UNIVERSIDADE FEDERAL DE PERNAMBUCO – UFPE

CENTRO DE BIOCIÊNCIAS – CB

DEPARTAMENTO DE BOTÂNICA – DB

PROGRAMA DE PÓS-GRADUAÇÃO EM BIOLOGIA VEGETAL – PPGBV

JACQUELINE BONFIM E CÂNDIDO

SISTEMÁTICA E EVOLUÇÃO DE *Piptolepis* Sch.Bip. (Compositae, Vernonieae)

Recife

2022

JACQUELINE BONFIM E CÂNDIDO

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Tese apresentada ao Programa de Pós-Graduação em Biologia Vegetal da Universidade Federal de Pernambuco, como parte dos requisitos para a obtenção do título de Doutor em Biologia Vegetal, na área de Sistemática e Evolução (Taxonomia, Anatomia e Filogenia Molecular).

Orientador: Benoît Francis Patrice Loeuille

Coorientador: Rafael Batista Louzada

Recife

2022

Catalogação na Fonte:
Bibliotecária Elaine Cristina Barroso, CRB4/1728

Cândido, Jacqueline Bonfim e
Sistemática e evolução de *Piptolepis* Sch.Bip. (Compositae, Vernonieae) / Jacqueline Bonfim e Cândido – 2022.

230 f. : il., fig., tab.

Orientador: Benoît Francis Patrice Loeuille
Coorientador: Rafael Batista Louzada
Tese (doutorado) – Universidade Federal de Pernambuco. Centro de Biociências. Programa de Pós-graduação em Biologia Vegetal, Recife, 2022.
Inclui referências, apêndices e anexo.

1. Compostas (Botânica) 2. Botânica- classificação 3. Nicho (Ecologia) I. Loeuille, Benoît Francis Patrice (orient) II. Louzada, Rafael Batista (coorient.). III. Título.

583.99 CDD (22.ed.) UFPE/CB – 2022- 180

JACQUELINE BONFIM E CÂNDIDO

SISTEMÁTICA E EVOLUÇÃO DE *Piptolepis* Sch.Bip. (Compositae, Vernonieae)

Ao décimo quinto dia do mês de agosto de dois mil e vinte e dois, em sessão pública, realizou-se a defesa de tese apresentada ao Programa de Pós-Graduação em Biologia Vegetal da Universidade Federal de Pernambuco, como parte dos requisitos para a obtenção do título de Doutor em Biologia Vegetal, na área de Sistemática e Evolução (Taxonomia, Anatomia e Filogenia Molecular). Nesta data a Comissão Examinadora reuniu-se deliberou e concedeu, a discente, a menção APROVADA.

Dr. Benoît Francis Patrice Loeuille (Orientador – Presidente)
Universidade Federal de Pernambuco / Royal Botanic Gardens, Kew

Dr. Caetano Troncoso Oliveira (Examinador externo)
Sítio Roberto Burle Marx - Instituto do Patrimônio Histórico Artístico Nacional

Dr. João Bernardo de A. Bringel Jr. (Examinador externo)
Universidade de Brasília

Dra. Nádia Roque (Examinadora externa)
Universidade Federal da Bahia

Dr. Roberto Lourenço Esteves (Examinador externo)
Universidade do Estado do Rio de Janeiro

À **minha mãe, Ailsa**, que sempre foi a maior incentivadora de todos os meus sonhos e objetivos.

AGRADECIMENTOS

Inicialmente, gostaria de agradecer ao **Programa de Pós-Graduação em Biologia Vegetal** da **Universidade Federal de Pernambuco**, em particular ao **laboratório de Morfo-Taxonomia Vegetal**, por me oferecerem toda a infraestrutura e condições necessárias para o desenvolvimento deste trabalho. Agradeço à Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (Finance Code 001) pela bolsa (CAPES/PROEX) concedida durante o período de 2018−2022 e ao **Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (IBAMA)**, assim como ao **Instituto Estadual de Florestas de Minas Gerais (IEF- MG)** pelas licenças de coletas.

Ao meu orientador, **Benoît**, por todo o suporte e apoio durante todos esses anos. Você sempre fez todo o possível para que esse trabalho se tornasse realidade, desde a idealização do projeto, conseguir verbas que eram necessárias, até possíveis parceiros e amigos que poderiam nos ajudar. Admiro o quanto foi um orientador acessível e prestativos e o quanto você me ajudou a construir e ampliar meu conhecimento, não só em relação as Lychnophorinae, mas sobre a pesquisa como um todo. O caminho ainda é longo, mas com toda certeza hoje eu tenho uma bagagem de conhecimento muito maior, obrigada por isso. Agradeço também por ter sido humano e parceiro quando o processo começou a se tornar pesado demais para lidar, seu suporte foi fundamental.

Ao meu co-orientador, **Rafael Louzada**, por ter me aceitado como sua orientanda durante esses anos e ter tornado possível meu estudo com as Asteraceae.

A todos que participaram em algum momento e/ou aceitaram fazer parte da construção deste trabalho, especialmente aos professores, doutores e pesquisadores: **Carolina Siniscalchi**, **Jaqueline Dias Pereira**, **Jennifer Mandel**, **José Rubens Pirani** e **Makeli Lusa**. Assim como, os colegas **Álvaro Nepomuceno**, **Hugo Araújo** e **Fábio Vitalino**.

Aos **revisores** de todos os manuscritos por suas sugestões valiosas.

As muitas pessoas e instituições que foram generosas com seu tempo e recursos, oferecendo hospedagem e apoio logístico durante as visitas a herbários e no trabalho de campo. Em especial, **Fabiane Nepomuceno da Costa** da Universidade Federal do Vale do Jequitinhonha e Mucuri (UFVJM), que generosamente me acolheu em Diamantina e me ajudou por um mês com meu trabalho de campo, sem você essa tese não seria a mesma.

Aos **curadores e técnicos** de todos os herbários visitados por me receberem muito bem e serem tão prestativos, especialmente: ALCB, BHCB, HUEFS, HUFU, R, RB, UEC por seus empréstimos e doações ao herbário UFP.

Aos amigos do Laboratório de Morfo-Taxonomia Vegetal pelos memoráveis e essenciais momentos juntos: **Aline Melo, Álvaro Nepomuceno, Camila Alcântara, Débora Cavalcante, Danielly Lucena, Fábio Alves, Francione Gomes, Gleison Soares, Josélia Costa, Lucía Marim, Márcio Bazante, Maiara Batista, Naédja Luna** e **Regina Maria Alcântara de Carvalho**, esta última um agradecimento especial pelas belíssimas ilustrações deste trabalho. Vocês foram minha família durante esses quatro anos e fizeram com que esse processo fosse mais leve de peregrinar. Agradeço por terem me dado uma palavra amiga em diversos momento, um conforto ou mesmo aquela ajuda em dúvidas específicas, você são demais!

Aos de todas as horas, **Jaynne, Bianca, Ana, Carol, Fagner, Carlos, Vinicius, Thiago, Diego** e especialmente minha mãe, **Ailsa**. Vocês escutaram sobre essa tese por horas e dias sem parar e por algum milagre, não só não desistiram de mim, como me deram suporte, acreditaram no meu potencial, me animaram e me deram amor, sou grata por existirem na minha vida. Eu amo vocês!

“Rochedos proeminentes, altas montanhas, terrenos arenosos e estéreis, cortados por um grande número de riachos, sítios os mais bucólicos, **uma vegetação tão curiosa quanto variada** (...)” (SAINT-HILAIRE, 1833. pp. 111).

RESUMO

Piptolepis Sch.Bip. (Vernonieae, Asteraceae) atualmente compreende 19 espécies endêmicas aos campos rupestres do Brasil e possui um centro de diversidade na região do Platô Diamantina em Minas Gerais. O objetivo deste estudo foi investigar a história evolutiva e a taxonômica de *Piptolepis*. Para tanto, o trabalho foi dividido em dois capítulos, o primeiro contendo estudos taxonômicos para o gênero, que compreendem: a descrição de três novas espécies para *Piptolepis*, um reestabelecimento nomenclatural do nome *Piptolepis pseudomyrtus* (A. St.-Hil.) Sch.Bip. e uma revisão para *Piptolepis*, contendo quatro novas espécies, descrições morfológicas, status de conservação, ilustrações, pranchas de fotos, mapas de distribuição, discussões taxonômicas e uma chave de identificação dos gêneros relacionados e para *Piptolepis* a nível específico. No segundo capítulo, um estudo morfométrico e de modelagem de nicho para *P. ericoides* Sch.Bip. é apresentado buscando esclarecer a existência de diferentes morfotipos nas populações ao longo da Cadeia do Espinhaço, assim como o provável processo biológico por trás dessas diferenças. A tese conta ainda com os demais trabalhos realizados em paralelo e que estão intimamente relacionados com o tema de estudo, são eles: uma nova espécie de *Piptolepis* encontrada no platô Goiano, duas espécies novas de *Lychnophorella* Loeuille, Semir & Pirani da Chapada Diamantina e um estudo anatômico da cipsela de *Piptolepis*. Diante do contexto, esse trabalho contribuiu com uma análise detalhada sobre o gênero, trazendo novas informações e maior entendimento desse pequeno grupo de plantas.

Palavras-chave: campos rupestres; endemismo; espécies ameaçadas; modelagem de nicho; morfometria.

ABSTRACT

Piptolepis Sch.Bip. (Vernonieae, Asteraceae) currently comprises 13 species endemics to the *campos rupestres* of Brazil and has a center of diversity in the Diamantina Plateau in Minas Gerais. The aim of this study was to investigate the evolutionary and taxonomic history of *Piptolepis*. Therefore, the work was divided in two chapters, the first containing taxonomic studies for the genus, which include: the description of three new species for *Piptolepis,* a nomenclatural reestablishment of the name *Piptolepis pseudomyrtus* (A. St.-Hil.) Sch.Bip. and a review for *Piptolepis*, containing four new species, morphological descriptions, conservation status, illustrations, photography, distribution maps, taxonomic discussions and an identification key of related genera and to *Piptolepis* at a specific level. In the second chapter, a morphometric and niche modeling study for *P. ericoides* Sch.Bip. is presented seeking to clarify the existence of different morphotypes in populations along the Espinhaço Range, as well as, the probable biological process behind these differences. The thesis also counts on other works carried out in parallel and that are closely related to the subject of study, they are: a new species of *Piptolepis* found in the Goiano Plateau, two new species of *Lychnophorella* from Chapada Diamantina and an anatomical study of the cypsela of *Piptolepis*. In this context, this work contributed with a detailed analysis of the genus, bringing new information and greater understanding of this small group of plants.

Keywords: campos rupestres; endemism; threatened species; niche modeling; morphometry.

SUMÁRIO

1 APRESENTAÇÃO

Neste trabalho, foi realizado um amplo estudo taxonômico de *Piptolepis*, com abordagem revisional, incorporando dados atualizados e inéditos para todo o gênero. Assim como, estudo morfométrico com modelagem de nicho para *P. ericoides* Sch.Bip., buscando esclarecer a existência de diferentes morfotipos nas populações ao longo da Cadeia do Espinhaço e o provável processo biológico por trás dessas diferenças.

Os resultados desses estudos foram organizados da seguinte maneira:
Artigo 1: apresenta uma revisão para *Piptolepis*, com quatro novas espécies, descrições morfológicas, status de conservação, ilustrações, pranchas de fotos, mapas de distribuição, discussões taxonômicas e uma chave de identificação para todo o gênero (artigo a ser submetido a Phytotaxa).

Artigo 2: apresenta um estudo da variação morfológica em *P. ericoides* em relação as diferenças ambientais presentes em cada população, dessa forma utilizou-se uma abordagem ecológica em conjunto com análises morfológicas, afim de melhor compreender a influência desses fatores abióticos nas variações fenotípicas encontradas na espécie (artigo a ser submetido ao periódico Flora).

Apêndices: Conta todos trabalhos realizados durante o doutorado e que já foram publicados, são eles: uma nova espécie de *Piptolepis* encontrada no platô Goiano (Artigo publicado no periódico Phytotaxa). Duas espécies novas de *Lychnophorella* Loeuille, Semir & Pirani da Chapada Diamantina (Artigo publicado no periódico Systematic Botany). Três novas espécies para o gênero *Piptolepis* (Artigo publicado no periódico Systematic Botany). Um estudo anatômico comparativo da cipsela de *Piptolepis* (Artigo publicado no periódico Flora). Por fim, um reestabelecimento nomenclatural, que traz uma investigação histórico taxonômica do nome *Piptolepis pseudomyrtus* (St.-Hil.) Sch.Bip. (Artigo publicado no periódico Phytotaxa).

2 FUNDAMENTAÇÃO TEÓRICA

A família Asteraceae compreende cerca de 25.000–30.000 espécies, pertencentes a 1.600–1.700 gêneros, que estão distribuídos em 16 subfamílias e 50 tribos (FUNK et al., 2009; SUSANNA et al., 2020; KEELEY; CANTLEY; GALLAHER, 2021). No Brasil, estima-se que existam 2.205 espécies pertencentes a 326 gêneros, destes 62% das espécies e 22% dos gêneros são exclusivos da flora brasileira (ROQUE et al., 2022).

Dentro das Asteraceae a tribo Vernonieae é considerada a quinta maior, com 21 subtribos e 129 gêneros que incluem cerca de 1.500 espécies (ROBINSON, 2007; PANERO; CROZIER, 2016). Essa tribo possui distribuição Pantropical e tem seus dois maiores centros de biodiversidade no Brasil e na África. Vernonieae tem como principais características sua diversidade de hábitos desde pequenas ervas a frondosas árvores, suas folhas são alternas e os capítulos discoides com flores roxas, alvas ou azuis, raramente vermelhas ou amarelas (KEELEY; ROBINSON, 2009).

A subtribo Lychnophorinae pertence à tribo Vernonieae e compreende 19 gêneros e 130 espécies, sendo essas principalmente subarbusto e arvoretas que ocorrem no cerrado e em campos rupestres brasileiros (LOEUILLE; SEMIR; PIRANI, 2019). O gênero *Piptolepis* Sch.Bip. foi descrito com setes novas combinações de espécies anteriormente incluídas no gênero *Vernonia* Schreb. em 1863 por Schultz-Bipontinus. Em 1873, Baker apresentou na 'Flora brasiliensis' de Martius o último tratamento taxonômico do gênero, com oito espécies.

Robinson; Bohlmann; King, (1980) realizaram uma classificação da tribo Vernonieae com base em dados fitoquímicos e morfológicos, levando a uma nova proposta de circunscrição da subtribo Lychnophorinae. Foram excluídos alguns táxons com presença de sincéfalos e incluídos gêneros com capítulos isolados, dentre estes *Piptolepis*. Essa classificação se manteve nos trabalhos realizados por Bremer (1994) e Robinson (1992; 1999). Loeuille; Keeley; Pirani, (2015a) e Loeuille et al., (2015b), estudaram as relações filogenéticas de Lychnophorinae com base em dados morfológicos e moleculares, corroborando com o posicionamento de *Piptolepis* dentro da subtribo e com o seu monofiletismo.

Piptolepis pode ser caracterizado como arbusto, subarbustos e arvoretas densamente ramificados, cobertos por indumento tomentoso a veludíneo, composto por tricomas com 3−5 braços. Possui folhas alternas, sésseis a pecioladas, com uma típica bainha foliar do tipo *pad-like* ou raramente semi-amplexicaule. Os capítulos são solitários, organizados em racemos ou pseudo-glomérulos terminais, raramente em sincéfalos e com brácteas involucrais laxamente imbricadas (LOEUILLE; SEMIR; PIRANI, 2019).

O gênero atualmente compreende 19 espécies ocorrendo nos campos rupestres da Cadeia do Espinhaço de Minas Gerais e possui um centro de diversidade no Platô Diamantina (LOEUILLE et al., 2012; LOEUILLE; SEMIR; PIRANI, 2019). *Piptolepis* apresenta um alto nível de microendemismo, com a maioria das espécies representadas por um ou dois locais de ocorrência e por pouquíssimas populações, o que se reflete no número de amostras coletadas para o gênero, sendo representado por poucas coleções em herbários, com exceção de *P. ericoides* Sch.Bip., uma espécie amplamente distribuída ao longo da Cadeia do Espinhaço de Minas Gerais (LOEUILLE; SEMIR; PIRANI, 2019). Consequentemente, o gênero ainda é pouco conhecido em diversos aspectos, como taxonômico, evolutivo, sistemático, ecológico e quanto ao status de conservação.

Problemas taxônomicos relacionados às questões de delimitação de espécies ocorrem principalmente com *P. ericoides* que apresenta uma grande variação no formato e tamanho das folhas, e entre *P. leptospermoides* (Mart. ex DC.) Sch.Bip., *P. imbricata* (Gardner) Sch.Bip., *P. glaziouana* Beauverd com expressivas semelhanças morfológicas semelhantes (LOEUILLE; SEMIR; PIRANI, 2019).

Diante desse contexto, tivemos como intuito investigar a história evolutiva e a taxonômica de *Piptolepis*, por meio do estudo revisional, com a contribuição de modelagem de nicho e estudos morfométricos.

3 ARTIGO I TAXONOMIC REVISION OF *PIPTOLEPIS* SCH.BIP. (VERNONIEAE, ASTERACEAE)

ARTIGO A SER SUBMETIDO AO PERIÓDICO PHYTOTAXA.

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Abstract

Piptolepis comprises 19 species, all of them endemic to the mountains of Minas Gerais State, Brazil. It is characterised by shrubs to treelets, with stems densely branched, marked by leaf scars and covered by a dense indumentum. The leaves are alternate, spiraled, discolorous, with a typical pad-like leaf sheath. The capitula are solitary, or organised in a terminal raceme, pseudoglomerule or rarely in a corymb. Most of the species (16) are microendemics and known by few populations. Thereby, the genus should be considered a priority for conservation. The main goal of this paper is to present the first taxonomic revision of the genus since the XIXth century, providing access to updated and detailed information of all species of *Piptolepis*. This revision describes four new species (*P. elaeoda*, *P. fulgens*, *P. redacta* and *P. speciosa*) and provides complete synonymies, descriptions, conservation status, illustrations, discussion of taxonomic affinities, distribution maps, and an identification key.

Key words: *Campos rupestres*, Compositae, endemism, nomenclature, systematic

Introduction

Asteraceae comprises about 25,000–30,000 species belonging to 1,600–1,700 genera, distributed in 16 subfamilies and 50 tribes (Funk *et al.* 2009, Susanna *et al.* 2020). The sixth largest tribe of this family, Vernonieae, comprises 21 subtribes, 129 genera and ca. 1,500 species (Robinson 2007, Panero & Crozier 2016, Keeley *et al.* 2021). Among the subtribes currently recognized in Vernonieae, Lychnophorinae, contains 19 genera and 140 species, consisting mostly of shrubs and treelets growing in the cerrados and *campos rupestres* of the Brazilian Central Plateau (Marques *et al.* 2018, 2021, Bringel *et al.* 2019, Loeuille *et al.* 2019, 2022, Cândido & Loeuille 2020, 2021, 2022, Gomes & Loeuille 2021, 2022 in press).

Piptolepis Schultz-Bipontinus (1863: 383), which belongs to Lychnophorinae, is endemic to Minas Gerais in *campos rupestres* areas. *Campos rupestres* are rock outcrops in dry or wet grasslands, with herbaceous to open shrubby vegetation in high elevations (above 800 m a.s.l.). Their soils are shallow and impoverished, originating from quartzite, sandstone, or ironstone (Fernandes, 2016). The genus' distribution is nearly restricted to the Espinhaço Range. Its center of diversity is the middle of Diamantina Plateau district (sensu Colli-Silva *et al.* 2019) with most of its species (15) exclusive of that area. Only three species, *P. pseudomyrtus* (A. St.-Hil.) Schultz-Bipontinus (1863: 384), *P. redacta* (here described) and *P. schultziana* Loeuille & D.J.N. Hind (2012:12) occur South to that region in Congonhas do Norte, Conceição do Mato Dentro and Santana do Riacho municipalities. *Piptolepis ericoides* Schultz-Bipontinus (1863: 63), the unique widespread species of the genus has a continuous distribution along the Espinhaço Range of Minas Gerais State and also reaching the Serra da Canastra (southwestern Minas Gerais) (Fig 1).

The genus is characterised by a variety of habits, ranging from spreading, straggling shrubs, rarely procumbent shrubs to virgate treelets, with stems densely branched and arching, marked by leaf scars and covered by a dense indumentum. The leaves are alternate, spiraled, discolorous, with a typical pad-like leaf sheath. The capitula are solitary, or organised in a terminal raceme, pseudoglomerule or rarely in a corymb. The taxa have been associated with different phytophysiognomies of *campos rupestres*: sandstone, quartzite rock outcrops, sandy soils or ironstone grassland, with populations frequently on the banks of small streams, waterlogged grasslands or nearby peatland areas, at elevations between 700 and 2,050 m.

Piptolepis was described in 1863 by Schultz-Bipontinus and had its last taxonomic treatment in 1873 provided by Baker in *Flora brasiliens*is of Martius. Robinson *et al.* (1980) based on phytochemical and morphological data included *Piptolepis* in Lychnophorinae and this classification was followed by Bremer (1994), Robinson (1992, 1999, 2007), Loeuille *et al.* (2019) and confirmed by phylogenetic analyses (Loeuille *et al.* 2015a, Siniscalchi *et al.* 2020, Keeley *et al.* 2021). The monophyly was confirmed by phylogenetic analyses (Loeuille *et al.* 2015b, Cândido *et al.* in prep.). However, the sister group relationship found between *Piptolepis* and *Eremanthus pabstii* Barroso (1964: 173) by Loeuille *et al.* (2015b) was not recovered by Cândido *et al.* (in press.) and, therefore, the inclusion of *E. pabstii* and its closely related species, *Piptolepis rosmarinifolia* Bringel, J.B.Cândido & Loeuille (2019: 272) into *Piptolepis* (Loeuille *et al.* 2019) is not followed here.

The main goal of this taxonomic revision is to update and provide detailed information for all species of *Piptolepis*. Aiming it, this work describes four new species and excludes two others, provides complete synonymies, descriptions, conservation status, illustrations, discussion of taxonomic affinities, distribution maps, and identification keys.

