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Calea repanda (Asteraceae: Neurolaeneae), a new species and novel characters for the taxonomy of the genus

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Abstract

We describe a new species, *Calea repanda*, from Brazil and discuss novel morphological characters for the taxonomy of this genus. This new species is morphologically similar to *C. gentianoides* and *C. diamantinensis* but is distinct due to repand (vs. entire) leaf margins, radiate (vs. discoid) capitulum, larger involucre 12.2–12.7 × 10.6–12 mm (vs. 5.5–9.4 × 2.7–5.2 mm), disc florets 30–40 (vs. 3–9), and fewer pappus scales 7–10 (vs. 15–20). *Calea repanda* is endemic to the Diamantina plateau in Minas Gerais state, Southeastern Brazil. We provide a map with the geographic occurrence of this species, an illustration with diagnostic characters, and the first taxonomic key for species of *C.* sect. *Calea* from Brazil. Furthermore, we propose a more detailed terminology to describe the proportion of the number of paleae and disc florets in the capitulum receptacle.

Keywords: Bem Diverso Project, Campo Rupestre, Cerrado, Compositae, Paleaceous

Introduction

Calea Linnaeus (1763: 1179) includes 158 species morphologically recognized by usually opposite leaves, radiate, sometimes discoid capitula, solitary or more commonly cymose or umbelliform capitulescences, yellow anthers, and pappus with 6–30 scales. *Calea* sect. *Calea* is the most widespread section of *Calea* and occurs from Mexico to Argentina. *Calea* sect. *Calea* is characterized by species with umbelliform to cymose capitulescences and pappus longer than the cypsela (Urbatsch *et al.* 1986). It encompasses 52 species mainly distributed in Venezuela (19 spp.), Colombia (19 spp.), Brazil (13 spp., including the new one described here), and Mexico (7 spp.).

Most species of *Calea* have a paleaceous capitulum receptacle (e.g., the axis of the inflorescence), however, historically paleae features have not been described with standard terminology. The first species description to detail the paleaceous receptacle was for *C. cordifolia* Swartz (1806: 1326), currently a synonym of *C. jamaicensis* (1763: 1179). Since then, the majority of descriptions for *Calea* include details about the receptacle and paleae, usually describing the shape of the receptacle, the presence of paleae, and the length, shape, and apex of these later structures. The receptacle and presence of paleae have had some taxonomic importance within the genus. The synonym, *Geissopappus* Benth (1840: 44), was studied by Robinson (1975) and according to him this epaleaceous receptacle was diagnostic for the genus. Later, this genus name was considered a synonym of *Calea* (Robinson 1979), in this paper it was commented that these species had in common short pappus, which justifies that these three species are placed into *C.* sect. *Meyeria* (Candolle 1836: 670) Benth & Hooker (1873: 391) and belong to two species complexes. Among these, *C. caleoides* (Candolle 1840: 294) Robinson (1975: 428) and *C. polycephala* (Baker 1884: 179) Robinson (1975: 428) belong to the *C. teucrifolia* complex, while *C. bahiensis* (Mattfeld 1925: 390) Robinson (1975: 428) belongs to the *C. pilosa* complex. Several authors consider the paleae (presence, shape and length) an informative taxonomic character in *Calea* (Pruski 1998, 2013, Pruski & Urbatsch 1987, Reis-Silva & Nakajima 2020, 2021, Roque & Carvalho 2011). Two different complexes inserted in *C.* sect. *Monanthoclea* (Lessing 1832: 242) Pruski (1998: 684) and *C.* sect.

Meyeria were characterized by having a “weakly or moderately” paleaceous receptacle (Pruski 1998) and “receptacles epaleate or partly so” (Pruski & Hind1998), respectively. Indicating that not only the presence or absence of paleae may be important, but also the proportion of paleaceous elements with respect to the number of disc florets.

