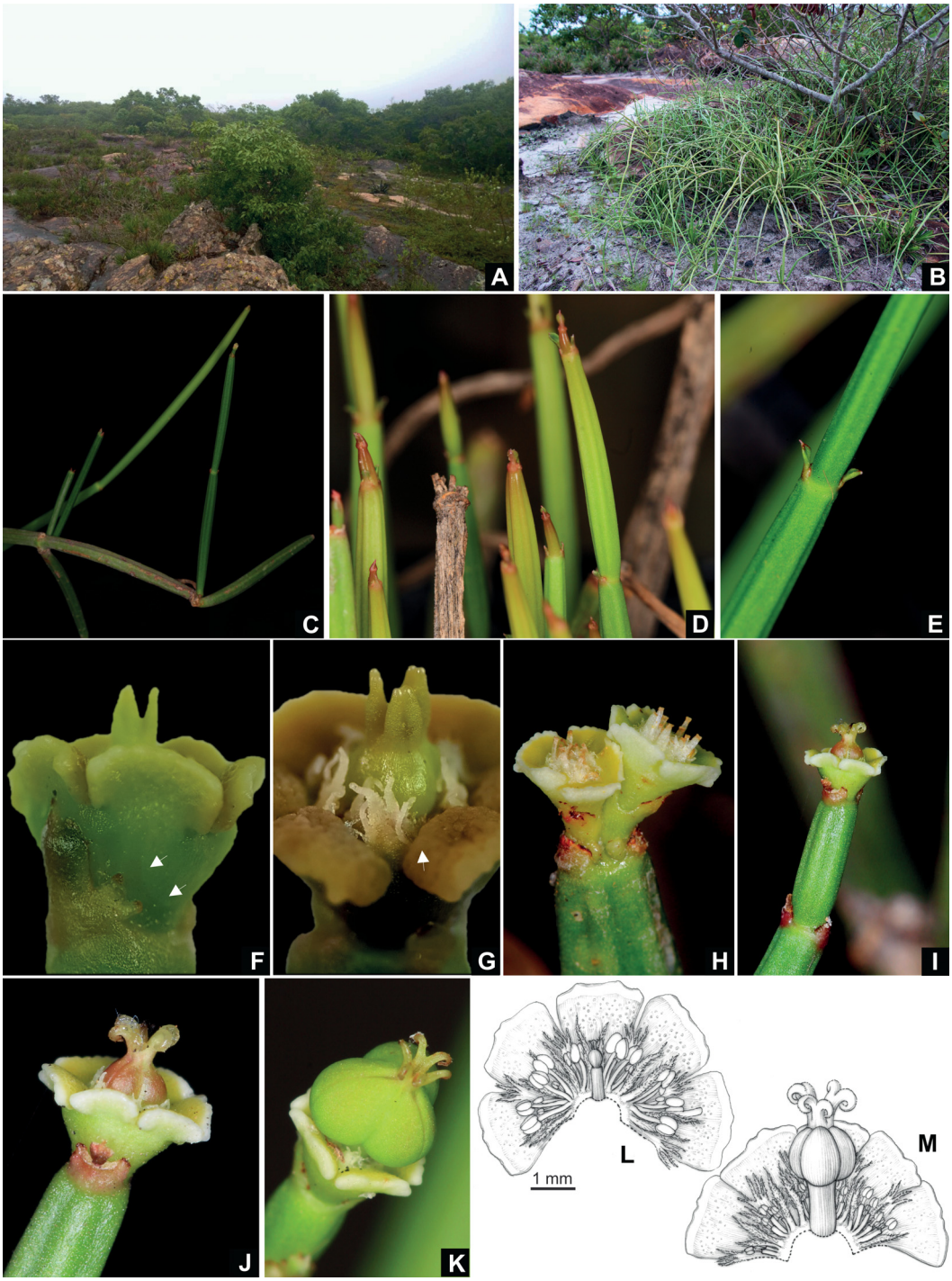

Fig. 4. *Euphorbia sobolifera* O.L.M.Silva & P.J.Braun sp. nov. **A**. Habitat. **B**. Habit. **C**. Portion of a branch producing soboles. **D**. Apical portion of branches with reduced opposite leaves. **E**. Detail of a node with opposite leaves. **F**. Cyathium showing one of the cyathophylls bearing colleters on its margin (arrows). **G**. Detail of a cyathium showing an involucre lobe (arrow). **H**. Grouped staminate cyathia. **I**. Solitary pistillate cyathium. **J**. Detail of a pistillate cyathium showing the pistillate flower. **K**. Immature fruit. **L**. Staminate cyathium opened, showing staminate cymules, bracteoles and a central pistillode. **M**. Pistillate cyathium opened, showing poorly developed staminate flowers and bracteoles. Photos: A–B: P.J. Braun in the field; C–K: O.L.M. Silva; L–M: Illustrations of plants cultivated at the Instituto de Botânica by Klei Souza.

is placed in *E.* sect. *Crossadenia* subsect. *Appariciannae* Riina by the combination of rudimentary and soon deciduous leaves (Fig. 4D–E) and cyathial glands with short crenulate appendages. (Fig. 4F–K; Yang *et al.* 2012).

Amongst the species of *Euphorbia* sect. *Anisophyllum* found in Brazil, *E. blepharadena* sp. nov. is most similar to *E. foliolosa*. due to its long and entire styles (Fig. 1H) and the presence of a colleter on the apex of leaf margin teeth (Fig. 1D; Silva *et al.* 2014). *Euphorbia bahiensis* (Klotzsch & Garcke) Boiss. and *E. hyssopifolia* L. also share with *E. blepharadena* sp. nov. the herbaceous and erect habit with cyathia arranged in dichasia, but lack the features shared with *E. foliolosa* mentioned above (Silva *et al.* 2014). A more detailed comparison among *E. bahiensis*, *E. blepharadena* sp. nov., *E. foliolosa* and *E. hyssopifolia* is presented in Table 1.