Materials & Methods

This study was based on literature review, observation of individuals in intensive fieldwork carried out from May to July 2019 in *campos rupestres* areas of Minas Gerais State, in online databases (Reflora–Herbário Virtual 2021, SpeciesLink 2021) and analyses of more than 760 specimens, including the types and historical gatherings belonging to the following herbaria: ALCB, B† [F negatives], BHCB, BHZB, BM, CEN, DIAM, E, ESA, F, GH, HDJF, HEPH, HUEFS, HUFU, HUSC, IAN, ICN, INPA, K, M, MA, MBM, MO, MPU, NY, OUPR, P, R, RB, S, SP, SPF, UB, UEC, UFG, UFP, US, VIC. (acronyms according to Index Herbariorum; Thiers 2021 continuously updated). All specimens cited were seen by either one or both the authors, unless indicated as 'not seen'. In the case of some specimens only online digital images were seen (indicated '*e*!'). Morphological descriptions were based in exsiccates and field observations. The specimens were analysed and illustrated using an 8–40 × magnification stereomicroscope. Measurements were taken using a digital caliper rule and optical graticule attached to the microscope. Morphology terminology followed Small (1919) for pappus and receptacle forms, Hickey (1973) for leaf shape and venation, Harris & Harris (2001) for indumentum and general morphology, Wagner *et al.* (2014) for trichomes and Beentje (2010) for general morphology and colors. Description provided for *Piptolepis buxoides* (Lessing 1829: 247) Schultz-Bipontinus (1863: 383) was based on the protologue and holotype images. A database containing georeferenced records of all *Piptolepis* species was built by gathering information from field data, examined specimen labels with geographic coordinates and extracted from SpeciesLink (2021). Then, the data were filtered to remove misidentified specimens, records with errors and inaccuracies. These data were used to produce distribution maps by the software Quantum GIS version 3.0 (QGIS Development Team 2018) and the conservation status obtained using GeoCAT Tool (Bachman *et al.* 2011). The IUCN default was used for Area of Occupancy (AOO) and Extent of Occurrence (EOO) (cell size of 2 km^2). The criteria evaluation was according to IUCN (2019). In the Representative Specimens Examined the selected material included were based on occurrence criteria, with only one specimen per specific localities cited, always prioritizing samples with different morphotypes and better representing the features of the species. Species with less than 10 gatherings had all the specimens cited.

Taxonomic History

1829. Lessing described the new species *Vernonia buxoides* Lessing (1829: 247) based on a Brazilian collection by Sellow and proposed the new combination *Vernonia ericoides* (Lamarck 1786: 92) Lessing 1829: 247 based on the Peruvian species *Conyza ericoides* Lamarck (1786: 92), also citing *Baccharis ericoides* (Lam.) Persoon (1807: 425) as a synonym. However, he misapplied the new combination to material of a Brazilian endemic species (Jeffrey & Hind 1994). Both species were allocated in tribe Vernonieae, genus *Vernonia* Schreber (1791: 541), "Sectio I".

1831. Lessing realizing his misapplication of the name *V. ericoides*, validly published a new combination *Liabum ericoides* (Lam.) Lessing (1831: 704), based on *Conyza ericoide*s, and excluded "*Vernonia ericoides* Less.". Simultaneously Lessing (1831: 629) validated a later homonym, *Vernonia ericoides* Less., non (Lam.) Less., explicitly excluding the Peruvian type (Jeffrey & Hind 1994). He maintained the species in the tribe Vernonieae, genus *Vernonia*, "Sectio I – *Hololepis*".

1833. Saint-Hilaire on his book "*Voyage dans le district des diamans et sur le littoral du Brésil*", described *Vernonia pseudomyrtus* Saint-Hilaire (1833: 94, 367), based on his own collection in the Itapanhoacanga region in the state of Minas Gerais.

1836. Candolle placed the three species in "Subtribo Vernonieae, Divisio Euvernonieae, Subdivisio Heterocomeae", *Vernonia,* Sectio II *Hololepis,* § 3 *Ericoideae, nempe fruticosae, ...*". He described and placed in the same group a new species, *Vernonia oleaster* Mart. ex Candolle (1836: 17) based on *Martius n° 1212*. But the other new species, *Vernonia leptospermoides* Mart. ex Candolle (1836: 17), based on *Martius n° 1310*, is placed in "Sectio *Leptospermoides*".

1840. Bentham established a new genus *Piptolepis* Bentham (1840: 29) in the Oleaceae to accommodate a Mexican species (*P. phillyreoides* Bentham (1840: 29)) collected by Hartweg.

1846. Gardner described three new species of this group: *Vernonia imbricata* Gardner (1846:209), *V. burchelliana* Gardner (1846: 209) and *V. martiana* Gardner (1846:210) based on his own gathering in Brazil. The new species were included in “tribe Vernoniaceae”, *Vernonia*, sect. *Hololepis*.

1863. Schultz-Bipontinus in the revision of *Lychnophora* Martius (1822: 148) considered the ‘Hololepidae’ group closely related to *Lychnophora*. In this group he established a new genus *Piptolepis* Schultz-Bipontinus (1863: 380) composed of the seven species previously placed in *Vernonia* and synonymized *V. burchelliana* in *Piptolepis oleaster* (Mart. ex Candolle 1836: 17).

Schultz-Bipontinus validly published the name *Piptolepis ericoides* Schultz-Bipontinus (1863: 383), although he has included all type material of the illegitimate earlier epithet (bringing as synonym).

Finally, he placed the species in an infrageneric classification based on leaf size: Sectio I *Microphyllum* divided in two "subgenera" *Leptospermoides* (with *P. leptospermoides* (Mart. ex Candolle 1836: 17) Schultz-Bipontinus (1863: 382)) and *Eupiptolepis* (*P. ericoides* and *P. buxoides*), Sectio II *Macrophyllum* without division in "subgenera" (*P. pseudomyrtus*), *P. oleaster*, *P. martiana* (Gardner) Schultz-Bipontinus (1863: 385)).

1873 (April). Bentham in Bentham & Hooker’s *Genera plantarum* placed *Piptolepis* within the Tribe Vernonieae, subtribe Euvernonieae, Series Stilpnopappeae.

1873 (June). Baker in *Flora brasiliensis* of Martius followed the same genus circumscription of Bentham (1873) and he provided the last taxonomic treatment of the *Piptolepis*.

He validly published a new species *Piptolepis gardneri* Baker (1873: 144). He understood the commentary “Allied to *V. oleaster*, DC. (Gardn. n. 4753) but sufficiently distinguished by its…” after the description of *Vernonia burchelliana*, as an element justifying that Gardner was describing a new species (‘*V. oleaster* Gardner’) based on the specimen *Gardner n° 4753*, and he placed that name in the synonmy of *P. gardneri*. However, it seems clear to us that Gardner presented a comparison between the new species *V. burchelliana* and *V. oleaster*, a closely related species for Gardner; in brief, the name ‘*Vernonia oleaster* Gardner’ has not been validly published.

Besides of that, Baker noticed that the material used by Schultz-Bipontinus to describe *P. pseudomyrtus* was in fact a different species from the one described by Saint-Hilaire. Thus, he separated both species, placed *V. pseudomyrtus* Saint-Hilaire as a synonym of *P. buxoides* and described a new species *P. pseudomyrtus* Baker (1873: 145), however as the name was pre-existing, he created a later homonym which is illegitimate (Cândido & Loeuille 2022).

1890. Hoffmann circumscribed *Piptolepis* into Tribe Vernonieae, subtribe Vernoninae and does not propose an infrageneric classification.

1909. Glaziou published the new species *Piptolepis schwackeana* in 'Liste des plantes du Brésil central recueillies en 1861–1895', but since it lacks a diagnosis, the name is considered as *nomen nudum* for *P. oleaster*.

1913. Beauverd described a new species, *Piptolepis glaziouana* Beauverd (1913:239), based on Glaziou collection in Diamantina, Brazil.

1935. The conservation of *Piptolepis* Sch. Bip. against the earlier homonym of Bentham was proposed by Mansfeld in the Bulletin of Miscellaneous Information, Kew (Rehder *et al.* 1935).

1940. The conservation of the name *Piptolepis* Sch.Bip. was approved by the "Special Committee for Phanerogamae and Pteridophyta" (Secretary, M.L. Green), transmitted to and published by the Secretary of the Executive Committee, T. A. Sprague, in the Bulletin of Miscellaneous Information, Kew 1940: 127.

1980. Robinson *et al.* carried out a classification of the Vernonieae based on phytochemical data, leading to a new proposal to circumscribe the subtribe Lychnophorinae. *Piptolepis* was included in this subtribe on the basis of the furanone heliangolides and general habit.

1981. Coile & Jones, in their revision of *Lychnophora*, suggested the species *Lychnophora albertinioides* Gardner (1846: 234), *L. brunioides* Martius (1822: 149) and *L. souzae* Robinson (1980: 104) may be placed in *Piptolepis*.

1983. Robinson maintained the three species previously cited in *Lychnophora*, but agreed that they have a dubious position.

1994 (February). Jeffrey & Hind typified *Piptolepis*, choosing *Gardner n° 4750* as lectotype of *P. ericoides*.

1994 (March). Bremer in "Asteraceae. Cladistics & classification" followed the same genus circumscription established by Robinson (1980).

1999. Robinson in "Generic and Subtribal Classification of American Vernonieae", kept the same generic circumscription as established in Robinson *et al.* (1980).

2012. Loeuille *et al.* noticing the error referring to *P. pseudomyrtus* Baker, described a new species, *Piptolepis monticola* Loeuille (2012: 14) for the plants previously identified by this illegitimate name. They also described two new species *Piptolepis campestris* Semir & Loeuille (2012:11) and *P. schultziana*.

2015. Loeuille *et al.* studied the phylogenetic relationships of Lychnophorinae, resulting in a new circumscription to maintain a monophyletic subtribe. The position of *Piptolepis* was corroborated within Lychnophorinae, emerging as the sister group of a clade composed by *Lychnophora* and *Eremanthus* Lessing (1829: 317). Its monophyly was supported by both molecular and morphological data. *Eremanthus pabstii* emerged as a sister-group of *Piptolepis* or even nested inside that clade depending on the analyses, suggesting the species might be best placed in *Piptolepis*.

2019 [March]. Loeuille *et al.* in the sinopsis of subtribe Lychnophorinae described a new species, *Piptolepis riparia* Loeuille, Semir & Pirani (2019: 95). They maintained *V. pseudomyrtus* A.St.-Hil. as a synonym of *P. buxoides* and synonymized *P. martiana* under *P. oleaster*. They transferred *E. pabstii* into *Piptolepis*. The authors included in an '*incertae sedis*' section, the *'Lychnophora brunioides'* group, containing, among others, the species *L. albertinioides*, *L. brunioides* and *L. souzae*, and point to the dubious taxonomic position of these species.

2019 [March]. Bringel *et al.* described a new species *Piptolepis rosmarinifolia*, which is closely related to *P. pabstii* (Barroso) Loeuille, Semir & Pirani (2019: 95).

2021. Cândido & Loeuille described three new species from the Diamantina Plateau: *Piptolepis corymbosa* J.B.Cândido & Loeuille (2021: 496), *Piptolepis pilosa* J.B.Cândido & Loeuille (2021: 497) and *Piptolepis procumbens* J.B.Cândido & Loeuille (2021: 498).

(2022). Cândido & Loeuille re-established the name *Piptolepis pseudomyrtus* (A. St.-Hil.) Schultz-Bipontinus (1863: 64).

(In prep.). Cândido *et al.* based on phylogenetic, anatomic and morphologic data, excluded *P. rosmarinifolia* and *P. pabstii* of *Piptolepis*.

Morphology and others important aspects in the taxonomy of *Piptolepis*

Habit

Species of *Piptolepis* presents a variety of habits, ranging from spreading, straggling shrubs (Fig. 2 A) or rarely procumbent (Fig. 2 B) shrubs of few centimeters to virgate treelets (Fig. 2 C, D) up to 4 meters. All the genus has arching stems densely branched.

Leaves

The leaves are simple, with phyllotaxy alternate, spiraled, ascending to patent, rarely descending or imbricate. The leaves are sessile (Fig. 3 B, M) to subsessile (Fig. 3 C, K) or shortly petiolate (Fig. 3 S) (0.1–4 mm), with a pad-like leaf sheath. The group displays a very large variety of leaf shapes ranging from very narrow elliptic (Fig. 3 I)), narrow elliptic (Fig. 3 K, P), elliptic (Fig. 3 B, D, N), wide elliptic (Fig. 3 O), lanceolate (Fig. 3 M), narrow oblanceolate (Fig. 3 J, L), oblanceolate (Fig. 3 Q, R), narrow oblong (Fig. 3 S), narrow obovate, obovate (Fig. 3 F), narrow ovate (Fig. 3 C), ovate (Fig. 3 E, H) to orbiculate (Fig. 3 A, G). The blade is discolorous, chartaceous, seldom coriaceous, with venation frequently hyphodromous (Fig. 3 I, J, K), seldom brochidodromous (Fig. 3 N, R) or eucamptodromous (Fig. 3 D, H, O, S) and the margins are entire, revolute (Fig. 3 B, C, D, E) or flat (Fig. 3 A, G, I, O).

Pad-like leaf sheath

The pad-like sheath was described the first time by Robinson (1983), but at the moment he interpreted the structure as a short petiole with raised pad shaped. This was modified by Semir (1991), who interpreted it as a reduced sheath (several Lychnophorinae display a semi-amplexicaul to amplexicaul leaf sheath). This result was corroborated by Luque & Menezes (2003). The sheath has proved to be a very important taxonomic character at the generic level and even between closely related species within the subtribe (Robinson 1983; Semir 1991; Loeuille *et al.* 2019). In *Piptolepis*, the pad-like leaf sheath varies from ligulate (in almost all species, Fig. 2 E) or semi-conical (*P. elaeoda* and *P. pseudomyrtus*, Fig. 2 F).

The use of leaf scars as a taxonomic feature is uncommon in Vernonieae, being cited in some taxonomic studies of Lychnophorinae (e.g. Semir 1991, Loeuille *et al.* 2012a, Siniscalchi *et al.* 2016, Loeuille *et al.* 2019, Cândido & Loeuille 2021, Gomes & Loeuille 2021). However, Semir (1991) pointed out the importance of these leaf scars in the separation and characterisation of species within *Lychnophora*. The same occurs for *Piptolepis*, since the scars proved to be quite useful in the differentiation among species, as well as in the identification at the specific level. The leaf scars in the genus are: deltate (in most species, Fig. 2 G), flattened deltate (*P. campestris* and *P. monticola*, Fig. 2 H), semicircular (*P. ericoides*, *P. gardneri*, *P. glaziouana* and *P. pilosa*, Fig. 2 I) or rarely winged (only in *P. oleaster*, Fig. 2 F).

Indumentum and trichomes

Leaf, stems and phyllaries indumentum quite varies in *Piptolepis* species. All species have indumentum in at least two of these three structures, since fully glabrescent leaves and stems are not encountered in the genus. The indumentum varies from hoary, hirtellous, lanate, lanulose, manicate, pannose, pilose, puberulent, pubescent, sericeous, setulose, tomentose, tomentulose, velutinous to villous. However, the stems are often becoming partially to completely glabrous with age.

Anatomical study of non-glandular leaf trichome of Lychnophorinae (Wagner *et al.* 2014) included five species of *Piptolepis* (*P. ericoides*, *P. monticola*, *P. oleaster*, *P. riparia* and *P. schultziana*) and found the following types of trichomes in the genus: unbranched, long and thin (*P. riparia*) (Fig. 4 A); unbranched, long, thin with top cell enlarged above stalk—auriculate (*P. monticola* and *P. oleaster*) (Fig. 4 B), branched, 3- to 5-armed (all species) (Fig. 4 C); branched, 3- to 5-armed, bladder-like (*P. monticola*, *P. oleaster* and *P. riparia*) (Fig. 4 D); simple stellate (*P. ericoides* and *P. schultziana*) (Fig. 4 E) or stellate, bladder-like (*P. oleaster*) (Fig. 4 F). Unbranched trichomes are not common in Lychnophorinae, but three of the five species sampled have unbranched type of trichomes (Wagner *et al.* 2014).

Non-glandular trichomes with elongated cells, protects the plant from herbivores, pathogens and water loss. In addition, the indumentum could play an important role in protection against the intense solar radiation, acting in light reflectance, thus, reducing absorption of light excess and of leaf temperature (Lusa *et al.* 2018). Moreover, the bladder-like trichomes may be have an important pathway of facilitation the foliar water uptake in Asteraceae species of the *campos rupestres*, benefiting the water fog uptake in the dry season, increasing the water potential of plant and therefore, minimizing the water stress due to low rainfall during this season (Eller *et al.* 2016; Boanares *et al.* 2019).

Inflorescence and capitula

The inflorescences are terminal at apices of branches, ranging from solitary capitulum, raceme of capitula (Fig. 5 A), pseudoglomerule of capitula (Fig. 5 B), raceme of pseudoglomerule to rarely corymb of capitula (Fig. 5 C). The genus has leaf-like bracts at base of inflorescence or capitula (Fig. 5 D, E). The capitula can be sessile (Fig. 5 D) or pedunculate (Fig. 5 E) with involucre cylindrical (Fig. 5 D) or campanulate (Fig. 5 E). The phyllaries are 5–6-seriate (*P. elaeoda*, *P. campestris*, *P. fulgens*, *P. glaziouana*, *P. leptospermoides*, *P. monticola*, *P. redacta* and *P. riparia*) or 6–7-seriate (*P. corymbosa*, *P. ericoides*, *P. gardneri*, *P. oleaster*, *P. pseudomyrtus*, *P. schultziana*, *P. speciosa*), rarely 4–5 (*P. imbricata*) or 7–8 (*P. pilosa*, *P. procumbens*), they are weakly imbricate and scarious (Fig. 5 F), rarely leaf-like in upper half (*P. fulgens*) (Fig. 5 G). The receptacle surface is flat, frequently areolate (Fig. 6 A) or fimbrillate (Fig. 6 B), rarely scrobiculate (Fig. 6 C) or foveolate (Fig. 6 D). The floret number ranging from 7 to 31, with actinomorphic corolla, deeply 5-lobed, normally glabrous (Fig. 5 I), rarely pubescent at apex of the corolla lobes (*P. fulgens*) (Fig. 5 H); The anthers have acute apices, rarely obtuse (*P. imbricata*) with sagittate base. The style shaft is glabrous throughout except for pubescence beneath style arms, its base is glabrous, lacking a basal node and arm apices acute with short pubescent outside throughout.

Pappus and Cypselae

The cypselae in *Piptolepis* are prismatic (Fig. 7 A) or cylindrical (Fig. 7 B), rarely turbinate (*P. fulgens*) (Fig. 7 C), 10-ribbed, glabrous or rarely pubescent (*P. leptospermoides*) and glandular-punctate. The carpopodium is annular, minute. The pappus is uniseriate or biseriate with subequal, equal (Fig. 7 A, B) or unequal (Fig. 7 C) with outer series shorter (Fig. 7 F) than inner series (Fig. 7 D, E), paleaceous to subpaleaceous, barbellate (Fig. 7 D) or serrulate (Fig. 7 E).
A recent work (Marques *et al.* 2022) focused on the morphology and anatomy of cypselae in *Piptolepis* including 11 species (*P. buxoides*, *P. campestris*, *P. ericoides*, *P. gardneri*, *P. glaziouana*, *P. imbricata*, *P. leptospermoides*, *P. monticola*, *P. oleaster*, *P. riparia* and *P. schultziana*). Their results showed that the insertion pattern of setae and the presence of a vestigial outer series have misled taxonomists when trying to interpret the number of series in the genus. *P. campestris*, *P. gardneri*, *P. monticola*, *P. pseudomyrtus* and *P. oleaster* have a basal overlap of setae from the same series as in a contorted aestivation. When observed with a stereomicroscope, the pappus superficially appears as biseriate with setae of both series having equal size. Therefore, it should be interpreted as a single developed pappus series. However, in *P. ericoides* and *chultziana*, there are no such setae overlap, with the insertion being similar to a valvate aestivation, and the two series show an equal or subequal size.

Moreover, according to Marques *et al.* (2022) a vestigial scale-like series was reported for *Piptolepis buxoides*, *P. campestris*, *P. gardneri*, *P. monticola*, *P. oleaster* and *P. schultziana*. Until now, it remains uncertain whether this vestigial series indicates an increase or decrease in the number of series during the evolution of *Piptolepis*.

Lastly, an outer mesocarp fully lignified was observed in *P. buxoides* and *P. riparia* cypselae and partially lignified / partially collenchymatous in the remaining species. The collenchymatic mesocarp in *Piptolepis* is a unique feature in Vernonieae (Marques *et al.* 2022).

Palynology and Pollination

The pollen of *Piptolepis* has recently been described by Souza-Souza *et al.* (2022) in a study that includes six species⁽¹⁾. The pollen is characterised as "uncommon type A", a type also found in *Eremanthus* (Loeuille *et al.* 2012b), *Lychnophora* (Marques *et al.* 2018) and *Paralychnophora* MacLeish (1984: 106) (Souza-Souza *et al.* 2016). The pollen grains are amb subcircular, tricolporate with a subechinolophate sexine which may be composed of three types of spines: prostrate and disorganised, elongated and narrow or conical. They are isopolar, prolate spheroidal in most of the species, more rarely oblate-spheroidal or spheroidal. Souza-Souza *et al.* (2022) suggest that *Piptolepis* pollen, despite being very similar each other have quantitative and qualitative features useful to distinguish taxa.

The reproductive biology of *Piptolepis* has never been studied. However, hummingbirds were reported as visit of *Piptolepis ericoides* in Serra do Cipó in Espinhaço Range (Rodrigues & Rodrigues 2014) and *Piptolepis leptospermoides*⁽²⁾ in Diamantina (Lopes et al. 2022). Although Asteraceae is rarely used as a food resource for hummingbirds, in *campos rupestres* regions the plant-hummingbird interactions may be overall generalized and endemic hummingbirds use more frequently Asteraceae as a resource source. Ants (Fig. 8 A, B), wasps (Fig. 8 C), bees (Fig. 8 D) and beetles (Fig. 8 E) were observed visiting individuals of *Piptolepis* during field work. However, more studies are necessary to determine if these insects are effective pollinators or occasional visitors.