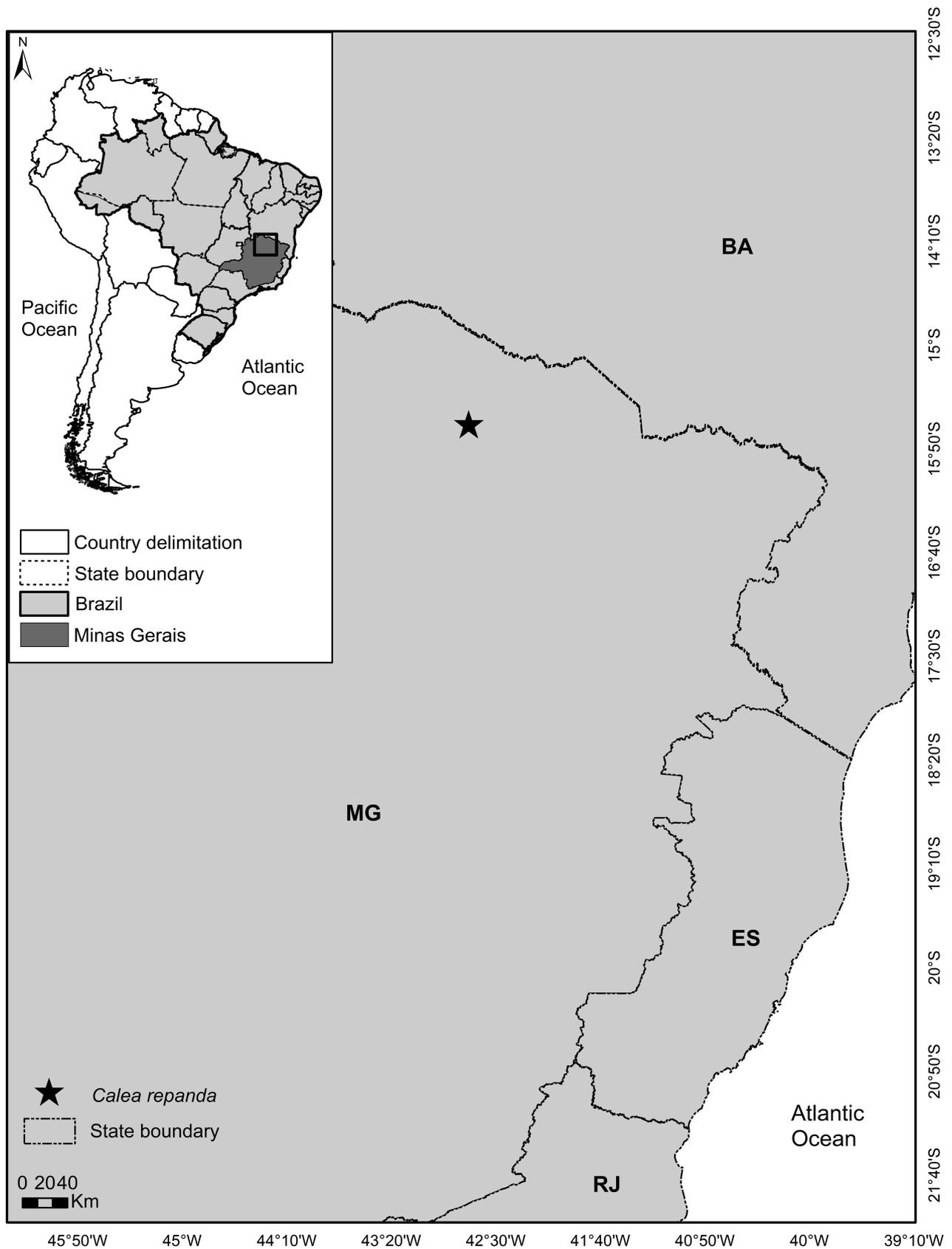


FIGURE 1. Distribution of *Calea repanda* (Neurolaeneae, Asteraceae) in Brazil. MG—Minas Gerais State, BA—Bahia State, ES—Espírito Santo State, RJ—Rio de Janeiro State.

We also highlight the importance of describing the number of paleae found when the receptacle is paleaceous. To assess this character, it is necessary to check if all the disc florets have associated paleae. Note that the position of the disc florets in the receptacle is not necessarily associated with the presence or absence of the paleae. In general the descriptions of paleae and receptacle characters and character states are rather ambiguous and/or inconsistent throughout the taxonomic literature for *Calea*. Species description and taxonomic delimitation could be improved by clarifying details about paleae, receptacles, and their associated characters and character states. We aim to clarify the description of these taxonomically important features in this work by providing a glossary of terms to accurately describe the proportion of paleae and florets in the receptacle.