The cyathial glands bearing digitate appendages (Fig. 1G) present in *Euphorbia blepharadena* sp. nov. are only found in a few species of *E.* sect. *Anisophyllum* (e.g., *E. hooveri* Wheeler), none of them are found in Brazil (Yang *et al.* 2012). Nevertheless, among Brazilian *Euphorbia*, this type of appendage is found in some species of *E.* sects. *Crossadenia* (e.g., *E. sarcodes* Boiss. and *E. adenoplicata* O.L.M.Silva & Cordeiro; Carneiro-Torres *et al.* 2012; Silva *et al.* 2020) and *Alectoroctonum* (Schltdl.) Baill. (*E. sciadophila* Boiss.; Silva *et al.* 2014).

Euphorbia longipedunculata sp. nov., the other new species placed in *E.* sect. *Anisophyllum*, was hidden in numerous herbaria collections under the common *E. potentilloides*, which is widely distributed across the Cerrado domain (Simmons & Hayden 1997). This was most probably due to the superficial resemblance of these species, especially considering the plasticity in leaf shape of *E. potentilloides* as described by Simons & Hayden (1997). Despite the high variability in leaf shape (Simons & Hayden 1997: fig. 17), *E. potentilloides* is not known to possess orbicular leaves as in *E. longipedunculata* sp. nov. (Fig. 3A). In *E. potentilloides*, the cyathia are arranged in pleiochasia and sit upon a peduncle that reaches up to 1.6 mm long (or rarely 12 mm) (Simons & Hayden 1997), whereas in *E. longipedunculata* sp. nov. they are solitary in the axils of dichotomous branches and, when young, the peduncle is 5–10 mm long, but reaches up to 45 mm long when mature (Fig. 3A–B). Nevertheless, cyathial glands appendages are conspicuously larger in *E. longipedunculata* sp. nov. (ca 3 × 4 mm; Fig. 3C) than in *E. potentilloides* (0.1–1(–2.1) mm long; Simons & Hayden 1997).

Another species that is also similar to *Euphorbia potentilloides* is *E. burchellii* Müll.Arg (Müller Argoviensis 1874). However, *E. burchellii* is only known from the type and rarely would be confused with *E. longipedunculata* sp. nov., due to its lanceolate to linear leaves (vs rounded in *E. longipedunculata* sp. nov.). A comprehensive comparison among these three species is given in Table 2.