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(1) There was misidentification of some species in this work: Martinelli, G. 2638 (*P. ericoides*); Mello Barreto 8543 (*P. ericoides*); Anderson 35435 (*P. leptospermoides*); Hatschbach, G. 27399 (*P. leptospermoides*); Romero et al. 8506 (*P. leptospermoides*); Magalhaes, M.G. 1575 (*P. monticola*).

(2) *P. imbricata* occurs between the areas of Capivari and Milho Verde in Serro region, the species in this work is *P. leptospermoides*, since it is the only species of *Piptolepis* occurring in UFVJM *campus.*

Phylogenetics relationships

All phylogenetic studies (Loeuille *et al.* 2015b; Siniscalchi *et al.* 2019; Cândido *et al.* in prep.) indicate *Piptolepis* as one of lineages that later diversified in relation to Lychnophorinae along with *Eremanthus*, *Lychnophora* and *Lychnophorella* Loeuille, Semir & Pirani (2019: 73). However, the relationships between these four genera are not well established and vary between phylogenetic studies. Loeuille *et al.* (2015b) found *Piptolepis* as the sister group of a clade containing *Eremanthus* and *Lychnophora*; in Siniscalchi *et al.* (2019) *Piptolepis* emerged as sister group of *Lychnophora* + *Lychnophorella* + *Eremanthus.* Cândido *et al.* (in prep), with a nearly complete taxonomic sampling of *Piptolepis*, found *Piptolepis* forming a clade with *Lychnophora* and having as sister group the clade *Eremanthus* + *Lychnophorella*. The relationships of *P. pabstii* and *P. rosmarinifolia* are not well established regarding to *Piptolepis* (Cândido *et al.* in prep), and more studies are necessary for a better understanding of their definitive taxonomic position within of Lychnophorinae.

Anatomy

Multivariate analysis for Lychnophorinae based on morphological and anatomical traits (Lusa *et al.* 2014), highlighted different functional types which might be linked to ecological conditions. *Piptolepis monticola*, the only species of the genus included, has leaves without crypts and chloroplasts in leaf epidermis, characteristics that may be related to foggy habitats. The authors explain that the presence of chloroplasts in leaf epidermis is an unusual feature in terrestrial plants, occurring mostly in plants that inhabit shaded and wet places. *P. monticola* occurs in habitats where fogs are frequent especially in cold days during winter and spring. The presence of chloroplasts in epidermis could improve light use for photosynthesis under this climatic condition (Lusa *et al.* 2014).

Lusa *et al.* (2018) studied morphology and anatomy of the leaf and stem of Lychnophorinae in order to provide informative characters for the group's taxonomy. In this study, no putative synapomorphy was found for *Piptolepis*, but the genus was characterised as: shrubs or treelets habit with very conspicuous indumentum on the stem; tall or voluminous epidermic cells (lacking in *P. ericoides*); overlapping leaves at stem apeices; bundle sheath extensions and midrib leaf adaxially round or flat, lightly projected, and abaxially round.

The tall or voluminous epidermal cells are present in *Piptolepis* e *Lychnophorella* that do not have hypodermis suggesting that the presence of this feature might have a function similar to the hypodermis, such as retention of water in plant tissues. In addition, the bundle sheath extensions probably have the same function of retention of water (Lusa *et al.* 2018).

Chemistry

Phytochemistry of *Piptolepis ericoides* and *P. leptospermoides* was explored by Bolhmann *et al.* (1981, 1982) and four new sesquiterpene lactones were isolated, three new germacranolides (zexbrevanolide, piptolepolide and piptospermolide) and one eremanthanolide (15-hydroxyeremantholide C6). However, even if these compounds have not been especifically investigated regarding their biological activities, antimicrobial, anti-inflammatory, toxicity and analgesic activities have been reported for similar germacranolides and eremanthanolides (Keles *et al.* 2010).

Chagas-Paula *et al.* (2015) studying the anti-inflammatory potential of Asteraceae species, found out that *Piptolepis monticola* display dual inhibition of enzymes that catalyze important inflammatory pathways. Therefore, this species would have potential to be a more effective pharmaceutical as anti-inflammatory medicines and with lower side effects than the currently available nonsteroidal anti-inflammatory drugs.

Diversification and dispersion

The processes of diversification and dispersion to *Piptolepis* are still poorly understood. Nonetheless, it has been reported that *Piptolepis* probably originated ~200 ka (confidence interval: 0.125–1.4408 Ma) (Alves & Loeuille in prep.), in the Iron Quadrangle region. From there, the lineage migrated along *campos rupestres* fragments towards the North of Minas Gerais State, to the Espinhaço Meridional and Septentrional, and southwards following the Brasília Arc (or Canastra arc) up to Capitólio region. Similar biogeographic patterns were also found for other genera of Lychnophorinae. Nonetheless, further studies are needed to corroborate these findings and to understand why the actual diversity center is found in the Diamantina Plateau whereas only the widespread *P. ericoides* occurs nowadays in the Iron Quadrangle (Cândido *et al.* in prep.).

Conservation

Among the 19 species of *Piptolepis*, 16 are microendemics known by low population numbers with few individuals and 15 species are restricted to the Diamantina Plateau.

All species are under some level of threats: nine were classified as Critically Endangered, three as Endangered, one as Near Threatened and six as Data Deficient being known only from the type collection (Table 1). Thirteen species have at least one population inside of a protected area (Fig. 9, 10, 11, 12, 13, 14) and seven species have all their known populations outside of protecting areas (Table 1). This information is unknown for *P. buxoides*, because the type material was collected in the beginning of the XIXth century and no other collection has been recorded since then.

A study of *P. ericoides* shows a trend of decrease in the niche area of that species in hotter and more humid climates and this kind of climate could almost lead to extinction of this species in the next 50 years (Candido *et al.* in prep.). If the other *Piptolepis* species display similar trends, then we could be very pessimistic for the genus conservation, since the Cerrado is becoming hotter with the Espinhaço Range region increasing its temperature from 1.5 to 2.5° C since 1990 (Hofmann *et al.*, 2021). In addition, anthropogenic activities, such as intentional fires, mining, and creation of pastures and farmlands are present in *campos rupestres*, leads to loss of natural habitat and difficulties in maintaining the conservation of this vegetation (Fernandes *et al.*, 2018).

Lastly, all these factors could affect mainly species with restricted distribution and small populations, can be easily and stochastically eliminated (Vasconcelos *et al.*, 2020), eventually leading to species extinction (Rapini *et al.*, 2020). Thereby, the *campos rupestres* and all endemic and microendemic species of this vegetation should be considered priority for conservation.

TAXONOMIC TREATMENT

Piptolepis – Schultz-Bipontinus (1863: 380), *nom. cons.*, non *Piptolepis* Bentham (1840: 29) [Oleaceae], *nom. rej*. LECTOTYPE:— *Piptolepis ericoides* Schultz-Bipontinus (designated by Jeffrey & Hind 1994: 95).

Shrubs or treelets; virgate or spreading, straggling or rarely procumbent. **Stems** densely branched, commonly arching, terete or corrugated, rarely furrowed, manicate or puberulent to pilose, seldom tomentose or villous, old stems rugose, glabrescent or puberulent; leaf scars deltate, flattened deltate, semicircular or rarely winged (*P. oleaster*). **Leaves** alternate, simple, spiraled, ascending to patent, rarely descending or imbricate, sessile to subsessile or petiolate, petiole (0–)0.1–4 mm long, with ligulate or semi-conical pad-like leaf sheath; blade discolorous, chartaceous, seldom coriaceous, venation frequently hyphodromous, seldom brochidodromous or eucamptrodomous, margins entire, revolute or flat. **Inflorescence** terminal at apex of branches, in solitary capitulum or pseudoglomerule of capitula, raceme of pseudoglomerule or raceme of capitula, rarely corymb of capitula, with leaf-like bracts at base of inflorescence or capitula. **Capitula** homogamous, discoid, sessile or pedunculate, peduncle (0–)3–18 mm long; involucre cylindrical or campanulate; phyllaries 5–6 or 6–7-seriate (rarely 4–5 or 7–8), weakly imbricate, deciduous or persistent, scarious, rarely leaf-like upper half, lanate or lanulose, rarely pubescent or sericeous, glandular-punctate, margins entire; receptacle flat, areolate or fimbrillate, rarely scrobiculate or foveolate. **Florets** 7–31; bisexual, fertile; corolla actinomorphic, deeply 5-lobed, purple or lilac, tube longer than lobes; corolla glabrous, rarely pubescent, glandular-punctate; anthers calcarate, apex acute, rarely obtuse (*P. imbricata*), base sagittate; style shaft glabrous throughout except for pubescence beneath style arms, style base glabrous, lacking basal node, style arms apex acute, short pubescent outside throughout. **Cypselae** prismatic or cylindrical, rarely turbinate (*P. fulgens*), 10-ribbed, glabrous or rarely pubescent (*P. leptospermoides*), glandular-punctate; carpopodium annular, minute; pappus setae uniseriate or biseriate, subequal, equal or unequal with outer series shorter than inner series, stramineous, rarely reddish at apex, paleaceous to subpaleaceous, serrulate or barbellate, tapering towards the apex, inner series straight or seldom twisted, deciduous rarely persistent.

Etymology:—"*Pipto*-" comes from the greek verb πίπτω which means "to fall, to drop" and "–*lepis*" from the greek substantive λεπίς, ίδος which means "scale (of animals)" The name refers to the deciduous phyllaries, a feature of most species of the genus.

KEY FOR THE GENERA CLOSELY RELATED TO *PIPTOLEPIS*

1. Leaves without leaf sheath 2

–. Leaves with semi-amplexicaul, amplexicaul or pad-like leaf sheath 3

2. Leaf blade not ericoid, margins flat, inflorescence in cyme of glomerules of capitula or cyme of syncephalia (second-order inflorescence) .... *Eremanthus*

–. Leaf blade usually ericoid, margins revolute, inflorescence in solitary syncephalium (second-order inflorescence) or rarely a congested spike of capitula .... *Lychnophora*

3. Stems poorly branched; leaves with semi-amplexicaul or amplexicaul sheath, inflorescence in solitary or group of 2–3 third order syncephalia .... *Lychnocephalus*

–. Stems densely branched; leaves with a pad-like sheath, inflorescence in solitary capitulum, solitary syncephalium (second-order inflorescence), congested dichasium of glomerules, pseudoglomerule of capitula, raceme of pseudoglomerule, raceme of capitula or corymb of capitula 4

4. Inflorescence in solitary syncephalium (second-order) or congested dichasium of glomerules, florets 1–5 and cypselae pubescent .... *Lychnophorella*

–. Inflorescence in solitary capitulum, pseudoglomerule of capitula, raceme of pseudoglomerule, raceme of capitula or corymb of capitula, florets 7–31 and cypselae glabrous .... *Piptolepis*

KEY TO THE SPECIES OF *PIPTOLEPIS*

1. Leaf margins revolute or slightly revolute 2

–. Leaf margins flat or slightly conduplicate 8

2. Inflorescence in terminal corymbs (Fig. 3 C, 15 C–D) .... 3. *P. corymbosa*

–. Inflorescence in racemes or solitary capitula 3

3. Leaves lanceolate or narrow elliptic 4

–. Leaves elliptic, obovate, narrow ovate or ovate 5

4. Leaf scars deltate, blade lanceolate, base rounded, adaxial surface densely sericeous, abaxially golden primrose lanate; capitula pedunculate (4–15 mm long), phyllaries with leaf-like apex; cypselae turbinate (Fig. 3 M, 20 A–L) .... 6. *P. fulgens*

–. Leaf scars semicircular, blade narrow elliptic, base attenuate, adaxial surface villous, abaxially sage-green pilose; capitula sessile, phyllaries with scarious apex; cypselae prismatic (Fig. 2 A, I, 3 K, 25 A–B) .... 13. *P. pilosa*

5. Leaves subsessile to petiolate (0.2–0.6 mm long), pappus series subequal or equal (Fig. 3 E, 28 A–M) .... 19. *P. speciosa*

–. Leaves sessile, outer pappus series shorter than inner series 6

6. Leaves 6–8 × 4 mm, apex subacute, base attenuate, adaxial surface glabrescent, abaxially light green, velutinous, with black glandular dots; inflorescence in sessile solitary capitula; involucre cylindrical and cypselae cylindrical (Fig. 3 F) .... 1. *P. buxoides*

–. Leaves 2.8–6.5 × 1.5–2 mm, apex acute or obtuse, base cuneate or obtuse to rounded, adaxial surface pubescent or tomentulose, abaxially lanate, without black glandular dots; inflorescence in raceme with shortly pedunculate capitula (3–5 mm long); involucre campanulate; cypselae prismatic 7

7. Leaves apex acute with a tuft of trichomes resembling an apiculus, venation eucamptodromous; involucre 4–5-seriate, outer phyllaries lanceolate, florets 9–10, apical anther appendages obtuse (Fig. 3 D, 21 E–F) .... 9. *P. imbricata*

–. Leaves apex obtuse without tuft of trichomes, venation hyphodromous; involucre 5–6-seriate, outer phyllaries triangular, florets 10–14, apical anther appendages acute (Fig. 3 B, 24 A–B) .... 10. *P. leptospermoides*

8. Leaf venation hyphodromous 9

–. Leaf venation brochidodromous or eucamptodromous 13

9. Leaves very narrow elliptic or narrow oblanceolate, adaxial surface tomentulose 10

–. Leaves wide elliptic, elliptic to narrow elliptic, orbiculate, narrow obovate, oblanceolate or ovate; adaxial surface setulose or glabrescent 11

10. Leaf scars semicircular, leaf apex acute, abaxial surface hoary; involucre 6–7-seriate; pappus series subequal or equal (Fig. 3 I, 9 E–F) .... 5. *P. ericoides*

–. Leaf scars deltate, leaf apex subacute to obtuse, abaxial surface lanate; involucre 5–6-seriate; outer pappus series shorter than inner series (Fig. 3 J, 18 C–D) .... 17. *P. riparia*

11. Spreading shrub; leaf scars semicircular, leaf base cuneate, adaxial surface setulose, midrib flat abaxially; cypselae prismatic, outer pappus series shorter than inner series (Fig. 3 A, 21 C–D) .... 8. *P. glaziouana*

–. Shrub or treelet virgate; leaf scars deltate, leaf base attenuate to rounded, adaxial surface glabrescent, midrib slightly prominent abaxially; cypselae cylindrical; pappus series subequal or equal 12

12. Shrub (0.4–1 m tall); leaves 3–10 × 1.5–3.6 mm; involucre campanulate, 5–6-seriate, 9–11 florets per capitulum (Fig. 3 G, 26 A–B, 27 A–M) .... 16. *P. redacta*

–. Treelet (1–1.30 m tall); leaves 5.5–20 × 2.5–9 mm; involucre cylindrical, 6–7-seriate, 20–28 florets per capitulum (Fig. 3 O, 18 E–F) .... 18. *P. schultziana*

13. Leaf scars winged, leaves petiolate (4–20 mm long), adaxial surface velutinous; receptacle scrobiculate (Fig. 2 J, 3 S, 24 E–F) .... 12. *P. oleaster*

–. Leaf scars semicircular, deltate or flattened deltate; leaves sessile or shortly petiolate (0.2–3 mm long), adaxial surface lanate, pannose, puberulent, tomentose, tomentulose or lanulose; receptacle fimbrillate 14

14. Leaf base rounded.. 15

–. Leaf base attenuate 16

15. Treelet (1.20–1.80 m tall), virgate; leaves 8–21 mm long; pappus series subequal to equal (Fig. 3 N, 15 A–B) .... 2. *P. campestris*

–. Shrub (0.5 m tall), procumbent; leaves 3.5–9 mm long; outer pappus series shorter than inner series (Fig. 2 B, 3 H, 25 C–D) .... 14. *P. procumbens*

16. Pad-like leaf sheath semi-conical 17

–. Pad-like leaf sheath ligulate 18

17. Treelet (0.7–1.4 m tall); leaf apex subacute to obtuse, venation eucamptodromous, adaxial surface tomentulose, abaxially velutinous; involucre campanulate, 6–7-seriate, florets 17–31 (Fig. 2 C, F, 3 P, 25 E–F) .... 15. *P. pseudomyrtus*

–. Shrub (0.4–0.6 m tall); leaf apex acute, venation brochidodromous, adaxial surface lanulose, abaxially lanate; involucre cylindrical, florets 11–13 (Fig. 3 L, 17 A–M) .... 4. *P. elaeoda*

18. Leaf apex acute to mucronate, venation eucamptodromous; inflorescence in raceme of 3–9 pseudoglomerules with 3–7 capitula; involucre 6–7-seriate; cypselae prismatic (Fig. 3 Q, 21 A–B) .... 7. *P. gardneri*

–. Leaf apex subacute to obtuse, venation brochidodromous; inflorescence in solitary pseudoglomerules with 3–7 capitula; involucre 5–6-seriate; cypselae cylindrical (Fig. 2 D, 3 R, 24 C–D) .... 11. *P. monticola*

1. *Piptolepis buxoides* (Lessing) Schultz-Bipontinus (1863: 383). *Vernonia buxoides* Lessing (1829: 247). Type:—BRAZIL. 'E. Brasilia tropica misit', *F. Sello(w) s.n.* (holotype: P! [P02511977]) (Fig. 3 F).

Shrub. **Stems** corrugated, tomentose, ochraceous, old stems, terete, rugose, glabrescent, dark brown; leaf scars deltate. **Leaves** ascending, sessile, pad-like leaf sheath ligulate; blade obovate to elliptic, 6–8 × 4 mm, apex subacute, base attenuate, chartaceous, venation hyphodromous, midrib sunken adaxially and prominent abaxially, adaxial surface glabrescent, dark olive green, abaxially light green, velutinous, with black glandular dots, margins slightly revolute. **Inflorescence** in solitary capitulum with leaf-like bract, few, elongate, apex obtuse, base attenuate. **Capitula** sessile; involucre cylindrical, 6 mm tall; outer phyllaries triangular, scarious, apex acute. **Florets** 7–∞, purple. **Cypselae** cylindrical, glabrous, glandular-punctate in furrows, light brown; pappus setae biseriate, unequal, paleaceous, outermost series shorter and wider than innermost series.

Distribution and habitat:—Little is known about its distribution and habitat (the only information source is the Sellow label), but it can be inferred that *P. buxoides* occurs in *campos rupestres* of the Espinhaço Range of Minas Gerais State, since the genus is endemic of this region.

Conservation Status:—This species is known only from the holotype collected in the beginning of the XIXth century, probably in third journey of Sellow, from states of Rio de Janeiro, São Paulo and Minas Gerais (1818-1821). No other collection recorded for it since then. This leads us to consider that the species is possibly extinct, due to the high level of microendemism within the genus, low population numbers and great anthropic activity in the region in the last 200 years. However, more collection efforts are still necessary to establish an accurate conservation status. Therefore, we classify the species as Data Deficient (DD).

Etymology:—This specific epithet refers to the species leaves which are similar to those of *Buxus* Linnaeus (1753: 983) (Buxaceae).

Phenology:—Unknown.

Notes:—This species had its description based only on the protologue and holotype images and due the absence of capitula in the material we could not to describe the reproductive features in more details.

P. buxoides resembles *P. redacta* by its shrubby habit, leaf shape (obovate), similar blade size range (6–8 × 4 mm vs. 3–10 × 1.5–3.6 mm) and cypselae shape (cylindrical). However, they can be set apart by the presence or absence of petiole (sessile vs. subsessile to petiolate, 0.4–

1.3 mm), inflorescence type (solitary capitulum vs. racemes of capitula) and the relative size of pappus series (unequal vs. subequal or equal). [See also *P. pseudomyrtus* notes].

2. ***Piptolepis campestris*** Semir & Loeuille in Loeuille *et al.* (2012: 11). Type:—BRAZIL. Minas Gerais: Diamantina, estrada para Conselheiro Mata, 11 April 1982, *L. Rossi et al. CFCR 3339* (holotype: SPF! [SPF23546]; isotypes: K! [K000374027], UEC! [UEC069471]) (Fig. 3 N, 15 A–B).

Treelet 1.20–1.80 m tall, virgate, branched towards the apex. **Stems** corrugated, manicate, ochraceous, old stems rugose, glabrescent, dark brown; leaf scars deltate to flattened deltate. **Leaves** ascending, petiolate, petiole 1–3 mm long, pad-like leaf sheath ligulate, 1–1.5 mm long; blade elliptic, 8–21 × 4–10 mm, apex acute to obtuse, base rounded, chartaceous, venation brochidodromous, midrib adaxially impressed, abaxially prominent, adaxial surface lanate, dark olive, abaxially tomentose, light-greyish, margins flat, sometimes slightly conduplicate. **Inflorescence** in solitary pseudoglomerules, terminal at apex of branches, with leaf-like bracts, 9.4–12.6 × 3.1–5 mm, apex subacute to obtuse or rounded, base attenuate. **Capitula** 2–6, pedunculate, peduncle 3–6 mm long; involucre cylindrical, 8–11 mm tall × 5.5–10 mm diam., 5–6-seriate; phyllaries deciduous, lanulose, outer phyllaries narrowly triangular to triangular, 1.8–2 × 0.2–0.5 mm, apex acute, light greenish, inner phyllaries oblong to lanceolate, 5–8 × 1.2–1.5 mm, apex cuspidate, light greenish with apex brownish; receptacle fimbrillate. **Florets** 19–21, corolla pale lilac, pubescent, densely glandular-punctate, 7–8 mm long, corolla tube 4.1–5 × 0.5–0.7 mm, corolla lobes 2.8–3.9 × 0.3–0.5 mm, apex acute; anthers apical appendages acute; style shaft 6–7 mm long, glabrous throughout except for pubescent upper 1 mm beneath style-arms, style arms 2 mm long. **Cypselae** prismatic, 2.1–2.9 × 0.8–1.0 mm, glabrous, reddish glandular-punctate in furrows, light ochreous; pappus setae uniseriate, subequal or equal, 4–6 mm long, stramineous, rarely reddish at apex, subpaleaceous, barbellate, tapering towards the apex, deciduous.