This new terminology is applied to the description of a specimen of *Calea* collected by the Bem Diverso Project (Sevilha *et al.* 2022) from Minas Gerais state, Southeastern Brazil. This specimen was collected near the border with Bahia state, in a transitional region between the Cerrado (Tropical Savanna) and the Caatinga (Seasonally Tropical Dry Forest) floristic regions, from the Espinhaço Range in Minas Gerais (Fig. 1) and has remained unidentified at the species level until recently. The new species is very distinct among other species of *C.* sect. *Calea* due the presence of repand leaf margins and a capitulescence with very few capitula. Based on its distinctive morphology, we describe this new species, provide an illustration and occurrence maps, and discuss its taxonomic affinities along with a taxonomic key for the species of *C.* sect. *Calea* from Brazil.

Material and methods

We reviewed all the available literature for *Calea* (Baker 1884, Barroso 1975, Bueno & Heiden 2021, in press, Bueno *et al.* 2021, Malme 1933, Pozo & Hind 2013, Pruski 1983, 1984, 1997, 1998, 2005, 2011, 2013, Pruski & Hind 1998, Pruski & Robinson 2018, Pruski & Urbatsch 1987, 1988, Reis-Silva 2019, Reis-Silva and Nakajima 2020, 2021, Robinson 1975, 1979, Roque & Carvalho 2011, Silva 2016, Silva *et al.* 2016, Urbatsch *et al.* 1986, Wussow *et al.* 1985).

Herbarium specimens were studied in person and through loans from the following herbaria: BHCB, BHZB, CEN, CESJ, DIAM, ECT, EFC, ESAL, FLOR, FURB, G, HBR, HDCF, HDJF, HEPH, HUCS, HUFU, IBGE, ICN, K, MBM, MO, NYBG, P, PACA, PAMG, PEL, R, RB, RFA, SALLE, SJRP, SMDB, SP, SPF, SPSF, UB, UEC, UFG, UPCB, US, VIC (acronyms according to Thiers 2022) or based on high definition images hosted online through the following digitized herbaria: ALCB, BM, CRI, FCAB, HUEFS, HURB, HUCP, HVASF, IPA, JOI, L, LY, MG, S. Several online herbarium databases were consulted, including the following: C. V. Starr Herbarium Virtual (2022), Reflora (2022), Smithsonian Virtual Herbarium (2022), SpeciesLink (2022), and Tropicos (2022).

We described vegetative structures from dried herbarium specimens and reproductive structures were described after rehydration in warm water (ca. 80°C) for one minute. We used a caliper, protractor, and the stereomicroscope to perform measurements and for additional description. Measurement outliers were based on calculation of medians, quartiles, and interquartile deviations. “Rarely” is utilized for characters that occur in up to 10% of the specimens studied, “sometimes” is applied for characters that occur between 10.01% and 25% of the specimens studied, “often” is used for characters that occur between 25.01% and 40% of the specimens analyzed. “Or” is adopted for characters that occur between 40 and 60% of the studied specimens.

The general morphological terminology follows Beentje (2010), Ellis *et al.* (2009), and Hickey (1973). Specialized Compositae terminology follows Funk *et al.* (2009), and specific terminology about the pappus of *Calea* follows Bueno and Heiden (2022a in press). The IUCN guidelines (2019) were followed for preliminary conservation status assessment. Distribution maps were prepared using Quantum GIS v. 3.0 (QGIS Development Team 2015).

We propose a more accurate terminology for the description of the paleaceous receptacle, specifically with respect to the proportion of the number of paleae relative to the number of disc florets in the receptacle (Table 1). In addition to the currently used term: epaleaceous - without paleae, we further detail the term “paleaceous” with five new terms that better represent the diversity of the proportion of paleae compared to the number of disc florets on receptacles of *Calea*. The following terms are proposed: epaleaceous – complete absence of paleae; pauperpaleaceous – up to 10% of disc florets has paleae associated; paucipaleaceous – between 10.01% and 25% of disc florets has paleae associated; oligopaleaceous – among 25.01% and 50% of disc florets has paleae associated; hemipaleaceous – amongst 50.01% and 99.99% of disc florets has paleae associated; and holopaleaceous – each disc floret has paleae associated.