Within *Euphorbia* sect. *Crossadenia*, the third newly described species, *E. sobolifera* sp. nov., is most similar to *E. appariciana* due to its 6-costate stems with short internodes (Fig. 4C–E) and unisexual cyathia (Fig. 4F–M) but differs from the latter by being dioecious (vs monoecious in *E. appariciana*) and presenting more conspicuous and opposite leaves (Fig. 4E), while in *E. appariciana***,** the leaves are completely absent or very rudimentary (Rizzini 1989). Additionally, *E. sobolifera* sp. nov. has longer and thinner stems that reach up to 2 m long, becoming decumbent (Fig. 4B), whereas in *E. appariciana*, stems are thicker, always erect and they usually reach up to 20 cm tall. Slender decumbent branches are also present in *E. teres* M.Machado & Hofacker, but the latter has terete stems (vs 6-costate stems in *E. sobolifera* sp. nov.; Fig. 4E). Finally, *Euphorbia flaviana* Carn.-Torres & Cordeiro also has terete stems, but these are always erect, reaching more than 1 m high, and its cyathial glands are similar to those of *E. sobolifera* sp. nov., but they lack an appendage (vs short crenulate appendage in *E. sobolifera* sp. nov.). A morphological comparison of the new species with the others mentioned above is given in Table 3.

Table 1. Morphological comparison among *Euphorbia bahiensis* (Klotzsch & Garcke) Boiss., *E. blepharadena* O.L.M.Silva & Cordeiro sp. nov., *E. foliolosa* Boiss. and *E. hyssopifolia* L.

	E. bahiensis	***E. blepharadena* sp. nov.**	***E. foliolosa***	***E. hyssopifolia***
Stem indumentum	glabrous	pubescent,with short (< 0.25 mm) curved and longer (ca 1 mm) erect simple trichomes	pubescent, with short (< 0.5 mm long) curved or erect simple trichomes	glabrous or pilose to pubescent, with short (< 0.5 mm long) curved or erect simple trichomes
Leaf margin	entire to inconspicuously serrate, without a colleter on the apex of each tooth	serrate, with a colleter on the apex of each tooth	serrate, with a colleter on the apex of each tooth	serrate, without a colleter on the apex of each tooth
Leaf venation	actinodromous	hyphodromous	actinodromous	actinodromous
Leaf indumentum	glabrous	pilose on the adaxial surface and densely pilose on the abaxial surface, both surfaces with long (ca 1 mm) erect simple trichomes	pilose on the adaxial surface and densely pilose on the abaxial surface, both surfaces with short (< 0.5 mm long) curved or erect simple trichomes	glabrous or with a few scattered short (< 0.5 mm long) curved or erect simple trichomes
Cyathia arrangement	in dichasia, with lateral axis not congested	solitary	solitary or in dichasia, with lateral axis not congested	in dichasia, with lateral axis congested
Cyathial glands appendages	petaloid	6–8-digitate	petaloid	petaloid
Ovary / fruit indumentum	glabrous	densely pubescent / pubescent with long (ca 1 mm) erect simple trichomes	glabrous	glabrous
Styles	short (up to 0.5 mm) and bifid half of their length	long (ca 2 mm) and entire	long (3.5–4 mm) and entire	short (up to 0.8 mm) and bifid half of their length

The dioecy of *Euphorbia sobolifera* sp. nov. was confirmed through the observation in cultivation of three distinct individuals. These were collected by B.G. Brito in the type locality and sent to São Paulo for cultivation at the São Paulo Botanical Garden (two individuals of different sexes) and also at the Botany Department at the University of São Paulo (one male individual). Individuals of different sexes were growing together in the São Paulo Botanical Garden and we have been observing them for around one year while one consistently produced staminate cyathia and the other pistillate ones. However, a single fruit was observed in an individual at São Paulo Botanical Garden (Fig. 4K), that unfortunately did not reach maturity. Therefore, fruits and seeds are missing in the description and type specimen of *E. sobolifera* sp. nov., because we were unable to cross the individuals to produce more viable fruits. Branches from both male and female individuals collected by B.G. Brito were gathered to compose a single herbarium sheet to better represent the species in the holotype in accordance with article 8.2 of the *International Code of Nomenclature for Algae, Fungi and Plants* (Turland *et al.* 2018). Although

Table 2. Morphological comparison among *Euphorbia burchelli* Müll.Arg., *E. longipedunculata* O.L.M.Silva & Riina sp. nov. and *E. potentilloides* Boiss.