Distribution and habitat:—Endemic to the Diamantina Plateau of the Espinhaço Range of mountains in Minas Gerais State. Specifically, among the municipalities of Diamantina, Curvelo and Gouveia (Fig. 16). *P. campestris* occurs, over rock outcrops and on the banks of small streams.

Conservation Status:—This species is considered Critically Endangered (CR) based on criteria B1a, b(iii,iv) (IUCN 2019). It has an extent of occurrence (EOO) of 69,528 km^2 and area of occupancy (AOO) of 28,000 km^2. All known *P. campestris* populations occur in areas outside of Protected Areas and have been affected by human impacts such as roads and deforestation.

Etymology:—This epithet to the species habitat in open formations of *campos rupestres* (Loeuille *et al.* 2012a).

Phenology:—Flowering and fruiting specimens were found from March to December, with flowering peaks occurring from March to May.

Notes:—*P. campestris* is not morphologically similar to any of its putative parental species, however it resembles *P. schultziana* by their treelet habitat, elliptic leaves with similar size range (8–21 × 4–10 mm vs. 5.5–20 × 2.5–9 mm), but *P. campestris* has leaves with brochidodromous venation (vs. hyphodromous), adaxially lanate (vs. glabrescent), abaxially tomentose (vs. velutinous) and capitula organized in pseudoglomerule (vs. raceme). [See also *P. procumbens* notes].

Representative Specimens Examined:—BRAZIL. MINAS GERAIS: Mun. Diamantina, estrada Diamantina-Gouveia, fl., fr., 18 July 1987, *D.C. Zappi et al. 10638* (HUFU, K, SPF); estrada Diamantina-Curvelo, fl., 5 April 1998, *V.C. Souza et al. 20945* (ESA, HUFU); ibid, fl., 30 October 1981, *A.M. Giulietti et al. 2302* (HUFU, UEC, UFP, SPF); estrada Diamantina-Conselheiro da Mata, [-18.307416°, -43.85266°], elev. 1251 m, fl., fr., 26 April 2019, *J.B. Cândido* & *F.N. Costa 298* (UFP);

3. *Piptolepis corymbosa* J.B.Cândido & Loeuille (2021: 496). Type:—BRAZIL. Minas Gerais, Buenópolis, Parque Nacional das Sempre Vivas, área de afloramento rochoso, logo atrás do alojamento, [-17.916472°, -43.784861°], elev. 1,267 m, fl., fr., 10 May 2019, *J.B. Cândido et al. 332* (holotype: UFP! [UFP88706]; isotypes: BHCB!, K!, RB!) (Fig. 3 C, 15 C–D).

Shrubs 0.4–0.7 m tall, densely branched, spreading, straggling, arching branches. **Stems** terete, puberulent to pilose, dark brown, old stems rugose, leaf scars deltate. **Leaves** patent to ascending, sessile to subsessile, petiole (0–) 0.1–0.5 mm, pad-like leaf sheath ligulate, 0.5–1 mm long; blade narrow elliptic to ovate, 2.2–5 × 1.2–1.8 mm, apex subacute, with a tuft of trichomes in the younger leaves, base cuneate to obtuse, coriaceous, venation hyphodromous, midrib adaxially impressed, mostly concealed by indumentum, abaxially prominent, adaxial surface pilose, olive green, abaxially lanate, citrine, margins revolute. **Inflorescence** in terminal corymbs, with leaf-like bracts at base of capitula, 4–6 × 1–1.5 mm, apex obtuse, base attenuate. **Capitula** 4–16, sessile; involucre campanulate, 6–7 mm tall × 6–7 mm diam., 6–7 seriate;

phyllaries persistent, scarious, lanulose, glandular-punctate, light-green, apex vinaceous, outer phyllaries triangular to lanceolate, 1.8–3 × 0.5–1 mm, apex acute, inner phyllaries lanceolate, 5–5.5 × 1–1.2 mm, apex subacute; receptacle fimbrillate. **Florets** 12–17, corolla purple, glabrous, glandular-punctate, 7.5–8 mm long, corolla tube 4–5 × 1–1.8 mm., corolla lobes 3 × 0.7–0.9 mm, apex acute; anthers apical appendages acute; style shaft 8–8.5 mm long, glabrous throughout except for pubescent upper 0.5 mm beneath style arms, style arms 1.6–2 mm long. **Cypselae** prismatic, 1.6–2 × 0.6–1 mm, 10 ribbed, glabrous, glandular-punctate, light brown; pappus setae biseriate subequal or equal, 4–4.5 mm long, stramineous, vinaceous at apex of younger pappus setae, paleaceous, serrulate, deciduous.

Distribution and habitat:—Endemic to the Diamantina Plateau of the Espinhaço Range of mountains in Minas Gerais State, at the Parque Nacional das Sempre Vivas a protected area within the boundaries of the municipalities of Olhos d'Água, Bocaiúva, Buenópolis and Diamantina (Fig. 10, 16). *P. corymbosa* occurs over rock outcrops and on the banks of small streams.

Conservation Status:—According to Cândido & Loeuille (2021), this species is considered Critically Endangered (CR) based on criteria B1a+B2a (IUCN 2019). It has an area of occupancy (AOO) of 8 km^2, and extent of occurrence (EOO) of 0.139 km^2, being known from a single population and four gatherings. Despite occurring in a Protected Area, its area has been affected with human impact such as arson fires during the dry season.

Etymology:—The epithet refers to the capitulescence type (Cândido & Loeuille 2021).

Phenology:—Flowering and fruiting specimens were found in May, September, and November.

Notes:—Samples of this species were misidentified under *P. leptospermoides* in herbaria, a pattern that can be explained as both species shares similar leaf morphology. However, the key character to distinguish this species is the inflorescence type, which is corymbose in *P. corymbosa* and racemose in *P. leptospermoides* and the relative size of pappus series (subequal or equal vs. unequal in *P. leptospermoides*). The leaf size and stems may resemble *P. imbricata* and *P. glaziouana*, however *P. corymbosa* differs from *P. imbricata* by its relative size of pappus series is subequal or equal (vs. unequal), as well as, *P. corymbosa* can ben distinguished of *P. glaziouana* by its leaves with revolute margins (vs. flat.). *P. leptospermoides*, *P. imbricata* and *P. glaziouana* do not occur in sympatry with *P. corymbosa* [see distribution and habitat of these species for more].

Representative Specimens Examined:—BRAZIL. MINAS GERAIS: Mun. Buenópolis, Parque Nacional das Sempre Vivas, área de afloramento rochoso atrás do alojamento dos guarda-parques, as margens de pequeno córrego, [-17.916666°, -43.785°], elev.1277 m, fl., fr., 19 November 2013, *D.A. Chaves 117* (HDJF, UB); ibid, [-17.916666°, -43.785555°], elev. 1280 m, fl., fr., 03 September 2014, *C.M Siniscalchi et al. 549* (DIAM, SPF, UFP); ibid, [-17.917°, -43.785666°], elev. 1267 m, fl., fr., 10 May 2019, *J.B. Cândido et al. 331* (UFP).

4. *Piptolepis elaeoda* J.B.Cândido & Loeuille, ***sp. nov.*** Type:—BRAZIL. Minas Gerais, Buenópolis, Parque Nacional das Sempre Vivas, Módulo RAPELD, próximo à casa da brigada, [-17.918333°, -43.795833°], 1302 m, fl., fr., 29 July 2014, *D.A. Chaves et al. 189* (holotype: HUFU! [HUFU71617], isotypes: HDJF [HDJF5664], HUFU! [HUFU71793], UB! [UB207135]) (Fig. 3 L, 17 A–M).

Specie Piptolepi ericoide simile, sed cicatricibus foliorum deltatis (non semicircularibus),vaginis podiformibus foliorum semiconicis (non ligulatis), foliis venatione brochidodroma (non hyphodroma), supra lanulosis, infra lanatis (non supra tomentulosis, infra incanis) et involucris cylindricis (non campanulatis) differt.

Shrub 0.4–0.6 m tall, densely branched, arching branches. **Stems** terete, puberulent, ochraceous to dark brown, old stems rugose, glabrescent, gray, leaf scars deltate. **Leaves** patent to ascending, subsessile to petiolate 0.3–0.8 mm, pad-like leaf sheath semi-conical, 0.7–1 mm long; blade narrow elliptic, 6–15 × 2–2.8 mm, apex acute, base attenuate, chartaceous, venation brochidodromous, midrib adaxially impressed, slightly concealed by indumentum, abaxially prominent, adaxial surface lanulose, dark olive, abaxially lanate, sage-green, margins flat or lightly conduplicate. **Inflorescence** in racemes, terminal at apex of branches, with leaf-like bracts at base of capitula, 8–9 × 1.8–2.2 mm, apex acute, base attenuate. **Capitula** 3–6, sessile; involucre cylindrical, 7–8 mm tall × 4.8–6 mm diam, 5–6 seriate; phyllaries persistent, scarious, lanulose, glandular-punctate, stramineous with reddish apex, outer phyllaries triangular, 2.3–3 × 1.4–1.2 mm, apex acuminate, inner phyllaries lanceolate, 5–6 × 1.3–1.5 mm, apex acute; receptacle fimbrillate. **Florets** 11–13, corolla purple, glabrous, glandular-punctate, 6–7 mm long, throat 1–2 mm long corolla tube 3.8–4.4 × 1–1.2 mm., corolla lobes 2.2–3 × 0.4–0.5 mm, apex acute; anthers pale lilac, apical appendages acute; style shaft 9–9.5 mm long, purple, glabrous throughout except for pubescent upper 1 mm beneath style arms, style arms 1.8–2 mm long. **Cypselae** prismatic, 1.8–2 × 0.8–1 mm, 10-ribbed, glabrous, yellow glandular-punctate in furrows, ochraceous; pappus setae biseriate subequal or equal, 4–4.5 mm long, stramineous, subpaleaceous, barbellate, deciduous.

Distribution and habitat:—Endemic to the Diamantina Plateau of the Espinhaço Range of mountains in Minas Gerais in the Parque Nacional das Sempre Vivas which covers parts of municipalities of Olhos d'Água, Bocaiúva, Buenópolis and Diamantina (Fig. 10, 18).

Conservation Status:—This species is only known from the type collection. Therefore, the GeoCAT analysis (Bachmann *et al.* 2011) does not provide a confident evaluation of conservation status and the species should be classified as Data Deficient (DD). Despite occurring in a Protected Area, the status of this species is worrying, since arson fires have already been registered in this park during the dry season.

Etymology:—The specific epithet *elaeoda*, comes from the Greek noun ἐλαία (olive tree) and the suffix -odes which indicates a resemblance. It refers to the striking green-olive tint of the foliage of this species.

Phenology:—Flowering and fruiting specimen was found in July.

Notes:—*P. elaeoda* resembles *P. ericoides* by its shrubby habit, very narrow elliptic blade with acute apex, attenuate base, flat margins, prismatic cypselae and subequal or equal size of pappus setae series, but the new species differs by its deltate leaf scars (vs. semicircular), semi-conical pad-like leaf sheath (vs. ligulate), brochidodromous venation (vs. hyphodromous), leaves lanulose adaxially and lanate abaxially (vs. tomentulose adaxially and hoary abaxially) and cylindrical involucre (vs. campanulate).

These species do not occur in sympatry, since there are no known records of *P. ericoides* in Parque Nacional Sempre Vivas.

This species also resembles *P. riparia,* however it has semi-conical pad-like leaf sheath (vs. ligulate), acute apex (vs. subacute to obtuse), brochidodromous venation (vs. hyphodromous), lanulose adaxial surface (vs. tomentulose) and subequal or equal size of pappus setae series (vs. unequal). Another species that resembles *P. elaeoda* is *P. fulgens*, but the former differs by its brochidodromous leaf venation (vs. hyphodromous), leaf adaxially lanulose (vs. densely sericeous), 3–6 sessile capitula per inflorescence (vs. 2–16 pedunculate capitula), prismatic cypselae (vs. turbinate) and subequal or equal size of pappus setae series (vs. unequal). Moreover, the latter two species only occur within the boundaries of São Gonçalo do Rio Preto.

In the Parque Nacional das Sempre Vivas, other four species of *Piptolepis* are found. *P. corymbosa*, *P. pilosa* and *P. speciosa* differ from *P. elaeoda* by their smaller leaves (*P. corymbosa* 2.2–5 × 1.2–1.8 mm, *P. pilosa* 3.2–9 × 0.8–1.6 mm, *P. speciosa* 2–7 × 1.5–3 mm vs. 6–15 × 2–2.8 mm) and revolute margins (vs. flat or slightly conduplicate). Lastly, *P.*

gardneri differs by its treelet habit (vs. shrubby) and larger leaves (8–68 × 3–9 mm, vs. 6–15 × 2–2.8 mm).

5. *Piptolepis ericoides* Schultz-Bipontinus (1863: 383). Type:—BRAZIL. Minas Gerais: near Itambé, August 1840, *G. Gardner 4750* (lectotype: K! [K000873815], designated by Jeffrey & Hind (1994: 95); isolectotypes: E*e*! [E00417135], GH! [GH00011275], K! [K000873813], BM [not seen], P! [P00683107, P00683108 (fragment)], US! [US01106273], NY! [NY01843332, NY01843416], R! [R000151306]. (Fig. 3 I, 15 E–F)

Vernonia ericoides Lessing (1831: 629), non *V. ericoides* (Lamarck 1786: 92) Lessing (1829: 247). Type:—BRAZIL. No other data, *F. Sello(w) s.n.* (lectotype: P [P02511962], designated by Loeuille *et al.* (2019: 90); isolectotype: F*e!* [F0051818F (fragment)]).

Lychnophora diosmaefolia Pohl ex Baker (1873: 143), *nom. nud. pro syn.*

Shrub 0.40–1 m tall, virgate, densely branched. **Stems** corrugated, tomentose, ochreous, old stems terete, puberulent, brown, leaf scars semicircular. **Leaves** ericoid, ascending, sessile, subsessile to petiolate (0–)0.5–2 mm, pad-like leaf sheath ligulate, 0.5–1.5 mm long; blade very narrow elliptic, 4–41 × 0.8–3.5 mm, apex acute, base attenuate, chartaceous, venation hyphodromous, midrib adaxially impressed, abaxially prominent, adaxial surface tomentulose, dark green, abaxially hoary, light green, margins flat. **Inflorescence** in raceme at apex of branches, with leaf-like bracts at base of capitula, 7–12 × 1–2 mm, apex subacute, base attenuate. **Capitula** 2–6, sessile; involucre campanulate, 6–10 mm tall × 7–12 mm diam., 6–7 seriate; phyllaries scarious, lanate, glandular-punctate, light green reddish at apex, outer phyllaries lanceolate to triangular, 2–4 × 0.5–1.8 mm, apex acute, persistent, inner phyllaries lanceolate, 5–8 × 1.8 mm, apex aristulate, deciduous; receptacle areolate. **Florets** 10–16; corolla lilac, glabrous, glandular-punctate, 6.1–9 mm long, corolla tube 3–6 × 1–1.8 mm, corolla lobes 2.1–3.5 × 0.5–0.8 mm, apex acute; anthers apical appendages acute; style shaft 8–10 mm long, glabrous throughout except for pubescent upper 0.5–1.5 mm beneath style-arms, style arms 1–2 mm long. **Cypselae** prismatic, 1.5–2.1 ×0.6–1 mm, 10-ribbed, glabrous, glandular-punctate in furrows, ochreous; pappus setae biseriate subequal or equal, 4–7 mm long, stramineous, paleaceous, serrulate, deciduous.

Distribution and habitat:—*Piptolepis ericoides* is the most widespread species of the genus with a continuous distribution along the North-South cline of Espinhaço Range (Fig. 19). The species occupy mosaic of *campos rupestres* areas under the influence of others vegetations, such as cerrado, caatinga and tropical rain forest. It occurs in drier and hotter areas, as well as in colder and wetter ones.

Conservation Status:—This species is considered Near Threatened (NT) based on its extent of occurrence (EOO) > 20,000 km^2. The area of occupancy (AOO) < 500 km^2 (CNCFlora 2022) It is known by ca. 110 gatherings. Five populations occur inside protected areas: Parque Estadual da Serra do Cabral (Fig. 10), Parque Estadual de Grão Mogol (Fig. 11), Parque Nacional da Serra do Cipó (Fig. 12), Parque Estadual do Itacolomi (Fig. 13) and Parque Nacional da Serra da Canastra (Fig. 14), the other populations are located outside of Protected Areas.

Etymology:—The specific epithet refers to the leaves, small, with short internodes and coriaceous, similar to the leaves of *Erica* Linnaeus (352: 1753).

Phenology:—Flowering and fruiting specimens were found in all months, with the exception of September and October, when only flowering specimens were found.

Notes:—*P. ericoides* presents different morphotypes along its distribution, with the main differences within the vegetative part. This variation is probably influenced by environmental changes according to the locality of each population. Populations occurring in *campos rupestres* of the north, center-west and south-west of the Minas Gerais Espinhaço Range (Grão-Mogol, Capitólio, Cristália, Santana de Pirapama and Gouveia municipalities) have larger leaves and habit, while the east and south populations (Ouro Preto, Itambé do Mata Dentro, Santa Bárbara, Conceição do Mato Dentro and Catas Altas municipalities) display a smaller leaves and habit. The Serra do Cipó population, exhibit a morphological intermediary, this can be linked to this area of ecologic tension with intermediate vegetational, physical and chemical characteristics, combined with its location between the two population groups (Cândido *et al.* in prep.).

P. ericoides resembles *P. riparia* by its leaf shape, hyphodromous venation, tomentulose adaxial surface, capitula organised in raceme and prismatic cypselae, however *P. ericoides* differs by its leaf scars semicircular (vs. deltate), leaves with hoary abaxial surface (vs. lanate) and pappus series of subequal or equal relative size (vs. unequal). These species do not occur in sympatry, since no known collection records for *P. ericoides* in Parque Estadual do Rio Preto (Fig. 9).

Also similar to *P. elaeoda* by its leaf shape (very narrow elliptic with acute apex and attenuate base), capitula in raceme and relative size of pappus series (subequal or equal). Both species can be distinguished by their leaf scars (semicircular vs. deltate), leaf indumentum (adaxially tomentulose, abaxially hoary vs. adaxially lanulose, abaxially lanate), venation (hyphodromous vs. brochidodromous) and involucre shape (campanulate vs. cylindrical). These species do not occur in sympatry, since *P. elaeoda* is endemic to the Parque Nacional das Sempre Vivas [See also *P. pilosa* notes].

Representative Specimens Examined:—BRAZIL. MINAS GERAIS: Mun. Santa Barbara, Serra Brucutu- Cocais, fl., fr., 6 February 1943, *M.G. Magalhães 2738* (HUFU, IAN, ICN); Mun. Itambé do Mato Dentro, Serra da Cabeça do Boi, [-19.414400° -43.321098°], fl., fr., 13 January 1982, *N. Hensold et al. CFCR2845* (SPF, UEC, UFP); Mun. Gouveia, Escarpas rochosas no vale do Ribeirão da Contagem (Rod. Gouveia - Curvelo), [-18.614167, -43.885278°], fl., 22 January 2004, *J.R. Pirani et al. 5238* (HUEFS, K, SPF); Mun. Mariana, Parque Estadual do Itacolomi, Trilha do sertão, [-20.377799°, -43.4160995°], fl., fr., 30 May 2006, *G.S.S. Almeida et al. 413* (HUFU, HUNEB, VIC); Mun. Catas Altas, Serra do Caraça, Pico do Inficionado, [-20.07469°, -43.407501°], fr., 5 April 2007, *Teles et al. 387* (BHCB, S); Mun. Capitólio, Estrada para as pedreiras, [-20.603611°, -46.293333°], fl., 5 November 2008, *L.S. Kinoshita 08/438* (HUFU, UEC); ibid, s/c, fl., 8 November 2007, *R. Romero et al. 8030* (HUFU); Mun. Santana do Riacho, Serra do Cipó, Rodovia MG-010, km 129, [-19.234167°, -43.509722°], fl., fr., 14 June 2010, *G. Heiden et al. 1366* (BHCB, RB, SPF, US); Mun. Cristália, Margem do rio Itacambiraçu, [-16.613°, -42.928083], fl., fr., 12 August 2010, *B. Loeuille 534* (SPF, UFP); Mun. Santana do Riacho, Serra do Cipó, Rodovia MG-010, próximo a estátua do Juquinha, [-19.260833°, -43.551833°], fl., fr., 16 May 2019, *J.B. Cândido 360* (UFP); Mun. Conceição do Mato Dentro, Estrada Conceição do Mato Dentro- Itambé do Mato Dentro, [-19.36575°, -43.332°], fl., fr., 21 May 2019, *J.B. Cândido 369* (UFP); Mun. Santana de Pirapama, PCH Quartel II., Trecho de vazão reduzida, [-18.638333°, -43.914444°], fl., fr., 28 May 2019, *D.T. Souza 237* (BHCB); Mun. Grão Mogol, Parque Estadual de Grão Mogol, cachoeira Véu de Noiva, [-16.6005277°, -42.955166°], fl., fr., 28 May 2019, *J.B.Cândido 390* (UFP); ibid, fl., fr., 24 March 1980, *G. Hatschbach 42925* (INPA, MBM, SPF, UFP, US); Mun. Ouro Preto, Parque Estadual do Itacolomi, trilha para o mirante, [-20.429027°, -43.474638°], fl., fr., 4 June 2019, *J.B. Cândido & L. Pedrosa 407* (UFP).

6. *Piptolepis fulgens* J.B.Cândido & Loeuille, ***sp. nov.*** Type:—BRAZIL. Minas Gerais, Diamantina, Parque Estadual do Rio Preto, [-18.228333°, -43.342222°], 1580 m, fl., fr., 19 March 2016, *G. Martinelli et al. 19097* (holotype: ALCB! [ALCB131389]; isotypes: DIAM! [DIAM7672], RB! [RB735301], SPF! [SPF239984], US *e!* [US3724912]). (Fig. 3 M, 20 A–L).