TABLE 1. Terminology for description of the proportion of the number of the paleae comparing with the number of the disc florets on the receptacle of *Calea* (Neurolaeneae, Asteraceae).

Receptacle	Definition	Example (hypothetic head has 100 disk florets)
Epaleaceous	Complete absence of paleae	0 paleae
Pauperpaleaceous	Up to 10% of disc florets have paleae associated	1 to 10 paleae
Paucipaleaceous	Between 10.01% and 25% of disc florets have paleae associated	11 to 25 paleae
Oligopaleaceous	Among 25.01% and 50% of disc florets have paleae associated	26 to 50 paleae
Hemipaleaceous	Amongst 50.01% and 99.99% of disc florets have paleae associated	51 to 99 paleae
Holopaleaceous	All the disc florets have paleae associated	100 paleae

Taxonomic treatment

Calea repanda V.R.Bueno, Gostel & G.Heiden, *sp. nov.* (Fig.2)

Type:—BRASIL. Minas Gerais, Rio Pardo de Minas, Serra Nova, sitio 25, ponto 2, 23 June 2017, *A. C. Sevilha 7016* (holotype: CEN!). *Calea repanda* is morphologically similar to *C. diamantinensis* and *C. gentianoides*; however, it can be distinguished by the leaves with repand margins (vs. entire margins), capitula radiate (vs. discoid), involucre 12.2–12.7 mm × 10.6–12 mm (vs. 5.5–9.4 mm × 2.7–5.2 mm), capitulum with holopaleaceous receptacle (vs. oligopaleaceous or epaleaceous, respectively), disc florets 30–40 (vs. 3–9), and pappus scales 7–10 (vs. 15–20).

Plants herbaceous, up to 0.6 m tall. **Stems** castaneous, cylindrical, striate, glabrous to sparse pilose, internodes 11.5–15 mm long. **Leaves** decussate, petiole 1.3–1.5 mm long; blades 1.37–3.31 × 0.59–2.1 cm, wide oblong to wide elliptic, often narrow oblong to elliptic, base rounded, apex obtuse, venation paralellodromous, margins repand, revolute, abaxial surface glabrous to sparsely pilose, rarely pilose, veins glabrous or hispidulous, glands absent, adaxial surface glabrous with margin scabrid, glands absent, coriaceous, discolourous, abaxial surface olivaceous, adaxial surface dark green. **Capitula** arranged in pairs, terminal; peduncle 0.45–0.7 cm long, hirtellous to hirsute, glandular-punctate. Capitulum heterogamous, radiate; involucre 12.2–12.7 × 10.6–12 mm, campanulate to broadly cylindrical. **Phyllaries** 6-seriate, conspicuously striate, margins entire, hyaline, flat; outermost series of phyllaries scarious with apex foliaceous, olivaceous with base yellowish green, first series 5.5–5.6 × 3.4–4 mm, broadly oblong or ovate, apex obtuse, sparsely hirsute to sparsely pilose, sparsely glandular-punctate in apex, 6–8-striate; second series 5.3 × 3.9 mm, ovate, apex obtuse, pilose to densely pilose, sparsely glandular-punctate in apex, 8-striate; innermost series scarious, glabrous, pale yellow to green, third series 5.5 × 3.7 mm, ovate, apex rounded, 9–12-striate; fourth series 5.4 × 5 mm, very broadly ovate, apex rounded, 15–18-striate; fifth series 9.6–10.1 × 4.6–4.9 mm, narrowly ovate, apex rounded, 14–15-striate; sixth series 10.4–10.9 × 3.7–4.3 mm, narrowly oblong to lanceolate, apex rounded, 10–12-striate; **receptacle** flat, holopaleaceous, paleae 8.2–9.6 mm long, narrowly elliptical, concave, apex acuminate or attenuate, light yellow. **Ray florets** 8–10, pistillate, corolla 13.4–13.8 mm long, liguliform, tube 2.9–3.3 mm long, limb 10.1–10.5 × 2.8–3.8 mm, oblanceolate, apex 3-lobed, 5-veined, abaxial surface glandular-punctate, adaxial surface glabrous, yellow; style arms 1.0–1.1 mm long, linear, yellow. **Disc florets** 30–40, bisexual, corolla 5–5.4 mm long, tubular, tube 1.3–1.6 mm long, lobes 0.8–1.2 mm long, glabrous, yellow; anthers 2.4–2.5 mm long, light yellow, apical anther appendages trullate; style arms 0.8–1.1 mm long, linear, yellow. **Cypselae** 3.0–3.2 mm long, black, prismatic, ray cypselae 3-angled, disc cypselae 4-angled, glabrous to pilose, ribs densely pilose; **pappus** 7–10, bitypic, scales bilength (1–2 distinctly longer) or polylength, free, uniseriate, shorter scales (1.1–) 2.4–3.5 mm long, medium scales 3–3.4 mm long (exclusively present when polylength), longer scales 3.1–4.3 mm long, narrow elliptic to lanceolate, apex long acuminate, margins entire, erose.