	E. burchelli	***E. longipedunculata* sp. nov.**	***E. potentilloides***
Leaf shape	lanceolate to linear	orbicular	ovate to oblong or lanceolate to linear
Cyathia arrangement	solitary	solitary	in pleiochasia (with posterior dichasial branching)
Length (mm) of cyathium peduncle	up to 5	5–10 (when young), up to 45 (when mature)	up to 1.6(–12)
Length (mm) of cyathial gland appendages	up to 1.5	ca 3 × 4	up to 1(–2)

Table 3. Morphological comparison among *E. appariciana* Rizzini, *E. flaviana* Carn.-Torres & Cordeiro, *E. sobolifera* O.L.M.Silva & P.J.Braun sp. nov. and *E. teres* M.Machado & Hofacker.

	E. appariciana	***E. flaviana***	***E. sobolifera* sp. nov.**	***E. teres***
Sexual system	monoecious	monoecious	dioecious	monoecious
Plant stature and disposition	erect, up to 20 cm high	erect, 80–150 cm high	decumbent, branches reaching up to 2 m long	erect or decumbent, up to 50 cm high or decumbent branches reaching up to 70 cm long
Stem cross section	6-costate	rounded	6-costate	rounded
Cyathia	unisexual	bisexual	unisexual	bisexual
Outer margin of cyathial glands	dentate	entire	dentate	dentate

seeds could not be observed in this species, representatives of *Euphorbia* sect. *Crossadenia* have highly conserved seed features (seed coat with low and rounded tubercles and the presence of a caruncle-like feature but without an elaiosome) that may be synapomorphic to the group (Yang *et al*. 2012; Silva *et al*. 2020).

In conclusion, the three new species presented in this work represent important additions to the Euphorbiaceae in the Flora of Brazil 2020 project, increasing the number of species of *Euphorbia* in Brazil to 67. These new species also show interesting uncommon features among the Brazilian species: the dioecy and soboliferous growth form of *E. sobolifera* sp. nov., the long pedunculate cyathia of *E. longipedunculata* sp. nov., and the digitate cyathial glands of *E. blepharadena* sp. nov., which is rare in *E.* sect. *Anisophyllum*. Although these species are only known from their types, descriptions of taxa from single collections are important for conservation and enhancement of sampling efforts in underexplored areas of the Neotropics (Wood *et al.* 2017; Antar *et al.* 2018; Riina *et al.* 2018; Silva *et al.* 2020).

Acknowledgements

We thank the curators of all the herbaria cited in this work for providing access to their collections. We are grateful to FAPESP for the scholarship awarded to the first author (FAPESP process number 2019/09237-0) and the financial support for I. Cordeiro (CNPq process number 309917/2015-8); to the two anonymous reviewers for their contributions to early versions of the manuscript; to Klei Souza for producing the illustrations presented in this work; and to B.G. Brito for collecting and sending samples of *Euphorbia sobolifera* sp. nov. for the elaboration of this manuscript.

References

Antar G.M., Santos M.F. & Sano P.T. 2018. Rediscovery and taxonomic reassessment of four angiosperms in the savannas of Jalapão, Central Brazil. *Edinburgh Journal of Botany* 75: 181–195. https://doi.org/10.1017/S0960428617000348

Beentje H. 2010. *The Kew Plant Glossary – an Illustrated Dictionary of Plant Terms*. Kew Publishing, Kew.