Specie Piptolepi riparia simile, sed foliis lanceolatis (non peranguste ellipticis ad anguste oblanceolata), basi rotundata (non attenuata), supra dense sericeis (non tomentulosis), infra aureis primulinis (non salviiviridibus), capitulis pedunculatis (non sessilibus), bracteis involucralibus aureis primulinis et foliiformibus dimidium superius versus (non stramineis et scariosis apicem versus) et cypselis turbinatis (non prismaticis) differt.

Shrub 0.4 m tall, densely branched, arching branches. **Stems** terete, ochreous pilose, old stems rugose, becoming glabrescent, dark brown, black glandular dotted, leaf scars deltate. **Leaves** patent to ascending, sessile, pad-like leaf sheath ligulate, 0.4–1.1 mm long, translucid glandular dotted; blade lanceolate, 4.6–8.5 × 1.7–1.9 mm, apex subacute to acute, base rounded, slightly chartaceous, venation hyphodromous, midrib adaxially impressed, abaxially prominent, both concealed by indumentum, adaxial surface densely sericeous, sage, in old leaf dark olive, light-yellow glandular dotted, abaxially lanate, golden primrose, margins revolute. **Inflorescence** in raceme terminal at apex of branches, with leaf-like bracts at base of capitula, 7–8 × 1.3–1.8 mm, apex subacute, with a tuft of trichomes resembling an apiculus, base truncate. **Capitula** 2–16, pedunculate, peduncle 4–15 mm long; involucre campanulate, 7–9 mm tall × 7–12 mm diam., 5–6 seriate; phyllaries persistent, scarious at base, leaf like at apex, sericeous, glandular-punctate, golden primrose, lanceolate, equal a subequal, 6.5–8 × 1–1.3 mm, apex acute; receptacle fimbrillate. **Florets** ca. 11, corolla lilac, glabrous throughout except for pubescent at apex of the corolla lobes, glandular-punctate, 6.5–8 mm long, throat ca. 1 mm long, corolla tube 4–5.4 × 0.4–0.6 mm., corolla lobes 2.8–3 × 0.5–0.6 mm, apex acute; anthers lilac, apical appendages acute; style shaft 6–7.5 mm long, pale lilac, glabrous throughout except for pubescent upper 0.5–1 mm beneath style arms, style arms 1.8–2 mm long. **Cypselae** turbinate, 1–1.5 × 0.6–0.8 mm, 10-ribbed with defined furrows, glabrous, glandular-punctate in the furrows, light brown; pappus setae biseriate unequal, outer series 0.5–1.4 mm long, serrulate, inner series 3–3.7 mm long, golden stramineous, paleaceous, serrulate, tapering towards the apex, persistent.

Distribution and habitat:—Endemic to the Diamantina Plateau of the Espinhaço Range of mountains in Minas Gerais State, the new species occurs in São Gonçalo do Rio Preto district, specifically at Parque Estadual do Rio Preto, a Protected Area (Fig. 9, 18). It grows on rock outcrops.

Conservation Status:—The species is known from two gatherings from the same locality and possibly from the same population. Therefore, the GeoCAT analysis (Bachmann *et al.* 2011) does not provide a confident evaluation of conservation status and the species should be classified as Data Deficient (DD).

Etymology:—The specific epithet *fulgens* means ‘shining’ or ‘bright-coloured’, and refers to the golden primrose yellow of the leaves abaxially, phyllaries and pappus.

Phenology:—Flowering and fruiting specimens were found in March and April.

Notes:—The new species occurs in the same locality of *P. riparia* and both are similar due to their deltate leaf scars, hyphodromous venation, midrib abaxially prominent, campanulate involucre and unequal relative size of pappus series. However, *P. fulgens* differs by its lanceolate blade (vs. very narrow elliptic to narrow oblanceolate), rounded leaf base (vs. attenuate), densely sericeous adaxial leaf surface (vs. tomentulose), leaves abaxially golden primrose yellow (vs. sage green), pedunculate capitula (4–15 mm long vs. sessile), golden primrose yellow phyllaries with leaf-like upper half (vs. stramineous completely scarious) and turbinate cypselae (vs. prismatic).

It also resembles *P. pilosa* by its shrubby habit, hyphodromous leaves venation, inflorescence racemose with 1–16 capitula, campanulate involucre and fimbrillate receptacle, but the new species differs by its deltate leaf scars (vs. semicircular), lanceolate blade (vs. narrow elliptic), rounded leaf base (vs. attenuate), densely sericeous adaxial leaf surface (vs. tomentulose), golden primrose yellow lanate abaxially (vs. sage-green pilose), pedunculate capitula (4–15 mm long vs. sessile), golden primrose yellow phyllaries with leaf-like upper half (vs. stramineous with brownish apex and completely scarious) and turbinate cypselae (vs. prismatic). These species do not occur in sympatry, since *P. pilosa* is endemic to the Parque Nacional das Sempre Vivas. [For more differences, see also *P. elaeoda*]

Representative Specimens Examined:—BRAZIL. Minas Gerais: Mun. São Gonçalo do Rio Preto, Parque Estadual do Rio Preto, subida para o Pico Dois Irmãos, elev. 1550 m, fl., fr., 10 April 2005, *P.L. Viana 2798* (BHCB, UFG).

7. *Piptolepis gardneri* Baker (1873: 144). Type:—BRAZIL. Minas Gerais: in Serra do Itambé, August 1840, *G. Gardner 4753* (lectotype: BM*e*! [BM000939725], designated by Loeuille *et al.* (2019: 93); isolectotypes: K! [K000484688, K000484689]) (Fig. 3 Q, 21 A–B).

Treelet 1–2.4 m tall, virgate, densely branched. **Stems** corrugated towards the apex, short manicate, ochreous, old stems terete, glabrescent, dark brown, leaf scars semicircular to deltate. **Leaves** patent to ascending, sessile, subsessile or petiolate (0–)1–3 mm long, pad-like leaf sheath ligulate, 1–2.5 mm long; blade oblanceolate to narrow oblanceolate, 8–68 × 3–9 mm, apex acute to mucronate, base attenuate, discolorous, chartaceous, venation eucamptodromous, midrib adaxially impressed, abaxially prominent, adaxial surface pannose, dark olive green, abaxially hirtellous, light-greyish, margins flat. **Inflorescence** in raceme of 3–9 pseudoglomerules, terminal at apex of branches, with leaf-like bracts at base of psudoglomerule, 6–10 × 2–3 mm, apex obtuse, base attenuate. **Capitula** 3–7, pedunculate, peduncle 3–18 mm long; involucre campanulate, 8–9 mm tall × 6–13 mm diam., 6–7 seriate; phyllaries deciduous, scarious, lanate, glandular-punctate, outer phyllaries triangular, 2.1–3 × 0.8–1 mm, apex acute, light greenish; inner phyllaries lanceolate, 6–8 × 1–1.2 mm, apex caudate, stramineous with apex brownish; receptacle fimbrillate. **Florets** 22–23, corolla lilac, glabrous, glandular-punctate, 8–11 mm long, corolla tube 5–7 × 0.6–2 mm, corolla lobes 3.4–4 × 0.4–0.6 mm, apex acute; anthers purple, apical appendages acute; style shaft 9–11 mm long, pale lilac, glabrous throughout except for pubescent upper 1.5–2 mm beneath style-arms, style arms 2 mm long. **Cypselae** prismatic, 1.2–2 ×0.8–0.9 mm, 10-ribbed, glabrous, densely glandular-punctate in furrows; dark brown; pappus setae uniseriate, subequal or equal, 6–7 mm long, light stramineous, subpaleaceous, serrulate, deciduous.

Distribution and habitat:—*P. gardneri* is known by few records. Endemic to the Diamantina Plateau of the Espinhaço Range of mountains in Minas Gerais State, it is distributed in two municipalities, Serro and Diamantina, specifically on the road from to Milho Verde and at the protected area Parque Nacional das Sempre Vivas (Fig. 10, 22). It occurs over rock outcrops.

Conservation Status:—The CNCFlora (2022) classified this species as Data Deficient (DD), since it was known only by the type material. As we have discovered new populations, we provide an update conservations status.

This species is considered Critically Endangered (CR) based on criteria B1a, b(iv) (IUCN 2019). It has an extent of occurrence (EOO) of 27,594 km^2 and area of occupancy (AOO) of 12,000 km^2. It is known by approximately eight gatherings, with one population occurring inside of protected area (Parque Nacional das Sempre Vivas), another known population is located outside the Protected Areas, close to a road and anthropized areas.

Etymology:— The species epithet refers to the Scottish botanist George Gardner (1810-1849) who gathered the type material (*Gardner 4753*).

Phenology:—Flowering and fruiting specimens were found in April and May.

Notes:—Similar to *P. oleaster* by its treelet and virgate habit, corrugated stems, attenuate base of the leaf with eucamptodromous venation and flat margins; inflorescence in raceme of pseudoglomerules and uniseriate pappus setae, but *P. gardneri* differs by its leaf scars semicircular to deltate (vs. winged), smaller leaves (8–68 × 3–9 mm vs. 19–125 × 6–30 mm), with oblanceolate to narrow oblanceolate blade (vs. narrow oblong or narrow elliptic), pannose adaxial surface (vs. velutinous) and hirtellous abaxially (vs. lanate); inflorescence in pseudoglomerules, seldom solitary capitulum (raceme of pseudoglomerules) and prismatic cypselae (vs. cylindrical). Both species have populations occurring in Serro [For more see distribution of these species]. [See also *P. monticola* notes]

Representative Specimens Examined:—BRAZIL. Minas Gerais: Mun. Serro, estrada Milho Verde, [-18.24939918°, -43.6002998352°], fl., 19 May 2008, *J.N. Nakajima et al. 4833* (HUFU); ibid, [-18.2917222°, -43.00719444°], elev. 972 m, fl., fr., 8 April 2009, *I.M. Franco et al. 877* (DIAM); ibid, [-18.53194444°, -43.4463888°], elev. 982 m, fl., fr., 25 May 2009, *M.M. Saavedra et al. 877* (HUFU, RB, SPF); ibid, [-18.53180555°, -43.442666°], elev. 1062 m, fl., fr., 14 May 2019, *J.B. Cândido 348* (UFP); ibid, [-18.52502777°, -43.44813888°], elev. 1011 m, fl., fr., 14 May 2019, *J.B. Cândido 349* (UFP); Mun. Buenópolis, Parque Nacional das Sempre Vivas, Serra do landim, [-17.8952777°, -43.76763888°], elev. 1415 m, fl., fr., 19 May 2017, *K.H. Silva & F.N. Costa 176* (DIAM); ibid, [-17.89497222°, -43.7642222°], elev. 1302 m, fl., fr., 10 May 2019, *J.B. Cândido 336* (UFP).

8. *Piptolepis glaziouana* Beauverd (1913: 239). Type:—BRAZIL. Minas Gerais: entre Sopa et Diamantina, *A.F.M. Glaziou 19550* (holotype: G-BOIS; isotypes: B†, K *e!* [K000497135], P *e!* [P00683109, P00683110, P00683111]), R! [R000015290]) (Fig. 3 A, 21 C–D).

Shrub 0.2–0.6 m tall, densely branched, spreading, arching branches. **Stems** terete, short manicate, dark brown, old stems rugose, leaf scars semicircular. **Leaves** patent, sessile, pad-like leaf sheath ligulate, 0.3–0.5 mm long.; blade elliptic to narrow elliptic, 2–5 × 1–1.6 mm, apex subacute to obtuse, base cuneate, chartaceous, venation hyphodromous, midrib slightly prominent adaxially and flat abaxially, adaxial surface setulose, dark green, abaxially lanulose, light-green, margins marginate, flat. **Inflorescence** in raceme or solitary capitulum, terminal at apex of branches, with leaf-like bracts at base of capitula, 3–4 × 0.7–1.3 mm, apex rounded, base attenuate. **Capitula** 2–9, peduncle 3–8 mm long; involucre campanulate, 6–7 mm tall × 8–12 mm diam., 5–6 seriate; phyllaries scarious, lanate, glandular-punctate, stramineous, outer phyllaries lanceolate to triangular, 1.5–2 × 0.2–0.5 mm, apex acute to attenuate, persistent, inner phyllaries lanceolate, 4–6 × 1–1.2 mm, apex acute, brownish, deciduous; receptacle scrobiculate. **Florets** 15–20, corolla lilac, glabrous, glandular-punctate, 7.5–8.5 mm long, corolla tube 4–5 × 1–1.3 mm, corolla lobes 3–4 × 0.4–0.8 mm, apex acute; anthers purple, apical appendages acute, style shaft 6–7 mm long, pale lilac, glabrous throughout except for pubescent upper 0.5 mm beneath style arms, style arms 2.5 mm long, apex acute, short pubescent outside throughout. **Cypselae** prismatic, 1.8–2 ×0.8–1 mm, 10-ribbed, glabrous, densely glandular-punctate in furrows and at all base, ochreous; pappus setae biseriate unequal, stramineous, barbellate, outermost series 0.3–1 mm long, paleaceous, persistent, innermost series 10–12 mm long, subpaleaceous, deciduous.

Distribution and habitat:—Endemic to the Diamantina Plateau of the Espinhaço Range of mountains in Minas Gerais State, among the boundaries of Diamantina, Conselheiro da Mata and Gouveia municipalities (Fig. 9, 23). *P. glaziouana* occurs in sandy soils with sandstone boulders, close to streams and rocks.

Conservation Status:—This species is considered Critically Endangered (CR) based on criteria B1a, b(iii,iv) (IUCN 2019). It has an extent of occurrence (EOO) of 19,852 km^2 and area of occupancy (AOO) of 16,000 km^2, a single population occurs inside of a protected area at Área de Proteção Especial (APE) Manancial Pau de Fruta (Fig. 9), all other populations are located outside Protected Areas and are close to roads and anthropized areas.

Etymology:—The species epithet refers to Auguste François Marie Glaziou, a renowned French landscape designer and botanist, who gathered the type material (*Glaziou 19550*).

Phenology:—Flowering and fruiting specimens were found in February, April, May, June, August, October and November.

Notes:—This is a striking bonsai-like species which loses most of its leaves during the dry season. *P. glaziouana* is similar to *P. imbricata* and *P. leptospermoides* by its shrubby habit, leaf shape and size, raceme inflorescence, prismatic cypselae and unequal relative size of pappus series. However, *P. glaziouana* differs from *P. imbricata* by its leaf scars semicircular (vs. deltate), shorter pad-like leaf sheath (0.3–0.5 mm vs. 0.6–1.3 mm long), subacute to obtuse leaf apex, without a tuft of trichomes (vs. acute with a tuft of trichomes resembling an apiculus), hyphodromous venation (vs. eucamptodromous), flat margins (vs. revolute) and a greater number of florets per capitulum (15–20 vs. 9–10). Moreover, *P. imbricata* only occurs in Capivari/ Milho Verde area within the region of Serro. *P. glaziouana* and *P. leptospermoides* occur in Diamantina, but the first species differs by its leaf scars semicircular (vs. deltate), shorter pad-like leaf sheath (0.3–0.5 mm vs. 0.5–1.5 mm long), flat margins (vs. revolute) and a greater number of florets per capitulum (15–20 vs. 10–14).

It also resembles *P. corymbosa* by its shrubby and spreading habit, corrugated stems, leaves with hyphodromous venation, revolute margins; fimbrillate receptacle and prismatic cypselae, but the latter species has leaf with scars deltate (vs. semicircular), revolute margins (vs. flat), pilose adaxial surface (vs. setulose), midrib abaxially prominent (vs. flat), inflorescence in corymbs (vs. racemes) and subequal or equal relative size of pappus series (unequal). Moreover, these species are not sympatric, *P. corymbosa* occurs only in Parque Nacional das Sempre Viva in Buenópolis (Fig. 10) and *P. glaziouana* in Diamantina. [See also *P. speciosa* notes].

Representative Specimens Examined:—BRAZIL. Minas Gerais: Mun. Diamantina, Guinda, [-18.249399°, -43.60029983°], fl., fr., 5 November 1937, *H.L.M. Barreto 9516* (BHCB); estrada Diamantina-Curvelo, fl., fr. 4 August 1990, *C.M Sakuragui & V.C. Souza 144* (ESA, HUFU, HUSC); estrada Diamantina-Gouveia, fl., fr., 16 February 1991, *M.M. Arbo et al. 5224* (SPF, UFP); Área da Copasa, Reserva Manancial Pau de Fruta, [-18.258333°, -43.673889°], elev. 1336m, fl., fr., 14 February 2007, *A.K.A. Santos 1070* (HUEFS); ibid, [-18.274°, -43.6674722°] elev. 1392 m, fl., fr., 7 May 2019, *J.B. Cândido 323* (UFP); estrada Dimantina-Conselheiro da Mata, [-18.274444°, -43.684444°], elev. 1409 m, fl., 7 October 2015, *R. Romero et al. 8813* (HUFU).

9. *Piptolepis imbricata* (Gardner) Schultz-Bipontinus (1863: 383). *Vernonia imbricata* Gardner (1846: 209). Type:—BRAZIL. Minas Gerais: bushy places on the Serro do Frio, near Milho Verde, August 1840, *G. Gardner 4751* (lectotype: BM *e!* [BM000939726] designated by Loeuille *et al.* (2019: 93); isolectotypes: B†, K! [K000484686, K000484687], NY! [NY00274851]) (Fig. 3 D, 21 E–F).

Shrub 0.3–0.4 m tall, densely branched, straggling, arching branches. **Stems** terete, puberulent to pilose, ochraceous, old stems rugose, glabrescent, dark brown, leaf scars deltate. **Leaves** ascending, densely imbricate, sessile, pad-like leaf sheath ligulate, 0.6–1.3 mm long; blade narrow ovate or elliptic, 3.5–6.5 × 1.5–2 mm, apex acute, with a tuft of trichomes resembling an apiculus, base obtuse to rounded, coriaceous, venation eucamptodromous, midrib adaxially impressed, concealed by indumentum, abaxially not prominent, adaxial surface tomentulose, olive green, abaxially lanate, light green, margins revolute. **Inflorescence** in short spike-like racemes terminal at apex of branches, with leaf-like bracts at base of capitula, 5–6 × 0.5–1.5 mm, apex subacute, base attenuate. **Capitula** 1–10, shortly pedunculate, peduncle 3–5 mm long; involucre campanulate, 5–6 mm tall × 7–8 mm diam, 4–5 seriate; phyllaries persistent, scarious, lanulose, glandular-punctate, stramineous with brownish apex, apex caudate, outer phyllaries lanceolate 3.1–3.8 × 0.6–0.9 mm, inner phyllaries narrowly oblong, 4.5–5 × 0.5–1 mm; receptacle fimbrillate. **Florets** 9–10, corolla lilac, glabrous, glandular-punctate, 6.5–8 mm long, throat ca. 1 mm long, corolla tube 3.2–4.1 × 0.5–1.4 mm., corolla lobes 3–3.5 × 0.6–0.8

mm, apex acute; anthers purple, apical appendages obtuse; style shaft 7–8 mm long, purple, glabrous throughout except for pubescent upper 0.5–0.8 mm beneath style arms, style arms 1.8–2 mm long. **Cypselae** prismatic, 1.2–1.8 × 0.8–1 mm, 10-ribbed, glabrous, glandular-punctate, dark brown; pappus setae biseriate unequal, outer series 0.5–1.8 mm long, inner series 2.5–4.5 mm long, stramineous, sub paleaceous, serrulate, tapering towards the apex, persistent.

Distribution and habitat:—Endemic to the Diamantina Plateau of the Espinhaço Range of Minas Gerais State. Specifically, between the areas of Capivari and Milho Verde in Serro region (Fig. 16). *P. imbricata* occurs over rock outcrops and next of small streams.

Conservation Status:—This species is considered Critically Endangered (CR) based on criteria B1a, b(iii,iv) (IUCN 2019). It has an extent of occurrence (EOO) of 44,989 km^2 and area of occupancy (AOO) of 24,000 km^2. All populations are located outside Protected Areas, in area where occur mining and tourism (CNCFlora 2022).

Etymology:—The epithet refers to the overlapping leaves of this species.

Phenology:—Flowering and fruiting specimens were found in April, May, June, September, and November.

Notes:—*P. imbricata* and *P. leptospermoides* are very similar and frequently confused. They share a shrubby habit, densely branched and arched, leaf scars deltate, leaves sessile with base obtuse, abaxially lanate, revolute margins, racemose inflorescence, prismatic cypselae and unequal relative size of pappus series. However, *P. imbricata* differs by its leaves with acute apex holding a tuft of trichomes resembling an apiculus (obtuse apex, without trichomes tuft), eucamptodromous venation (vs. hyphodromous), involucre 4–5-seriate (5–6-seriate), outer phyllaries lanceolate (vs. triangular), number of florets per capitulum 9–10 (vs. 10–14) and anthers apical appendages obtuse (vs. acute). Moreover, *P. leptospermoides* only occurs within the boundaries of Diamantina locality, whereas *P. imbricata* is restricted to Serro region.

It may also resemble *P. corymbosa* by its shrubby and straggling habit, terete, puberulent to pilose stems, deltate leaf scars, revolute margins, campanulate involucre and prismatic cypselae, but *P. imbricata* differs from the latter by its leaves with eucamptodromous venation (vs. hyphodromous), raceme inflorescence (corymbs), lower number of florets per capitulum (9–10 vs. 12–17), anthers apical appendages obtuse (vs. acute) and relative size of pappus series (unequal vs. subequal or equal). These species do not occur in sympatry, since *P. corymbosa* is endemic to the Parque Nacional das Sempre Vivas. [See also *P. glaziouana* and *P. speciosa* notes]

Representative Specimens Examined:—BRAZIL. Minas Gerais: Mun. Serro, Distrito de São Gonçalo do Rio das Pedras, [-18.431944°, -43.476389°], elev. 1174 m, fl., fr., 20 June 2008, *T.E. Almeida et al. 1394* (BHCB); Monumento Natural Estadual Várzea do Lajeado, Lajeado de Milho Verde, [-18.469842°, -43.4899°], elev. 1078m. fl., fr., 3 April 2010, *M. Augsten & P.B. Meyer 390* (BHCB); Capivari, entorno do Parque Estadual do Pico do Itambé, [-18.39541666°, -43.3860555°], elev. 1220, fl., fr., 23 April 2010, *I.M. Franco et al. 355* (DIAM, SPF, UEC); ibid, [-18.397667°, -43.389083°], elev. 1212 m, fl., fr., 17 November 2011, *B. Loeuille et al. 581* (SPF, UFP); estrada Milho Verde para Capivari. APA Águas Vertentes, [-18.449444°, -43.446667°], elev. 1249 m, fl., fr., 25 September 2012, *N. Roque & A.S. Quaresma 3739* (ALCB, US); estrada Serro-Capivari, a 6km de Capivari, morro ao lado esquerdo da estrada, [-18.45063888°, -43.40113888°], elev. 1241 m, fl., fr., 17 May 2019, *J.B. Cândido 364* (UFP)*;* ibid *365* (UFP)*;* ibid *366* (UFP)*;* ibid *367* (UFP).