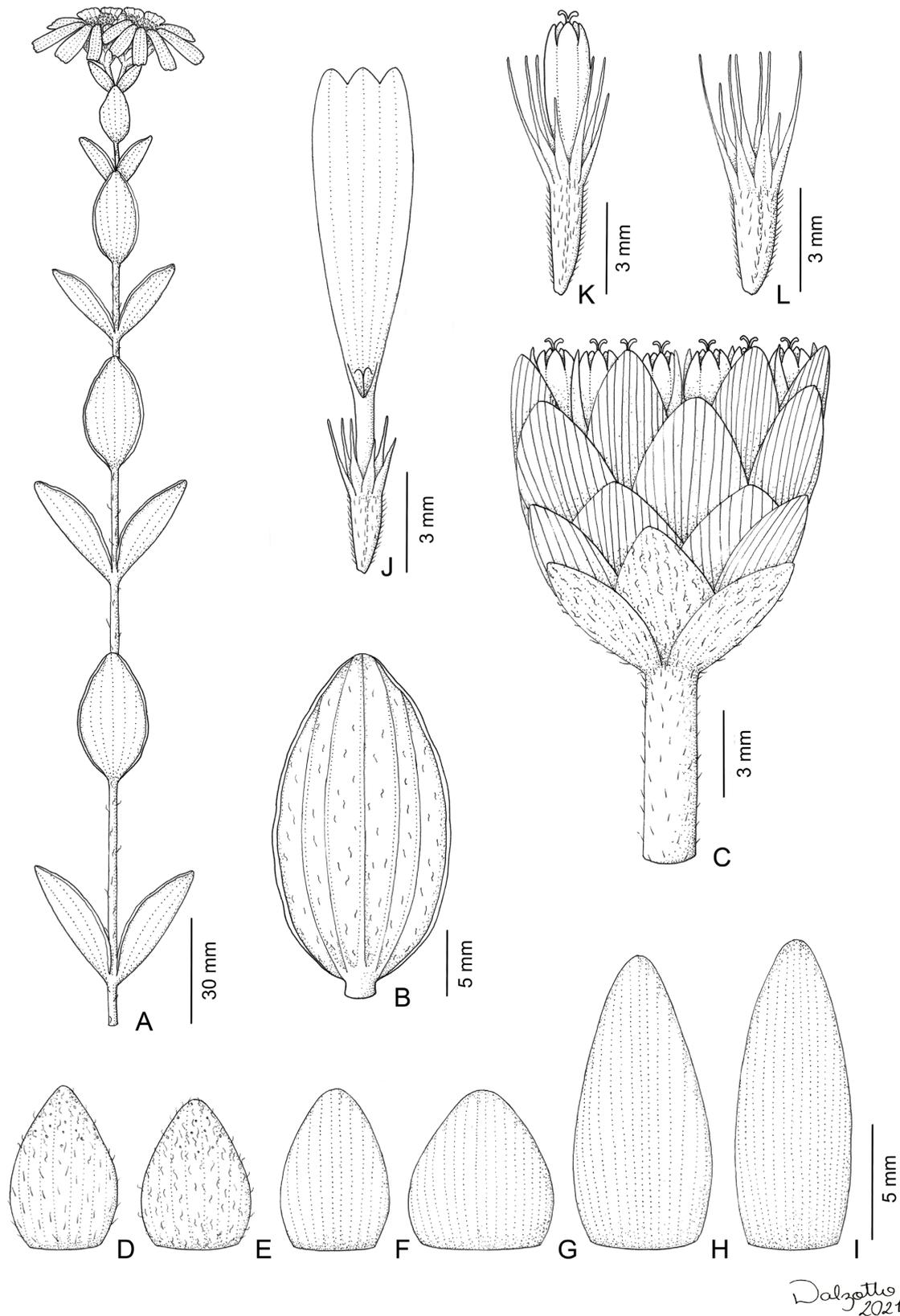


FIGURE 2. *Calea repanda* sp. nov. (Neurolaeneae, Asteraceae) A. Flowering branch. B. Leaf, abaxial surface. C. Capitula with ray florets removed to show involucre, paleae and disc florets arrangements. D. First series of phyllaries. E. Second series of phyllaries. F. Third series of phyllaries. G. Fourth series of phyllaries. H. Fifth series of phyllaries. I. Sixth series of phyllaries. J. Ray floret. K. Disc floret with bilength pappus scales. L. Cypselum with polylength pappus scales. A–L drawn from *A. C. Sevilha 7016* (CEN); A–L: millimeter scale. Illustration by Débora Dalzotto.

Distribution and Habitat:—*Calea repanda* is a stenoendemic species that occurs exclusively in one municipality in the north of Minas Gerais state: Rio Pardo de Minas (Fig. 1). This new species grows in areas of Campo Rupestre (rocky outcrops tropical grasslands) in elevations around 800 m.

Informal Conservation Status:—Critically Endangered (B1; B2a; C2 i, ii; D). *Calea repanda* is represented by one single specimen. A. C. Sevilha (the collector) is one of the coordinators of the Bem Diverso Project (Sevilha *et al.* 2022) and tried to find the species in the surroundings during other trips to the field, but he failed (pers. comm.). The species was collected in an area where the Bem Diverso Project is being developed, which aims to combine sustainable development with nature conservation (Sevilha *et al.* 2022), but it is not a protected area. According to the IUCN (2019) criteria, this new species meets the following requirements: the criteria B1 (less than 100 km² of extent of occurrence), B2 (less than 10 km² of area of occupancy) and the condition A of criterion B (because it has one known location); criterion C, conditions i and ii of C2, and the criterion D are applied for having only one known mature adult individual.