Carneiro-Torres D.S., Cordeiro I., Giulietti A.M. & Riina R. 2012. *Euphorbia flaviana*, a new species from the inselbergs of Bahia (Brazil) and lectotypification of *E. crossadenia*. *Systematic Botany* 37: 688–693. https://doi.org/10.1600/036364412X648652

Carrillo-Reyes P. & Steinmann V.W. 2011. Two new species of *Euphorbia* sect. *Nummulariopsis* (Euphorbiaceae) from South America. *Anales del Jardín Botánico de Madrid* 68: 167–173. https://doi.org/10.3989/ajbm.2282

Dorsey B.L., Haevermans T., Aubriot X., Morawetz J.J., Riina R., Steinmann V.W. & Berry P.E. 2013. Phylogenetics, morphological evolution, and classification of *Euphorbia* subgenus *Euphorbia*. *Taxon* 62: 291–315. https://doi.org/10.12705/622.1

Flora do Brasil. 2020 (in construction). *Euphorbia*. Jardim Botânico do Rio de Janeiro. Available from: http://floradobrasil.jbrj.gov.br/reflora/floradobrasil/FB17561 [accessed 15 Aug. 2020].

Govaerts R., Frodin D.G. & Radcliffe-Smith A. 2000. *World Checklist and Bibliography of Euphorbiaceae (and Pandaceae)* 2. Kew Publishing, Kew.

Horn J.W., van Ee B.W., Morawetz J.J., Riina R., Steinmann V.W., Berry P.E. & Wurdack K.J. 2012. Phylogenetics and the evolution of major structural characters in the giant genus *Euphorbia* L. (Euphorbiaceae). *Molecular Phylogenetics and Evolution* 63: 305–326. https://doi.org/10.1016/j.ympev.2011.12.022

Hurbath F., Leal B.S.S., Silva O.L.M., Palma-Silva C. & Cordeiro I. 2018. A new species and molecular phylogeny of Brazilian succulent *Euphorbia* sect. *Brasilienses*. *Systematics and Biodiversity* 16: 658–667. https://doi.org/10.1080/14772000.2018.1473897

IUCN Standards and Petitions Committee. 2019. *Guidelines for Using the IUCN Red List Categories and Criteria*, ver. 14. Prepared by the Standards and Petitions Subcommittee of the IUCN Species Survival Commision. Available from https://nc.iucnredlist.org/redlist/content/attachment_files/RedListGuidelines.pdf [accessed 29 Feb. 2020].

Küllkamp J., Silva O.L.M., Valduga E., Iganci J.R.V., Cordeiro I. & Baumgratz J.F.A. 2018. First record of *Euphorbia pedersenii* Subils (Euphorbiaceae) for Brazil. *Phytotaxa* 379: 287–292. https://doi.org/10.11646/phytotaxa.379.4.2

Müller Argoviensis J. 1874. Euphorbiaceae. *In*: Martius C.F.P. von & Eichler A.W. (eds) *Flora Brasiliensis* 11 (2). Frid. Fleischer, München.

Peirson J.A., Bruyns P.V., Riina R., Morawetz J.J. & Berry P.E. 2013. A molecular phylogeny and classification of the largely succulent and mainly African *Euphorbia* subg. *Athymalus* (Euphorbiaceae). *Taxon* 62: 1178–1199. https://doi.org/10.12705/626.12

Prenner G., & Rudall P.J. 2007. Comparative ontogeny of the cyathium in *Euphorbia* (Euphorbiaceae) and its allies: exploring the organ, flower, inflorescence boundary. *American Journal of Botany* 94: 1612–1629. https://doi.org/10.3732/ajb.94.10.1612

QGIS Development Team. 2020. *QGIS Geographic Information System*. Open Source Geospatial Foundation Project. Available from http://qgis.osgeo.org [accessed 29 Feb. 2020].

Radcliffe–Smith A. 2001. *Genera Euphorbiacearum*. Kew Publishing, Kew.

Riina R., Peirson J.A., Geltman D.V., Molero J., Frajman B., Pahlevani A., Barres L., Morawetz J.J., Salmaki Y., Zarre S., Kryukov A., Bruyns P.V. & Berry P.E. 2013. A worldwide molecular phylogeny and classification of the leafy spurges, *Euphorbia* subgenus *Esula* (Euphorbiaceae). *Taxon* 62: 316–342. https://doi.org/10.12705/622.3

Riina R., Berry P.E., Secco R.S., Meier W. & Caruzo M.B.R. 2018. Reassessment of *Croton* sect. *Cleodora* (Euphorbiaceae) points to the Amazon Basin as its main center of diversity. *Annals of the Missouri Botanical Garden* 103: 330–349. https://doi.org/10.3417/2018131

Rizzini C.T. 1989. Cactiform species of *Euphorbia* from Brazil (Euphorbiaceae). *Revista Brasileira de Biologia* 49: 979–997.