10. *Piptolepis leptospermoides* (Mart. ex Candolle 1836: 17) Schultz-Bipontinus (1863: 382). *Vernonia leptospermoides* Mart. ex Candolle (1836: 17). Type:—BRAZIL. Minas Gerais: in editis campis ad Tejuco, Serro Frio, 25 May 1818, *C.F.P. von Martius 1310 (541)* (lectotype: M e! [M0029434], designated by Loeuille *et al.* (2019: 94); isotype: P! [P04318894]) (Fig. 3 B, 24 A–B).

Shrub 0.3–0.6 m tall, densely branched, spreading, arching branches. **Stems** terete, villous, ochreous, old stems rugose, tomentose, dark brown, leaf scars deltate. **Leaves** patent to ascending, sessile, pad-like leaf sheath ligulate, 0.5–1.5 mm long; blade elliptic, 2.8–5.3 × 1.5–2 mm, apex obtuse, base cuneate to obtuse, coriaceous, venation hyphodromous, midrib adaxially impressed, abaxially prominent, adaxial surface pubescent, dark green, abaxially lanate, light-green, margins revolute. **Inflorescence** in raceme terminal at apex of branches, sessile, with leaf-like bracts at base of capitula, 5.5–9.5 × 1–1.5 mm, apex rounded, base attenuate. **Capitula** 5–18, shortly pedunculate, peduncle 3–5 mm long; involucre campanulate, 6–7.5 mm tall × 8–10 mm diam., 5–6 seriate; phyllaries scarious, lanate, glandular-punctate, outer phyllaries triangular, 1.8–2.5 × 0.5–1 mm, apex acute, light greenish, persistent, inner phyllaries lanceolate, 5–6 × 1 mm, apex acute, stramineous with apex brownish, deciduous; receptacle flat areolate. **Florets** 10–14; corolla pale lilac, glabrous, glandular-punctate, 7–8 mm long, corolla tube 4–5 × 0.5–1.1 mm, corolla lobes 3–3.5 × 0.6–0.8 mm, apex acute; anthers purple, apical appendages acute; style shaft 8.2–8.5 mm long, pale lilac, glabrous throughout except for pubescent upper ca. 1 mm beneath style arms, style arms 2.2–2.5 mm long. **Cypselae** prismatic, 1.8–2 × 1 mm, 10-ribbed, glabrous or pubescent, glandular-punctate at furrows, apex and base, brown; pappus setae biseriate unequal, stramineous, outermost series 0.5–1.5 mm long, paleaceous, serrulate, persistent, innermost series 5–6 mm long, subpaleaceous, barbellate, deciduous.

Distribution and habitat:—Endemic to the Diamantina Plateau of the Espinhaço Range of Minas Gerais State. Specifically, in Diamantina and Gouveia region (Fig. 9, 22). *P. leptospermoides* occurs over rock outcrops and nearby small streams.

Conservation Status:—This species is considered Critically Endangered (CR) based on criteria B1a,b(iii,iv)+B2a (IUCN 2019). It has an area of occupancy (AOO) of 4 km^2. There is one known population occur inside of protected areas at Parque Estadual Biribiri.

Etymology:— This specific epithet refers to the small size of the cypselae.

Phenology:—Flowering and fruiting specimens were found in all months, with the exception of November and December, when only flowering specimens were found.

Notes:—The main distinctive features are: deltate leaf scars, obtuse apex leaves, venation hyphodromous revolute margins, racemose inflorescence type, 10–14 florets per capitulum and unequal relative size of pappus series. Similar to *P. corymbosa*, *P. glaziouana*, *P. imbricata* and *P. speciosa* see those species notes for a discussion of the differences and distribution.

Representative Specimens Examined:—BRAZIL. Minas Gerais: Mun. Diamantina, estrada Diamantina-Medanha, 5km após UFVJM, fl., fr., 17 October 1967, *A.P. Duarte 10518* (RB, SPF, UB); ibid, [-18.1820555°, -43.5521666°], elev. 1232 m, fl., fr., 5 May 2019, *J.B. Cândido 312* (UFP); Mun. Diamantina, distrito de Guinda, elev. 1300 m, fl., fr., 7 September 1971, *G. Hatschbach 27399* (MBM, RB); Mun. Diamantina, BR 367, sentido Diamantina-Couto Magalhães, beira da estrada antes da ponte do Córrego do Soberbo, [-18.1816666°, -43.5625°], elev. 1294m, fl., fr., 8 January 2003, *L.P. Queiroz 7573 et al.* (ALCB, HUFS); Mun. Diamantina, estrada Diamantina-Araçuaí, entrada logo após o Córrego do Soberbo, [-18.183533333333°, -43.552725°], elev. 1419m, fl., fr., 15 August 2003, *M.E. Mansanares 351 & C.F. Verola* (UEC); Mun. Diamantina, Campus II da UFVJM, trilha logo após o laboratório de microbiologia do solo da engenharia florestal, [-18.1974444°, -43.56830555°], elev. 1360 m, fl., 17 November 2009, *A.S. Quaresma 20 & I.M. Franco* (DIAM, HUFU); Mun. Diamantina, estrada Diamantina-Gouveia, ca. de 7 km de Diamantina [-18.3360972222°, -43.6691694444°], elev. 1379m, fl., fr., 23 September 2010, *J.Y. Costa 191 et al.* (HUFU); Mun. Gouveia, estrada Gouveia-Curvelo, [-18.5834444°, -43.92638888°], elev. 1192m, fl., fr., 14 August 2013, *D.A. Chaves 182* (HDJF, UB).

11. *Piptolepis monticola* Loeuille (2012: 14). Type:—BRAZIL. Minas Gerais: Santo Antônio de Itambé, Pico do Itambé, *B. Loeuille et al.* 464 (holotype: SPF! [SPF189309]; isotypes: K! [K000374028], US! [US3676312]) (Fig. 2 D, 3 R, 24 C–D).

Piptolepis pseudomyrtus Baker (1873: 145), *nom. illeg.*, non *Piptolepis pseudomyrtus* (A. St.-Hil.) Schultz-Bipontinus (1863: 64). Type:—BRAZIL. Minas Gerais: habitat in Serra Itambé do Mato Dentro, *C.F.P. von Martius s.n. (545)* (holotype: M [not seen]; isotype: P! [P04318893 (fragment)]).

Treelet 1–4 m tall, virgate, densely branched. **Stems** terete, manicate, ochreous, old stems rugose, becoming glabrescent, dark brown, leaf scars flattened deltate. **Leaves** ascending, sessile, pad-like leaf sheath ligulate, 1.1–1.5 mm long; blade narrow elliptic to oblanceolate, 15–55 × 5–13 mm, apex subacute to obtuse, base attenuate, chartaceous, venation brochidodromous, midrib adaxially impressed, abaxially prominent, adaxial surface puberulent, dark gray olive, black glandular dotted, abaxially velutinous, sage, margins flat. **Inflorescence** in solitary pseudoglomerules, terminal at apex of branches, with leaf-like bracts at base of pseudoglomerule, 9–17 × 3–8 mm, apex subacute to obtuse, base attenuate. **Capitula** 3–7, sessile or shortly pedunculate, peduncle (0–)3–4 mm long; involucre cylindrical to campanulate, 9–10 mm tall × 7–11 mm diam., 5–6 seriate; phyllaries deciduous, scarious, stramineous, apex acute, glandular-punctate, lanate outer phyllaries narrowly triangular, 2–3.5 × 0.9–1.1 mm, inner phyllaries lanceolate, 6–9 × 1–1.2 mm; receptacle fimbrillate. **Florets** 15–23; corolla lilac, glabrous, glandular-punctate, 8–10 mm long, throat 1.5–1.8 mm long, corolla tube 5–6 × 0.4–1 mm., corolla lobes 2.8–3.5 × 0.4–0.6 mm, apex acute; anthers purple, apical appendages acute; style shaft 9–11 mm long, lilac, glabrous throughout except for pubescent upper 1 mm beneath style arms, style arms 2 mm long, apex acute, pubescent outside throughout. **Cypselae** cylindrical, 2–2.5 × 0.8–1 mm, 10-ribbed, glabrous, furrows glandular-punctate, ochreous; pappus setae uniseriate, subequal or equal, 5–6 mm long, stramineous, subpaleaceous, barbellate, tapering towards the apex, deciduous.

Distribution and habitat:—Endemic to the Diamantina Plateau of the Espinhaço Range of Minas Gerais State. This species is only known by three municipalities: Diamantina, São Gonçalo do Rio Preto and Serro (Fig. 9, 22). *P. monticola* occurs in elevation from 1383 to 1727 m, over rock outcrops.

Conservation Status:—CNCFlora (2022) classified this species as Data Deficient (DD), due to the lack of information of the occurrence localities and mismatched taxonomic information. Therefore, we prepared an updated state of conservation, this species is considered Endangered

(EN) based on criteria B1a,b(iii,iv)+B2a (IUCN 2019). It has an extent of occurrence (EOO) of 127,207 km^2 and area of occupancy (AOO) of 28,000 km^2. Two of the three populations occur inside of protected areas, Parque Estadual Pico do Itambé in Serro region and Parque Estadual do Rio Preto in São Gonçado do Rio Preto (Fig. 9).

Etymology:— The epithet derives from the "name" *Albertinia monticola* written on the label of the oldest known collection (Loeuille *et al.* 2012a).

Phenology:—Flowering and fruiting specimens were found from January to November.

Notes:—Similar to *P. gardneri* by its treelet habit, attenuate leaf base with flat margins, 3–7 capitula per pseudoglomerule, fimbrillate receptacle and uniseriate pappus setae, however *P. monticola* differs by its leaf scars flattened-deltate (vs. semicircular to deltate), leaf apex subacute to obtuse (vs. acute to mucronate), venation brochidodromous (vs. eucamptodromous), inflorescence with solitary pseudoglomerules (vs. with 3–9 pseudoglomerules) and cylindrical cypselae (vs. prismatic). These species do not occur in sympatry, since *P. gardneri* is endemic to the road from to Milho Verde and to the Parque Nacional das Sempre Vivas. [See also *P. oleaster* notes]

Representative Specimens Examined:—BRAZIL. MINAS GERAIS: Mun. Felício dos Santos, APA Felício, Mata do Isidoro e arredores, [-18.283333°, -43.466667°], elev. 1510 m, fl., fr., 30 August 2008, *P.L. Viana et al. 3740* (HUFU); Mun. São Gonçalo do Rio Preto, Parque Estadual do Rio Preto, [-18.215833°, -43.313333°], elev. 1550 m, fl., fr., 18 March 2016, *G. Martinelli et al. 19038* (ALCB, RB, SPF); Mun. Santo Antônio do Itambé, Parque Estadual do Itambé, trilha para o Pico, [-18.39841666°, -43.3319444°], elev. 1727 m, fl., fr., 13 May 2019, *J.B. Cândido 342* (UFP).

12. *Piptolepis oleaster* (Mart. ex Candolle) Schultz-Bipontinus (1863: 384). *Vernonia oleaster* Mart. ex Candolle (1836: 17). Type:—BRAZIL. Minas Gerais: in Serra da Piedade, May 1818, *C.F.P. von Martius 1212 (543)* (holotype: M *e!* [M0029436]) (Fig. 2 J, 3 S, 24 E–F).

Albertinia oleaster Mart. ex Candolle (1836: 17), *nom. nud. pro syn.*

Vernonia burchelliana Gardner (1846: 209). Type:—BRAZIL. Minas Gerais: Serro Frio, Diamond District, August 1840, *G. Gardner 4754* (lectotype: BM *e!* [BM000939737], designated by Loeuille *et al.* (2019: 94); isolectotypes: K! [K000484690, K000484691], NY! [NY00274753], P [not seen]).

Vernonia martiana Gardner (1846: 210), *Piptolepis martiana* (Gardner) Schultz-Bipontinus (1863: 385). Type:—BRAZIL. Minas Gerais: rocky places near Cidade Diamantina, August

1840, *G. Gardner 4754/2* (lectotype: BM *e!* [BM000948022], designated by Loeuille *et al.* (2019: 94); isolectotypes: P [not seen], W *e!* [W1889-0008783]).

Albertinia gonoclados Mart. ex Baker (1873: 144), *nom. nud. pro syn.*

Treelet 0.8–2 m tall, virgate, branched. **Stems** corrugated, lanulose, citrine, old stems terete, tomentose, dark brown, leaf scars winged. **Leaves** ascending to patent, old leaves descending, petiolate 4–20 mm, pad-like leaf sheath ligulate, 1.2–5 mm long; blade narrow oblong or narrow elliptic, 19–125 × 6–30 mm, apex acute to obtuse, base attenuate, chartaceous, venation eucamptodromous, midrib adaxially impressed, abaxially prominent, adaxial surface velutinous, olive, black trichomes dotted, abaxially lanate, citrine, margins flat. **Inflorescence** in raceme of 3–4 pseudoglomerules, terminal at apex of branches, interspersed by leaf-like bracts, 12–20 × 3–9 mm, apex obtuse, base attenuate. **Capitula** 3–5, sessile or shortly pedunculate, peduncle (0–)3–4 mm long; involucre cylindrical to campanulate, 9–10 mm tall × 5–8 mm diam., 6–7 seriate; phyllaries scarious, lanate, glandular-punctate, stramineous, outer phyllaries narrowly triangular, 2–4 × 0.8–1.4 mm, apex acute, persistent, inner phyllaries lanceolate, 7.5–8.5 × 0.9–1.1 mm, apex obtuse, deciduous; receptacle scrobiculate. **Florets** 15–22, corolla lilac, glabrous except for pubescent at apex corolla lobes, glandular-punctate, 11–13 mm long, corolla tube 7–9 × 0.3–1.5 mm., corolla lobes 3.1–3.5 × 0.4–0.5 mm, apex acute; anthers pale lilac, apical appendages acute; style shaft 12–15 mm long, lilac, glabrous throughout except for pubescent upper 2 mm beneath style arms, style arms 1.5–2 mm long, apex acute, pubescent outside throughout. **Cypselae** cylindrical, 2–2.5 × 0.8–1 mm, 10-ribbed, glabrous, densely glandular-punctate, ochreous; pappus setae uniseriate, subequal or equal, 7–8 mm long, stramineous, paleaceous, serrulate, tapering towards the apex, deciduous.

Distribution and habitat:—Endemic to the Diamantina Plateau of the Espinhaço Range of Minas Gerais State. *P. oleaster* is known by only three municipalities, Diamantina, São Gonçalo do Rio Preto and Serro (Fig. 9, 23). However, there are Martius historical gatherings from Serra da Piedade, if this Serra name refers to the same locality currently known, it is located in Caeté municipality, ca. 250 km southwards, indicating that the species may have had a larger geographical distribution.

Conservation Status:—CNCFlora (2022) classified this species as Data Deficient (DD), due to the lack of information of the species occurrence. Therefore, with the new data gathered here, we prepared an updated conservation status. The species is considered Endangered (EN) based on criteria B1a,b(iii,iv)+B2a (IUCN 2019). It has an extent of occurrence (EOO) of 1,110,815 km^2 and area of occupancy (AOO) of 44,000 km^2. All three known populations occur inside of protected areas, Parque Municipal do Biribiri in Diamantina, Parque Estadual do Rio Preto in São Gonçado do Rio Preto (Fig. 9) and Monumento Natural Estadual Várzea do Lageado e Serra do Raio in Serro.

Etymology:— The suffix -aster has a diminutive sense in this epithet which means 'small olive tree' and refers to the color of the leaves and stems of this species.

Phenology:—Flowering specimens were found in January and February. Flowering and fruiting from March to June, August, November, and December. The flowering peaks occurring from January to May

Notes:—Similar to *P. monticola* by its treelet habit, attenuate leaf base with flat margins, 15–23 florets per capitulum, cylindrical cypselae and uniseriate pappus. These species have populations occurring in sympatry at the Parque Estadual do Rio Preto, however *P. oleaster* differs by its corrugated stems (vs. terete), winged leaf scars (vs. flattened deltate), larger leaves (19–125 × 6–30 mm vs. 15–55 × 5–13 mm), petiolate leaves (vs. sessile), narrow oblong blade (vs. narrow oblanceolate), eucamptodromous venation (vs. brochidodromous) and inflorescence in raceme of 3–4 pseudoglomerules (vs. in pseudoglomerules terminal at apices of branches). [See also *P. gardneri* notes]

Representative Specimens Examined:—BRAZIL. Minas Gerais: Mun. Serro, Monumento Estadual Várzea do Lajeado e Serra do Raio/APA Água Vertentes, [-18.470556°, -43.489722°], elev. 1073 m, fl., fr., 12 February 2014, *M. Verdi et al. 6946* (HUFU, RB, SPF); Mun. Diamantina, Parque Estadual do Biribiri, próximo a cachoeira da Sentinela, [-18.18441666°, -43.6197222°], elev. 1090 m, fl., fr., 1 May 2019, *J.B. Cândido 309* (UFP); Mun. São Gonçalo do Rio Preto, Parque Estadual do Rio Preto, [-18.0927222°, -43.341777°], elev. 839 m, fl., fr., 9 May 2019, *J.B. Cândido 328* (UFP).

13. *Piptolepis pilosa* J.B.Cândido & Loeuille (2021: 497). Type:—BRAZIL. Minas Gerais, Buenópolis, Parque Nacional das Sempre Vivas, próximo ao rio Jequitaí, estrada à direita do alojamento ca. de 4 km de distância, [-17.891833º, -43.806166º], 1,236 m, fl., fr., 23 May 2019, *J.B. Cândido 376* (holotype: UFP! [UFP88705]; isotypes: BHCB!, K!, RB!) (Fig. 2 A, I, 3 K, 25 A–B).

Shrub 0.4–0.6 m tall, densely branched, spreading, straggling, arching branches. **Stems** terete, puberulent to pilose, ochraceous, old stems rugose, glabrescent, dark brown, leaf scars semicircular. **Leaves** patent to ascending, sessile to subsessile, petiole (0–)0.2–0.5 mm, pad-like leaf sheath ligulate, 0.4–0.7 mm long; blade narrow elliptic, 3.2–9 × 0.8–1.6 mm, apex acute, with a tuft of trichomes resembling an apiculus, base attenuate, coriaceous, venation hyphodromous, midrib adaxially impressed, slightly concealed by indumentum, abaxially slightly prominent, adaxial surface villous, olive green, abaxially pilose, sage-green, margins revolute. **Inflorescence** in racemes or solitary capitulum, terminal at apex of branches, with leaf-like bracts at base of capitula, 6.5–7.5 × 0.4–1 mm, apex obtuse, base attenuate. **Capitula** 1–16, sessile; involucre campanulate, 6.5–7 mm tall × 5–6 mm diam, 7–8 seriate; phyllaries persistent, scarious, lanulose, glandular-punctate, stramineous with brownish apex, outer phyllaries triangular, 2–3.6 × 0.8–1.1 mm, apex acuminate, inner phyllaries lanceolate,4.5–6 × 1–1.2 mm, apex acute; receptacle fimbrillate. **Florets** 10–13purple, glabrous, glandular-punctate, 6–7.2 mm long, corolla tube 3.3–4.2 × 0.6–1.2 mm., corolla lobes 2.5–3 × 0.5–0.6 mm, apex acute; anthers pale lilac, apical appendages acute; style shaft 4.5–6.5 mm long, purple, glabrous throughout except for pubescent upper 1–1.5 mm beneath style arms, style arms 1.5–2 mm long. **Cypselae** prismatic, 2–2.4 × 0.8–1 mm, 10-ribbed, glabrous, densely glandular-punctate, ochraceous; pappus setae biseriate subequal or equal, 4–5 mm long, stramineous, purplish at apex of younger pappus setae, rarely purplish when older, paleaceous, barbellate, deciduous.

Distribution and habitat:—This species occurs in the Parque Nacional das Sempre Vivas, a protected area within the boundaries of the municipalities of Olhos d’Água, Bocaiúva, Buenópolis and Diamantina (Fig. 9, 22). *P. pilosa* grows in areas of quartzite rock outcrops in sandy and rocky soils, close to the stream.

Conservation Status:—According to Cândido & Loeuille (2021), this species is considered Critically Endangered (CR) based on criteria B1a+B2a (IUCN 2019). It has an area of occupancy (AOO) of 4 km^2, and null extent of occurrence (EOO), being known from a single locality. Despite occurring in a Protected Area, its area has been affected with human impact such as its occurrence in the border of the main road in the park and fire during the dry season.

Etymology:— The epithet refers to the abaxial indumentum of the leaves (Cândido & Loeuille 2021).

Phenology:— Flowering and fruiting specimens were found in May, and in November, only fruiting specimens.

Notes:—*P. pilosa* resembles *P. ericoides* due to its leaves with acute apex, attenuate base and hyphodromous venation. However, *P. pilosa* differs from that species by its spreading, straggling stems (vs. virgate) and by leaves characteristics such as leaf apex with a tuft of trichomes resembling an apiculus (vs. without a tuft of trichomes), adaxial surface villous (vs. tomentulose), abaxially pilose (vs. hoary) and margins revolute (vs. flat). *P. pilosa* does not occur in sympatry with *P. ericoides*, since there are no known collection records for the latter species in Parque Nacional Sempre Vivas.