Etymology:—The epithet “repanda” refers to the repand margins leaf, a morphological trait not found in any other species of *Calea* from Brazil.

Phenology:—The holotype was collected with florets and fruits in June.

Taxonomic comments:—The unbranched stem, heads arranged in pairs, and especially the repand margin leaf distinguishes this species and is likely why this specimen remained unidentified since its collection. The repand margin is a unique trait in Brazilian *Calea* and the capitula arranged in pairs are also quite uncommon. Despite the importance of capitulescence in differentiation of sections of *Calea* (Bueno *et al.* 2021), the reduced capitulescence of *C. repanda* did not provide any hint in which section it would be likely placed.

The morphological feature from the specimen supports its recognition as a new species. The analyses of the pappus, predominantly longer than the cypselae, corroborates that the new species belongs to *C. sect. Calea*. The two more widespread species of this section in Brazil are *C. pinnatifida* (Brown 1818: 109) Lessing (1830: 158) and *C. lantanoides* Gardner (1848: 416). *Calea repanda* is easily distinguishable from these two species by the habit herbaceous 0.6 m tall (vs. shrubby 1–5 m), petiole 1.3–1.5 mm long (vs. 3.5–9 mm), leaf margin repand (vs. pinnatifid or serrate), capitula arranged in pairs (vs. cymose umbelliform), involucre wide 10.6–12 mm (vs. 3.4–8 mm), corolla of the ray florets 13.4–13.8 mm (vs. 7–11.2 mm, absent in *C. lantanoides*), disc florets 30–40 (vs. 7–21), and pappus scales 7–10 (vs. 16–43).