Silva O.L.M. & Cordeiro I. 2015. *Euphorbia sarcoceras*, a new species of *Euphorbia* sect. *Alectoroctonum* from Brazil. *Systematic Botany* 40: 962–967. https://doi.org/10.1600/036364415X690003

Silva O.L.M., Cordeiro I. & Caruzo M.B.R. 2014. Synopsis of *Euphorbia* (Euphorbiaceae) in the state of São Paulo, Brazil. *Phytotaxa* 181: 193–215. https://doi.org/10.11646/phytotaxa.181.4.1

Silva O.L.M., Antar G.M, Riina R. & Cordeiro I. 2020. *Euphorbia adenoplicata*, a new species of *Euphorbia* sect. *Crossadenia* from Brazil. *Systematic Botany* 45: 131–136. https://doi.org/10.1600/036364420X15801369352388

Simmons M.P. & Hayden W.J. 1997. Revision of the cerrado hemicryptophytic *Chamaesyce* of Boissier's "Pleiadeniae" (Euphorbiaceae). *Brittonia* 49: 155–180. https://doi.org/10.2307/2807678

Steinmann V.W. 2013. Three new species of *Euphorbia* subg. *Chamaesyce* (Euphorbiaceae) from Bolivia. *Phytotaxa* 114: 23–32. https://doi.org/10.11646/phytotaxa.114.1.2

Thiers B. continuously updated. *Index Herbariorum: A Global Directory of Public Herbaria and Associated Staff.* The New York Botanical Garden, New York. Available from http://sweetgum.nybg.org/ih/ [accessed 15 Aug. 2020].

Turland N.J., Wiersema J.H., Barrie F.R., Greuter W., Hawksworth D.L., Herendeen P.S., Knapp S., Kusber W., Li D., Marhold K., May T.W., McNeill J., Monro A.M., Prado J., Price M. & Smith G.F. 2018. *International Code of Nomenclature for Algae*, *Fungi*, *and Plants (Shenzhen Code) Adopted by the Nineteenth International Botanical Congress Shenzhen*, *China*, *July 2017*. Koeltz Scientific Books, Königstein.

Webster G.L. 2014. Euphorbiaceae. *In*: Kubitzki K. (ed.) *The Families and Genera of Vascular Plants* 11: 51–216. Springer Verlag, Berlin & Heidelberg. https://doi.org/10.1007/978-3-642-39417-1_10

Wood J.R.I., Muñoz-Rodriguez P., Degen R. & Scotland R.W. 2017. New species of *Ipomea* (Convolvulaceae) from South America. *PhytoKeys* 88: 1–38. https://doi.org/10.3897/phytokeys.88.12891

Yang Y., Riina R., Morawetz J.J., Haevermans T., Aubriot X. & Berry P.E. 2012. Molecular phylogenetics and classification of *Euphorbia* subgenus *Chamaesyce* (Euphorbiaceae). *Taxon* 61: 764–789. https://doi.org/10.1002/tax.614005

Manuscript received: 8 September 2020
Manuscript accepted: 16 November 2020
Published on: 3 February 2021
Topic editor: Frederik Leliaert
Desk editor: Radka Rosenbaumová

Printed versions of all papers are also deposited in the libraries of the institutes that are members of the *EJT* consortium: Muséum national d'histoire naturelle, Paris, France; Meise Botanic Garden, Belgium; Royal Museum for Central Africa, Tervuren, Belgium; Royal Belgian Institute of Natural Sciences, Brussels, Belgium; Natural History Museum of Denmark, Copenhagen, Denmark; Naturalis Biodiversity Center, Leiden, the Netherlands; Museo Nacional de Ciencias Naturales-CSIC, Madrid, Spain; Real Jardín Botánico de Madrid CSIC, Spain; Zoological Research Museum Alexander Koenig, Bonn, Germany; National Museum, Prague, Czech Republic.