Representative Specimens Examined:—Brazil. Minas Gerais: Mun. Buenópolis, Parque Nacional das Sempre Vivas, próximo ao rio Jequitaí, estrada à direita do alojamento ca. de 4 km de distância, [-17.891111°, -43.806944°], elev. 1231 m, fl., fr., 28 November 2014, *L. Echternacht et al. 2572* (DIAM, HUFU); ibid, [-17.891666°, -43.806388°], elev.1238 m, fr., 1 November 2016, G. *Martinelli et al. 19506* (ALCB, DIAM, RB, SPF, UFP); ibid, [-17.891166º, -43.806888°], elev. 1232 m, fl., fr., 23 May 2019, *J.B. Cândido 377* (UFP).

14. *Piptolepis procumbens* J.B.Cândido & Loeuille (2021: 498). Type:—BRAZIL. Minas Gerais, Diamantina, Reserva Ambiental Pau de Fruta, [-18.2785°, -43.674388º], elev. 1,399 m, fl., fr., 07 May 2019, *J.B. Cândido 324* (holotype: UFP! [UFP88707]; isotypes: BHCB!, K!, RB!) (Fig. 2 B, 3 H, 25 C–D).

Shrub 0.5 m tall, crown 1.5 m diam., procumbent, densely branched. **Stems** terete, manicate, brownish, old stems rugose, becoming glabrescent, dark grey, leaf scars deltate. **Leaves** patent to ascending, subsessile, petiole 0.2–0.5 mm long, pad-like leaf sheath ligulate, 0.5–1 mm long; blade ovate to elliptic, 3.5–9 × 4–9 mm, apex subacute, base rounded, chartaceous, venation brochidodromous, midrib adaxially impressed, not concealed by indumentum, abaxially prominent, adaxial surface tomentose, dark olive green, abaxially lanate, light green, margins flat. **Inflorescence** in pseudoglomerules, terminal at apex of branches, with leaf-like bracts at base of pseudoglomerule, 5–9 × 1–3.5 mm, apex subacute, base rounded to attenuate. **Capitula** 2–7, sessile or shortly pedunculate, peduncle (0–)4–6 mm long; involucre cylindrical, 8–9 mm tall × 5–8 mm diam., 7–8 seriate; phyllaries persistent, scarious, lanate, glandular-punctate, apex acute, outer phyllaries narrowly triangular, 2–3.5 × 0.2–1 mm, stramineous, inner phyllaries lanceolate, 6.5–8 × 1–1.2 mm, stramineous with reddish apex; receptacle fimbrillate. **Florets** 14–22, corolla lilac, glabrous, glandular-punctate, 8–9 mm long, corolla tube 4–5 × 1–1.3 mm., corolla lobes 3–6 × 0.5–0.6 mm, apex acute; anthers lilac, apical appendages acute; style shaft 7–8 mm long, pale lilac, glabrous throughout except for pubescent upper 0.5–1 mm beneath style arms, style arms 2–2.5 mm long. **Cypselae** prismatic, 2–2.2 × 0.8–1 mm, 10-ribbed, glabrous, furrows glandular-punctate, light brown; pappus setae biseriate unequal, stramineous, paleaceous, outer series 0.6–1.5 mm long, serrulate, persistent, inner series 4–7 mm long, barbellate, tapering towards the apex, deciduous.

Distribution and habitat:—Endemic to the Diamantina plateau of the Espinhaço Range of mountains in the state of Minas Gerais, at the Área de Proteção Especial (APE) Manacial Pau de Fruta, within the boundaries of Diamantina (Fig. 9, 23). *P. procumbens* occurs in areas with quartzite rock outcrops in sandy and rocky soils, with nearby peatland areas.

Conservation Status:—According to Cândido & Loeuille (2021), this species is known from a single collection, locality and population. Therefore, the GeoCAT analysis (Bachmann *et al.* 2011) does not provide a confident evaluation of conservation status and the species should be classified as Data Deficient (DD).

Etymology:— The epithet refers to the species habit: leaning over or reclining on the ground (Cândido & Loeuille 2021).

Phenology:—Flowering and fruiting specimens were found in May.

Notes:—*Piptolepis procumbens* resembles *P. campestris* by its patent to slightly ascending, chartaceous leaves, with rounded base, and capitula organised in pseudoglomerules. However, *P. procumbens* differs from the latter by its height (0.5 m tall vs. 1.2–2 m tall), procumbent stems (vs. virgate), smaller leaves (3.5–9 mm vs. 8–21 mm long) and unequal pappus series (vs. subequal or equal). Both species have populations occurring in Diamantina, but in different localities.

15. *Piptolepis pseudomyrtus* (A. St.-Hil.) Schultz-Bipontinus (1863: 64), non *P. pseudomyrtus* Baker (1873: 145), *nom. illeg. Vernonia pseudomyrtus* Saint-Hilaire (1833: 367). Type:—BRAZIL. Minas Gerais: près Tapinhoancanga, *A. de Saint-Hilaire catologue B' 910, n° 574* (lectotype: P! [P00683104] designated by Loeuille *et al.* (2019: 90); isolectotypes: B†, K! [K000497136], MPU *e!* [MPU023508], P! [P00683105, P00683106]) (Fig. 2 C, F, 3 P, 25 E–F).

Treelet 0.7–1.4 m tall, virgate, densely branched towards apex. **Stems** corrugated, manicate, ochraceous, old stems terete, puberulent, light brown, leaf scars deltate. **Leaves** ascending, subsessile to petiolate, 0.3–1 mm, pad-like leaf sheath semi-conical, 0.5–1 mm long; blade very narrow elliptic to elliptic or oblanceolate, 6–19 × 1.8–6 mm, apex subacute to obtuse, base attenuate, chartaceous, venation eucamptodromous abaxially concealed by indumentum, midrib prominent abaxially and sunken adaxially, adaxial surface tomentulose, dark olive green, black glandular dotted, abaxially velutinous, light green, margins flat. **Inflorescence** in terminal raceme, with leaf-like bracts at base of capitula, 8–12 × 1.5–3.5 mm, apex acute, base attenuate. **Capitula** 3–6, sessile; involucre campanulate, 9–12 mm tall × 7–15 mm diam, 6–7 seriate; phyllaries persistent, scarious, glandular-punctate, outer phyllaries triangular to narrowly triangular or lanceolate, 2.5–4.2 × 0.9–1.2 mm, apex acute, lanulose, stramineous, inner phyllaries narrowly oblong, 9–10 × 0.9–1.6 mm, apex acuminate, pubescent, stramineous sometimes with reddish apex; receptacle fimbrillate. **Florets** 17–31; corolla pale lilac, glabrous, glandular-punctate, 9–11 mm long, corolla tube 5–8 × 0.5–1.4 mm., corolla lobes 3.6–4 × 0.6–0.7 mm, apex acute; anthers apical appendages acute; style shaft 6–11 mm long, glabrous throughout except for pubescent upper 1 mm beneath style-arms, style arms 1.5–3 mm long. **Cypselae** prismatic, 2–2.2 × 0.6–1 mm, 10-ribbed, glabrous, glandular-punctate, dark brown; pappus setae uniseriate, subequal or equal, 4–6.5 mm long, stramineous, paleaceous, barbellate, tapering towards the apex, deciduous.

Distribution and habitat:—Endemic to the Espinhaço Range in the state of Minas Gerais, the species currently occurs within the regions of Serro and Alvorada de Minas (in the Itaponhacanga region) (Fig. 18). *P. pseudomyrtus* occurs in areas of quartzite rock outcrops in sandy and rocky soils, close to small streams.

Conservation Status:—According to Cândido and Loeuille (2022), this species is considered Endangered (EN) based on criteria B1a+B2a (IUCN 2019). It has an area of occupancy (AOO) of 24,000 km^2, and extent of occurrence (EOO) of 334,189 km^2, being known by few gatherings. All known populations occur outside of Protected Area and has been affected by human impacts such as touristic interest, roads and inhabited areas.

Etymology:—This epithet refers to its resemblance with *Myrtus* Linnaeus (1753: 471).

Phenology:—Flowering and fruiting specimens were found in April and May, only flowering were found in November.

Notes:—*P. pseudomyrtus*, in the last taxonomic treatment of the genus (Baker 1973), was considered a synonym of *P. buxoides*. However, thorough examination of the type material of *P. buxoides* and its heterotypic synonym makes clear that these taxa are not conspecific (Cândido & Loeuille 2022). *P. pseudomyrtus* differs from *P. buxoides* by its habit, (treelet vs. shrub), leaf shape (narrowly elliptic to elliptic or oblanceolate vs. obovate), and size (6–19 × 1.8–6 mm vs. 6–8 × 4 mm), number of florets per capitulum (17–31 vs. 7), cypselae shape (prismatic vs. cylindrical) and length of pappus series (equal to subequal vs. unequal).

Similar to *P. schultziana* by its treelet habit, deltate leaf scars, subacute apex, flat margins and racemose inflorescence, however *P. pseudomyrtus* can be distinguished by its leaves with eucamptodromous venation (vs. hyphodromous), fewer capitula per inflorescence (3–6 vs. 7–18), campanulate involucre (vs. cylindrical), prismatic cypselae (vs. cylindrical) and shorter pappus (4–6.5 vs. 6–7 mm long). It also resembles *P. ericoides* by its corrugated stems, leaves with attenuate base, tomentulose adaxial surface, flat margins, racemose inflorescence, campanulate involucre, 6–7 seriate and prismatic cypselae, however *P. pseudomyrtus* differs by its leaves with eucamptodromous venation (vs. hyphodromous) and higher number of florets per capitulum (17–31 vs. 10–16). There is no register of other *Piptolepis* species co-occurring with *P. pseudomyrtus*.

Representative Specimens Examined:—BRAZIL. Minas Gerais: *s.l.*, fr., *s.d.*, *G. Gardner 4752* (NY, R, S); Serra da Lapa, *s.d.*, *Riedel 911* (K, NY); Diamantina, ao tombador, fl., fr., 7 April 1892, *A.F.M. Glaziou 19552* (R); Diamantina, fl., 9 May 1905, *L. Damazio s.n* (RB 57108); Ouro Preto, fl., fr., *s.d., L. Damazio s.n* (RB 57107); Serro, Distrito de Mato Grosso, Pedra do Cruzeiro, elev. 1,132 m, [-18.693611°, -43.458333°], fl., fr., 28 May 2001, *J.N. Nakajima & R. Romero 3066* (HUFU). Alvorada de Minas, Itapanhoacanga, trilha para a cachoeira Campina, elev. 846 m, [-18.7975°, -43.443055°], fl., 14 November 2007, *M.M. Saavedra et al. 529* (RB, UFP, SPF); ibid, elev. 672 m, [-18.805277°, -43.436388°], fl., 19 November 2011, *B. Loeuille et al. 599* (K, MA, MBM, RB, SPF, UFP, US); ibid, elev. 696 m, [-18.804722°, -43.436666°], fl., fr., 14 May 2019, *J.B. Cândido 345 & Almir* (UFP).

16. *Piptolepis redacta* J.B.Cândido & Loeuille, ***sp. nov.*** Type:—BRAZIL. Minas Gerais, Congonhas do Norte, estrada Congonhas-Dimantina, entrando na Fazenda Pinhões da Serra, [-18.80919444°, -43.75147222°], elev. 1282 m, fl., fr., 15 March 2019, *J.B. Cândido 353* (holotype: UFP! [UFP88701]; isotypes: DIAM!, RB!, SPF!). (Fig. 3 G, 26 A–B, 27 A–M)

Specie Piptolepi buxoide simile, sed foliis subsessilibus ad petiolata (0.4–1.3 mm, non sessilibus), inflorescentia racemosa (non capitulo solitario) et pappi setis subaequalibus vel aequalibus (non inaequalibus) differt.

Shrub 0.4–1 m tall, virgate, densely branched. **Stems** terete, corrugated, manicate, ochraceous, old stems rugose, glabrescent, grey to dark brown, leaf scars deltate. **Leaves** patent to ascending, subsessile to petiolate 0.4–1.3 mm, pad-like leaf sheath ligulate, 0.3–1 mm long; blade elliptic to narrow elliptic or orbiculate or narrow obovate to oblanceolate, 3–10 × 1.5–3.6 mm, apex obtuse to rounded, base attenuate or rounded, chartaceous, venation hyphodromous, midrib adaxially impressed, abaxially slightly prominent, adaxial surface glabrescent, dark olive green, black glandular dotted, abaxially velutinous, light green, margins flat. **Inflorescence** in racemes, terminal at apex of branches, with leaf-like bracts, 6.2–8.1 × 1–3 mm at base of capitulum, apex rounded to obtuse, base attenuate. **Capitula** 4–6, sessile or pedunculate, peduncle (0–)0.5–1.2 mm long; involucre campanulate, 7–9 mm tall × 8–10 mm diam, 5–6 seriate; phyllaries persistent, scarious, lanulose, glandular-punctate, stramineous with brownish apex, outer phyllaries triangular, 2.2–3.5 × 0.6–1.1 mm, apex acuminate, inner phyllaries lanceolate, 5–7.2 × 0.9–1.2 mm, apex acute; receptacle areolate. **Florets** 9–11, corolla pale lilac, glabrous, glandular-punctate, 6.5–10 mm long, corolla tube 4.5–6 × 0.5–1.4 mm., corolla lobes 2.9–3.4 × 0.5–0.6 mm, apex acute; anthers pale lilac, apical appendages acute; style shaft 6–8 mm long, pale lilac, glabrous throughout except for pubescent upper ca. 1 mm beneath style arms, style arms 1.8–2 mm long. **Cypselae** cylindrical, 1.6–2.2 × 0.8–1 mm, 10-ribbed, glabrous, slightly glandular-punctate, ochraceous; pappus setae biseriate subequal or equal, 4–5.5 mm long, stramineous, paleaceous, barbellate, frequently slightly twisted, tapering towards the apex, deciduous.

Distribution and habitat:—Endemic to the Espinhaço Range in the state of Minas Gerais, the species occurs in Congonhas do Norte region (Fig. 18). *P. redacta* occurs over rock outcrops and next of small streams.

Conservation Status:—The species is only known from two gatherings from the same population. Therefore, the GeoCAT analysis (Bachmann *et al.* 2011) does not provide a confident evaluation of conservation status and the species should be classified as Data Deficient (DD). However, it is important to emphasise that the region, where this species occurs, is within the limits of a farmland and the place is heavily affected by frequent human activities, such as agriculture, livestock and deforestation, which makes the conservation of this species extremely worrying.

Etymology:—The specific epithet *redacta* means ‘reduced’, ‘diminished’. It refers to the reduced leaf size and height of this new species.

Phenology:—Flowering and fruiting specimens were found in May and June, however senescent capitula were observed in the field, so this species may flower before May.

Notes:—Similar to *P. buxoides* by its shrubby habit, obovate leaf shape, size (6–8 × 4 mm vs. 3–10 × 1.5–3.6 mm) and cylindrical cypselae, however the new species differs by its subsessile to petiolate leaves (0.4–1.3 mm vs. sessile), racemose inflorescence (vs. solitary capitula) and subequal or equal relative size of pappus series (vs. unequal).

The new species occurs nearby the type locality of *P. schultziana* and both are similar due to their leaves with hyphodromous venation, glabrescent adaxial surface and abaxially velutinous, cylindrical cypselae and subequal or equal relative size of pappus series, but the new species differs by its shrubby habit (vs. treelet), smaller leaves size (3–10 × 1.5–3.6 mm vs. 5.5–20 × 2.5–9 mm), campanulate involucre (vs. cylindrical), and lower number of florets per capitulum (9–11 vs. 20–28).

Representative Specimens Examined:—BRAZIL. Minas Gerais: Mun. Congonhas do Norte, Serra Talhada, Acesso para a Fazenda dos Pinhões da Serra, ca. 8 km na estrada Diamantina -

Congonhas do Norte, [-18.808333°, -43.751667°], fl., fr. 23 June 2013, *G.M. Antar et al. 211* (SP, SPF, UFP).

17. *Piptolepis riparia* Loeuille, Semir & Pirani (2019: 95). Type:—BRAZIL. Minas Gerais: São Gonçalo do Rio Preto, Parque Estadual do Rio Preto, margem do Córrego das Éguas, 8 February 2010, *B. Loeuille et al. 516* (holotype: SPF! [SPF221000]; isotypes: BHCB!, K!, NY!, P!, RB!, UFP!, US!) (Fig. 3 J, 26 C–D).

Shrub 0.40–1 m tall, virgate, densely branched with long and arching branch. **Stems** slightly corrugated, puberulent, saffron, old stems rugose, becoming glabrescent, dark brown, leaf scars deltate. **Leaves** ericoid, ascending, sessile to subsessile, petiole (0–)0.5–1.5 mm long, pad-like leaf sheath ligulate, 0.6–1.8 mm long; blade very narrow elliptic to narrow oblanceolate, 5–15 × 1.5–4 mm, apex subacute to obtuse, base attenuate, chartaceous, venation hyphodromous, midrib adaxially sunken, slightly concealed by indumentum, abaxially prominent, adaxial surface tomentulose, dark olive green to gray green, abaxially lanate, sage, margins flat. **Inflorescence** in raceme, terminal at apex of branches, with leaf-like bracts at base of capitulum, 7–10 × 0.6–2.3 mm, apex subacute to obtuse, base attenuate. **Capitula** 2–10, sessile; involucre campanulate, 6–8 mm tall × 6.5–10 mm diam., 5–6 seriate; phyllaries persistent, scarious, glandular-punctate, outer phyllaries narrowly triangular, 3–4 × 0.2–1 mm, apex acute, lanate, stramineous, inner phyllaries lanceolate, 5–7 × 0.5–1.1 mm, apex subacute to obtuse, lanate only at apex, light green; receptacle fimbrillate. **Florets** 13–15; corolla lilac, glabrous, glandular-punctate, 8–9 mm long, corolla tube 4–5 × 0.5–1.5 mm., corolla lobes 3.4–3.8 × 0.5–0.9 mm, apex acute; anthers lilac, apical appendages acute; style shaft 7–11 mm long, pale lilac, glabrous throughout except for pubescent upper ca. 1 mm beneath style arms, style arms 2–2.2 mm long. **Cypselae** prismatic, 1.5–2 × 0.8–1.2 mm, 10-ribbed, glabrous, slightly glandular-punctate, light brown; pappus setae biseriate unequal, outer series 0.3–1.4 mm long, persistent, inner series 2.8–4 mm long, stramineous, subpaleaceous, serrulatate, tapering towards the apex, deciduous.

Distribution and habitat:—Endemic to the Diamantina Plateau of the Espinhaço Range in the state of Minas Gerais, in São Gonçalo do Rio Preto (Fig. 9, 23). This species occurs in areas of quartzite rock outcrops in rocky banks of rivers.

Conservation Status:—Loeuille *et al.* (2019) classified this species as Data Deficient (DD), since it was known only from the type material. Here, we recovered more populations data and an update conservations status. This species is considered Critically Endangered (CR) based on criteria B1b(iv) (IUCN 2019). It has an extent of occurrence (EOO) of 3.881 km^2 and area of occupancy (AOO) of 12.000 km^2. The two known populations occur inside of protected areas at Parque Estadual do Rio Preto (Fig. 9).

Etymology:—The epithet refers to the habitat of the species, which was collected on the rocky banks of a river (Loeuille *et al.* 2019).

Phenology:—Flowering and fruiting specimens were found from March to June.

Notes:—This species is known from few gatherings. *P. riparia* is recognised by its shrubby and densely branched habit with long and arching branches, narrow elliptic to narrow oblanceolate leaf blade with prominent midrib abaxially, 13–15 florets per capitulum, prismatic cypselae and pappus series of unequal relative size.

The species *P. fulgens*, *P. monticola* and *P. oleaster* occur in sympatry with *P. riparia* in the Parque Estadual do Rio Preto, however *P. riparia* differs from *P. monticola* and *P. oleaster* by its shrubby habit (vs. treelet), 2–10 florets per capitulum (vs. 15–23), prismatic cypselae (vs. cylindrical), pappus series of unequal relative size (vs. equal to subequal) and it differs from *P. fulgens* by its leaves very narrow elliptic to narrow oblanceolate (vs. lanceolate), base attenuate (vs. rounded), tomentulose adaxial surface (vs. densely sericeous), flat margins (vs. revolute), phyllaries scarious at apex (vs. leaf like) and prismatic cypselae (vs. turbinate). [For similar species see *P. ericoides*, *P. fulgens* and *P. elaeoda* notes].

Representative Specimens Examined:—BRAZIL. Minas Gerais: Mun. São Gonçalo do Rio Preto, Parque Estadual do Rio Preto, próximo a prainha, [-18.116667°, -43.333333°], fl., fr. 13 June 1999, *J.A. Lombardi 3054* (BHCB, MBM, US); ibid, [-18.116°, -43.345°], elev. 790 m, fl., fr. 14 May 2012, *C. Delfini 464* (BHCB, ESA, HUFU, RB, SPF); ibid, [-18.11525°, -43.3414444°], elev. 768 m, fl., fr. 9 May 2019, *J.B. Cândido 325* (UFP); ibid, [-18.11672222°, -43.3407222°], elev. 770 m, fl., fr. 9 May 2019, *J.B. Cândido 326* (UFP); Parque Estadual do Rio Preto, trilha para a cachoeira do Criolo, [-18.145556°, -43.370556°], elev. 900 m, fl., fr. 21 March 2016, *G. Martinelli 19248* (ALCB, HUFU, RB); ibid, [-18.14561111°, -43.36658333°], elev. 873 m, fl., fr. 24 May 2019, *J.B. Cândido 380* (UFP); ibid, [-18.14575°, -43.36102777°], elev. 851 m, fl., fr. 24 May 2019, *J.B. Cândido 381* (UFP); ibid, [-18.1437777°, -43.35902777°], elev. 831 m, fl., fr. 24 May 2019, *J.B. Cândido 382* (UFP).

18. *Piptolepis schultziana* Loeuille & D.J.N.Hind (2012: 12). Type:—BRAZIL. Minas Gerais: Congonhas do Norte, Fazenda Imbaúbas, 20 January 2007, *Loeuille et al. 76* (holotype: SPF! [SPF211000]; isotype: K! [K000374029, K001092363]) (Fig. 3 O, 26 E–F).