Calea repanda is morphologically similar to *C. gentianoides* Candolle (1836: 672) and *C. diamantinensis* Silva & Nakajima (2020: 200); these three species form a likely group placed in *C. sect. Calea*. The *C. gentianoides* group is characterized by the herbaceous habit (uncommon in this section), elliptical to oblong leaves, capitulescences with few capitula, and pappus 2.5–5 mm long. Due to the unusual herbaceous habit in the section, the reduced number of capitula in the capitulescence, and because two of the three species have either epaleaceous or oligopaleaceous receptacles (a putative derived character in *Calea*), we suspect that the *C. gentianoides* group probably has diverged recently within *C. sect. Calea*.

Calea repanda can be distinguished from the remaining species of the *C. gentianoides* group (*C. diamantinensis* and *C. repanda*) by the venation paralellocladous (vs. eucamptodromous or acrodromous), margin repand (vs. entire), capitulum radiate (vs. discoid), involucre 12.2–12.7 mm × 10.6–12 mm (vs. 5.5–9.4 mm × 2.7–5.2 mm), receptacle holopaleaceous (vs. oligopaleaceous or epaleaceous), disc florets 30–40 (vs. 3–9), and pappus scales 7–10 (vs. 15–20).

Regarding the new terminology proposed to describe the proportion of paleae compared to disc florets on capitulum receptacles (Tab. 1), we expect this terminology will be applicable to species of all sections of *Calea* (Pruski 1998). From the five sections, only *C. sect. Haplocalea* Pruski (1998: 683–684) unanimously have holopaleaceous species. From the other sections, at least 18 species of *Calea* (ca. 11% of the genus) have a smaller proportion of paleae compared to disc florets. Meanwhile, leastwise 17 species (ca. 11% of the genus) have an epaleaceous receptacle.

Key to the species of *Calea* sect. *Calea* from Brasil

1. Capitula radiate.....2.
- Capitula discoid.....6.
2. Capitulum solitary or capitula arranged in pairs.....3.
- Capitula arranged in capitulescences with three or more capitula.....4.
3. Involucre 3-seriate, 7.5–10 mm long, receptacle epaleaceous; ray florets 5–7, disc florets ca. 15; pappus scales 0.8 mm long.....*C. caleoides*
- Involucre 6-seriate, 12.2–12.7 mm long, receptacle holopaleaceous; ray florets 8–10, disc florets 30–40; pappus scales 1.1–4.3 mm

	long.....	<i>C. repanda</i>
4.	Ray florets 11–12; pappus scales ca. 15.....	<i>C. lucidivenia</i>
-	Ray florets 2–10; pappus scales 25–43.....	5.
5.	Leaf margins pinnatifid; capitula sparsely arranged.....	<i>C. pinnatifida</i>
-	Leaf margins serrate; capitula densely arranged.....	<i>C. serrata</i>
6.	Phyllaries foliaceous, longer than the involucre.....	7.
-	Phyllaries foliaceous, of the same length or shorter than the involucre.....	8.
7.	Ray florets 12–25.....	<i>C. lutea</i>
-	Ray florets 4–5.....	<i>C. papposa</i>
8.	Receptacle epaleaceous.....	<i>C. gentianoides</i>
-	Receptacle oligopaleaceous or holopaleaceous.....	9.
9.	Involucre 4-seriate; pappus scales 1.9–2.3 mm long.....	<i>C. divergens</i>
-	Involucre 5–8-seriate; pappus scales 2.7–5.5 mm long.....	10.
10.	Involucre 5-seriate.....	11.
-	Involucre 7–8-seriate.....	12.
11.	Involucre 3.5–5.2 mm long; receptacle oligopaleaceous, paleae 2–4; disc florets 7–9; cypselae 2.7–3 mm long.....	<i>C. diamantinensis</i>
-	Involucre 6.7–8.4 mm long; receptacle holopaleaceous, paleae 20–30; disc florets 20–30; cypselae 2–2.5 mm long.....	<i>C. oliveri</i>
12.	Leaf blade glabrous; pappus scales 15.....	<i>C. abelioides</i>
-	Leaf blade pilose; pappus scales 16–25.....	13.
13.	Petiole 0.5–1.5 mm long, leaf surface abaxially pubescent.....	<i>C. solidaginea</i>
-	Petiole 3–7 mm long, leaf surface abaxially tomentose.....	<i>C. lantanoides</i>

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