Treelet 1–1.30 m tall, virgate, densely branched. **Stems** slightly furrowed, manicate, saffron, old stems terete, puberulent, dark brown, leaf scars deltate. **Leaves** ascending, subsessile, petiole 0.5–1 mm long, pad-like leaf sheath ligulate, 1 mm long; blade elliptic to wide elliptic, more rarely ovate, 5.5–20 × 2.5–9 mm, apex obtuse to subacute, base attenuate to rounded, chartaceous, venation hyphodromous, midrib adaxially impressed, not concealed by indumentum, abaxially slightly prominent, adaxial surface glabrescent, dark olive green, abaxially velutinous, citrine, black glandular dotted, margins flat. **Inflorescence** in raceme, terminal at apex of branches, with leaf-like bracts at base of capitula, 10–12 × 4–5 mm, apex subacute, base attenuate. **Capitula** 7–18, sessile; involucre cylindrical, 8–10 mm tall × 8–9 mm diam., 6–7 seriate; phyllaries persistent, scarious, lanate, glandular-punctate, stramineous, outer phyllaries narrowly triangular, 2.8–3.5 × 1.1–1.5 mm, apex acute, inner phyllaries lanceolate, 6–8.5 × 1–1.5 mm, apex obtuse; receptacle scrobiculate. **Florets** 20–28, corolla lilac, glabrous, densely glandular-punctate, 8–8.5 mm long, corolla tube 4.1–5.6 × 0.5–1.4 mm., corolla lobes 3–4 × 0.4–0.5 mm, apex acute; anthers purple, apical appendages acute; style shaft 7–8 mm long, pale lilac, glabrous throughout except for pubescent upper ca. 1 mm beneath style arms, style arms 2–3 mm long. **Cypselae** cylindrical, 1.5–2.1 × 0.6–0.8 mm, 10-ribbed, glabrous, slightly furrows glandular-punctate, light brown; pappus setae biseriate subequal or equal, 6–7 mm long, stramineous, paleaceous, serrulate, tapering towards the apex, deciduous.

Distribution and habitat:—Endemic to the Espinhaço Range in the state of Minas Gerais, the species currently occurs within the boundaries of the municipalities of Conceição do Mato Dentro, Congonhas do Norte, Santana do Riacho and Santana do Pirapama (Fig. 16). *P. schultziana* occurs in rock outcrops areas.

Conservation Status:—This species is considered Critically Endangered (CR) based on criteria B1a,b(iii,iv)+B2a (IUCN 2019). It has an extent of occurrence (EOO) of 999.442 km^2 and area of occupancy (AOO) of 60.000 km^2. All known populations occur outside of Protected Area.

Etymology:—The epithet refers to Carl Heinrich Schultz-Bipontinus, a German physician and botanist, who described the genus *Piptolepis* (Loeuille *et al.* 2012a).

Phenology:—Flowering and fruiting specimens were found in all months, except by August and September.

Notes:—*P. schultziana* it the only species that occur in sympatry with *P. ericoides* in Santana do Riacho, but *P. schultziana* is very distinct by its treelet habit (vs. shrub), deltate leaf scars (vs. semicircular), wider leaves (2.5–9 mm vs. 0.8–3.5 mm), elliptic to wide elliptic, more rarely ovate blade (vs. very narrow elliptic), 20–28 florets per capitulum (vs. 10–16) and cylindrical cypselae (vs. prismatic). [Also resembling *P. pseudomyrtus* and *P. redacta*, see these species notes for more discussion of the differences].

Representative Specimens Examined:—BRAZIL. Minas Gerais: Mun. Santana do Riacho, Lapinha, elevações imediatamente a nordeste de Lapinha, nas nascentes do córrego do Boqueirão, trilha para o alto do paredão, [-19.1058888°, -43.67555555°], elev. 1315 m, 22 April 2006, *B. Loeuille et al. 20* (K, SPF, UFP); Distrito de São José da Cachoeira, Serra da Lapa, trilha do João Carrinho, [-19.048°, -43.73869444°], elev. 756–1080 m., 18 February 2007, *V.C. Souza et al. 32693* (BHCB, ESA, K, SPF); Mun. Conceição do Mato Dentro, Solidão, Fazenda da Boa Esperança, propriedade da Anglo American, [-18.924444°, -43.477778°], elev. 750 m, fl., fr. 29 June 2016, *J.E.Q. Faria 6093* (HUFU, HDJF, RB, UB); Mun. Congonhas do Norte, estrada sentido Conselheiro da Mata, [-18.92397222°, -43.67691666°], elev. 1190 m, fl., fr. 5 May 2019, *J.B. Cândido 351* (UFP).

19. *Piptolepis speciosa* J.B.Cândido & Loeuille, ***sp. nov.*** Type:—BRAZIL. Minas Gerais, Olhos-D'água, Parque Nacional das Sempre Vivas, Trilha do Telégrafo, Campo João Alves. Bacia do Rio Jequitinhonha, [-17.732778°, -43.699444°], elev. 1134 m, fl., fr., 28 April 2016, *F.N. Costa 1849* (holotype: HUFU! [HUFU76204]; isotype: DIAM! [DIAM5900]) (Fig. 3 E, 28 A–M).

Specie Piptolepi imbricata simile, sed foliis petiolatis (non sessilibus), apice obtuso ad roduntatum (non acuto), venatione hyphodroma (non eucamptodroma), capitulorum pedunculo breviore (0.6–1 mm, non 3–5 mm) et pappi setis subaequalibus vel aequalibus (non inaequalibus) differt.

Shrub ca. 0.9 m tall, densely branched. **Stems** terete, manicate, ochraceous, leaf scars deltate. **Leaves** patent to ascending, subsessile to petiolate 0.2–0.6 mm, pad-like leaf sheath ligulate, 0.6–1.5 mm long; blade elliptic to ovate, 2–7 × 1.5–3 mm, apex obtuse to rounded, base rounded, chartaceous, venation hyphodromous, midrib sunken adaxially and slightly prominent abaxially, adaxial surface tomentulose, dark olive green, abaxially lanulose, light green, margins revolute. **Inflorescence** in racemes or capitula solitary, terminal at apex of branches, with leaf-like bracts at base of capitula, 5–7.3 × 1.7–2.6 mm at base of capitulum, apex rounded to obtuse, base attenuate. **Capitula** 1–3, sessile or pedunculate, peduncle (0–)0.6–1 mm long; involucre campanulate, 6–8 mm tall × 6–7.2 mm diam, 6–7 seriate; phyllaries persistent, scarious, lanulose, glandular-punctate, outer phyllaries triangular, 1.8–3 × 0.6–1.2 mm, apex acute, stramineous, inner phyllaries lanceolate, 5–6 × 1–1.3 mm, apex acute, stramineous with apex reddish; receptacle foveolate. **Florets** 16purple, glabrous, glandular-punctate, 5.5–6 mm long, corolla tube 3.3–4 × 0.6–1.1 mm., corolla lobes 2.2–3 × 0.3–0.6 mm, apex acute; anthers pale lilac, apical appendages acute to obtuse; style shaft 7–8 mm long, pale lilac, glabrous throughout except for pubescent upper ca. 1 mm beneath style arms, style arms 1.8–2 mm long. **Cypselae** prismatic, 2–2.2 × 0.8–1 mm, 10-ribbed, glabrous, yellow glandular-punctate in furrows and accumulated at bases, light brown; pappus setae biseriate subequal or equal, 3.7–4.4 mm long, stramineous, paleaceous, serrulate, tapering towards the apex, deciduous.

Distribution and habitat:—Endemic to the Diamantina Plateau of the Espinhaço Range of mountains in Minas Gerais State, at Parque Nacional das Sempre Vivas, a protected area within the boundaries of Olhos d'Água, Bocaiúva, Buenópolis and Diamantina (Fig. 10, 16).

Conservation Status:—The species only known from the type collection. Therefore, the GeoCAT analysis (Bachmann *et al.* 2011) does not provide a confident evaluation of conservation status and the species should be classified as Data Deficient (DD). Despite occurring in a Protected Area, its area has been affected with human impact such as arson fires during the dry season.

Etymology:—The specific epithet *speciosa* means 'beautiful', 'splendid', 'elegant'..

Phenology:—Flowering and fruiting specimens were found in April.

Notes:—Similar to *P. imbricata* by its shrubby habit, deltate leaf scars, elliptic to ovate leaf blade of similar size with rounded base, racemose inflorescence and prismatic cypselae. However, *P. speciosa* differs by its petiolate leaves (0.2–0.6 mm vs. sessile), obtuse to rounded apex without tuft of trichomes (vs. acute, with a tuft of trichomes resembling an apiculus), hyphodromous venation (vs. eucamptodromous); 1–3 capitula per inflorescence with shorter peduncle (0.6–1 mm) (vs. 1–10 capitula per inflorescence with 3–5 mm long peduncle) and subequal or equal relative size of pappus series (vs. unequal). *P. speciosa* does not occur in sympatry with *P. imbricata*, since the new species occur in Parque Nacional das Sempre Vivas in Buenópolis and the latter only hase register in Serro close to Capivari and Milho Verde.

P. glaziouana also resembles this new species by its leaves with lanulose indumentum abaxially and hyphodromous venation, capitula organised in racemes or solitary, campanulate involucre and prismatic cypselae. However, *P. speciosa* differs from that species by its leaf scars deltate (vs. semicircular), leaves subsessile to petiolate (vs. sessile), base rounded (vs. cuneate), margins revolute (vs. flat), midrib sunken adaxially and slightly prominent abaxially (vs. slightly prominent adaxially and flat abaxially, longer pad-like leaf sheath (0.6–1.5 mm vs. 0.3–0.5 mm long) and subequal or equal size of pappus setae series (vs. unequal).

In the Parque Nacional das Sempre Vivas, four other species of *Piptolepis* are found. *P. speciosa* differs from *P. corymbosa* by its leaves with tomentulose adaxial surface (vs. pilose) and racemose inflorescence with 1–3 capitula (vs. inflorescence in corymbs with 4–16 capitula), from *P. Pilosa* by its deltate leaf scars (vs. semicircular), wider leaves (1.5–3 mm vs. 0.8–1.6 mm) with elliptic to ovate blade shape (vs. narrow elliptic), obtuse to rounded apex without a tuft of trichomes, (vs. acute apex, with a tuft of trichomes resembling an apiculus) and rounded base (vs. attenuate). *P. gardneri* by its shrubby habitat (vs. treelet), smaller leaves (2–7 × 1.5–3 mm vs. 8–68 × 3–9 mm) with elliptic to ovate blade (vs. oblanceolate to narrow oblanceolate), from *P. elaeoda* by its elliptic to ovate blade shape (vs. narrow elliptic), smaller leaves (2–7 × 1.5–3 mm vs. 6–15 × 2–2.8 mm), obtuse to rounded apex (vs. acute apex) and rounded base (vs. attenuate), revolute margins (vs. flat or lightly conduplicate).

Excluded species

1. *Piptolepis rosmarinifolia* Bringel, J.B. Cândido & Loeuille (2019: 272) Type:—BRAZIL. Goiás: Água Fria de Goiás, estrada para torre repetidora do Roncador, 14 May 2017, *J.B.A. Bringel Jr. et al. 1329* (holotype: CEN! [CEN109714]; isotypes: HUFU!, HUEFS! [HUEFS257670], K!, MBM! [MBM33931], NY!, RB! [RB01410047], SPF!, UFP!, US!).

2. *Piptolepis pabstii* (Barroso) Loeuille, Semir & Pirani, in Loeuille *et al.* (2019: 95). *Eremanthus pabstii* Barroso (1964: 173). *Vernonia pabstii* (G.M. Barroso) MacLeish (1984: 135). Type:—BRAZIL. Goiás: Cristalina, ca. 1250 m, 24 March 1963, *E.P. Heringer 9229/1442* (holotype: HB; isotypes: HEPH! [HEPH00014781], RB! [RB00282958], UB! [UB1525])

Notes:—These two species are endemics to the *campos rupestres* of the Goiás Plateau, occurring in disjunction from the other *Piptolepis* species. *P. pabstii* and *P. rosmarinifolia* are morphologically similar between them, displaying a subshrubby, caespitose habit, unbranched or sparsely towards the apex; narrow linear leaf blades and capitula fused in a syncephalium with only one floret per capitulum. All these features are absent in *Piptolepis*, having only the presence of a pad-like leaf sheath as a feature in common with *Piptolepis*.

A recent anatomic study (Marques *et al.* 2022) also found significative differences between these two species from the congeneric species. *P. pabstii* and *P. rosmarinifolia* differ anatomically by the absence of calcium oxalate crystals in the outer mesocarp, cylindrical and flat cypselae shape in transverse section (vs. sulcate furrows) and abundance of twin, bifurcated trichomes hairs in the cypselae (vs. glabrous cypselae (in almost all *Piptolepis*) or slightly pubescent (only in *P. leptospermoides*).

Moreover, preliminary data from phylogenetic analyses (Cândido *et al.* in prep), based on 961 nuclear markers, indicates that both species form a clade within *Eremanthus*, whereas Loeuille *et al.* (2015b) found *P. pabstii* nested within of *Piptolepis* or sister group to that clade, using four plastidial and nuclear regions. In addition, a preliminary phylogenetic network analysis (Cândido *et al.* in prep) point to an intrageneric hybrid origin (one of the parental species belonging to *Eremanthus*). Thus, we decided here to exclude these species from *Piptolepis*. Therefore, further investigation is needed to determine the taxonomic position of these taxa and explore their putative hybrid origin.

3. *Piptolepis phillyreoides* Bentham (1840: 29) = ***Forestiera phillyreoides*** (Benth.) Torrey (1859: 167) [Oleaceae].

4. *Piptolepis schwackeana* Glaziou (1909: 377), nom. nud. = *Heterocoma* Candolle (1810: 190)

Acknowledgements

J.B. Cândido would like to thank the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (Finance Code 001) for the granted fellowship (CAPES/PROEX). All curators of the visited herbariums; especially ALCB, BHCB, HUEFS, HUFU, R, RB, UEC for loans of specimens. Instituto Estadual de Florestas - Minas Gerais and ICMBio for issuing collection permits. Regina Maria Alcântara de Carvalho for line drawings. The many people and institutions who have been generous with their time and resources, providing hosting and logistic support during fieldwork. Specially, Fabiane Nepomuceno da Costa from Universidade Federal do Vale do Jequitinhonha e Mucuri (UFVJM).

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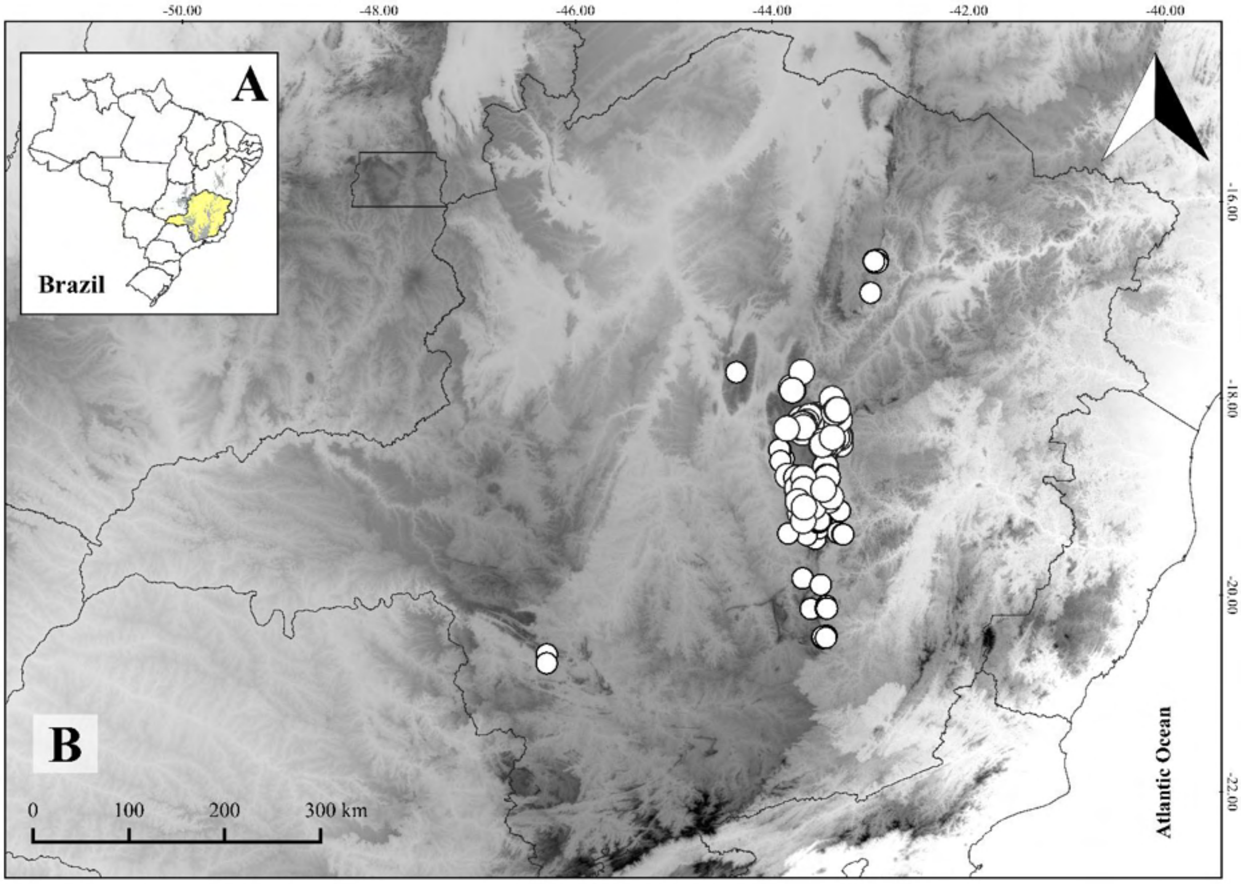

FIGURE 1. Distribution map. **A.** Brazil with Minas Gerais state highlighted. **B.** Distribution of *Piptolepis* (white dots), endemic to the *campos rupestres* of Espinhaço Range of Minas Gerais.

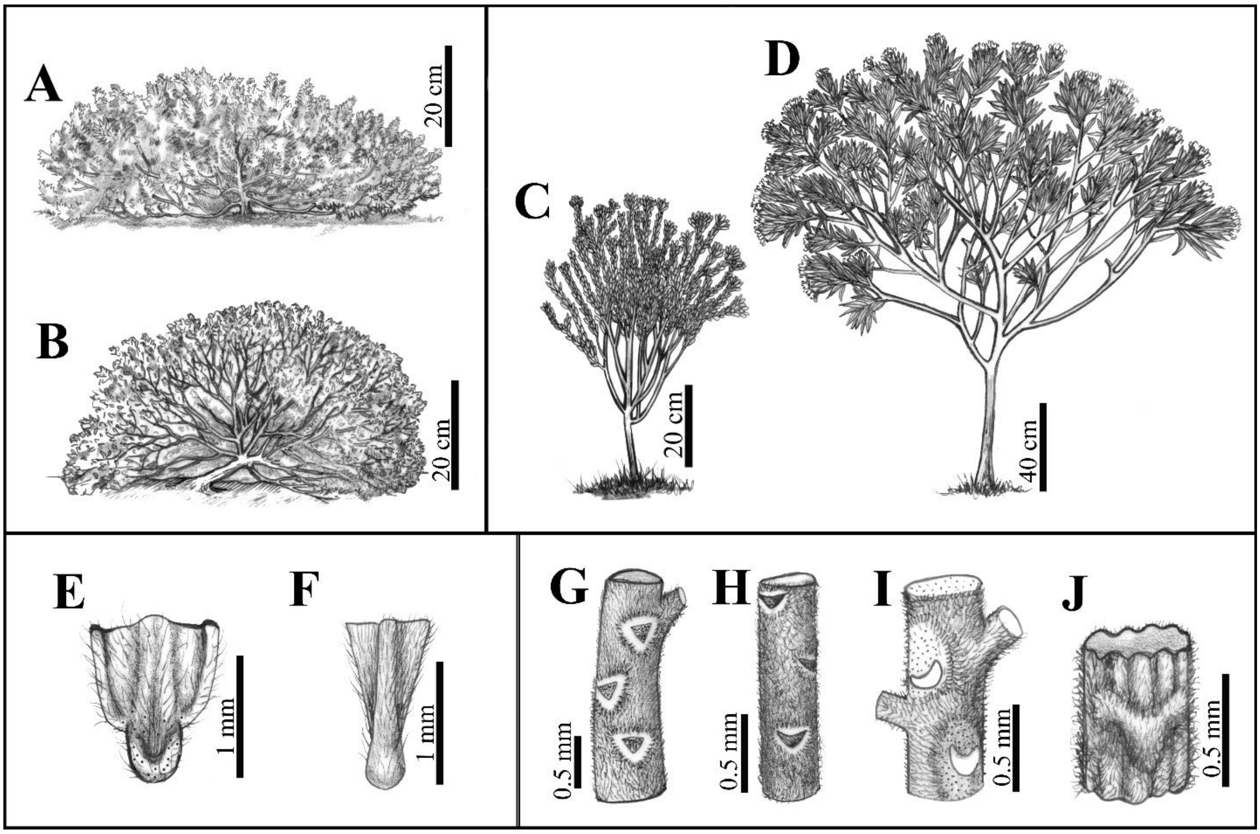

FIGURE 2. Diagnostic morphological features. **A–B.** Shrub habit: **A.** spreading, straggling (*P. pilosa*). **B.** procumbent (*P. procumbens*). **C.** Treelet habit, virgate (*P. pseudomyrtus*). **D.** Treelet habit, virgate (*P. monticola*). **E–F.** Pad-like leaf sheath shape: **E.** ligulate (*P. fulgens*). **F.** Semi-conical (P. *elaeoda*). **G–J.** Leaf scars shape. **G**. deltate (*P. redacta*). **H.** flattened deltate (P. *elaeoda*). **I.** semicircular (*P. pilosa*). **J**. winged (*P. oleaster*). **A–J.** Drawings by Regina Carvalho.

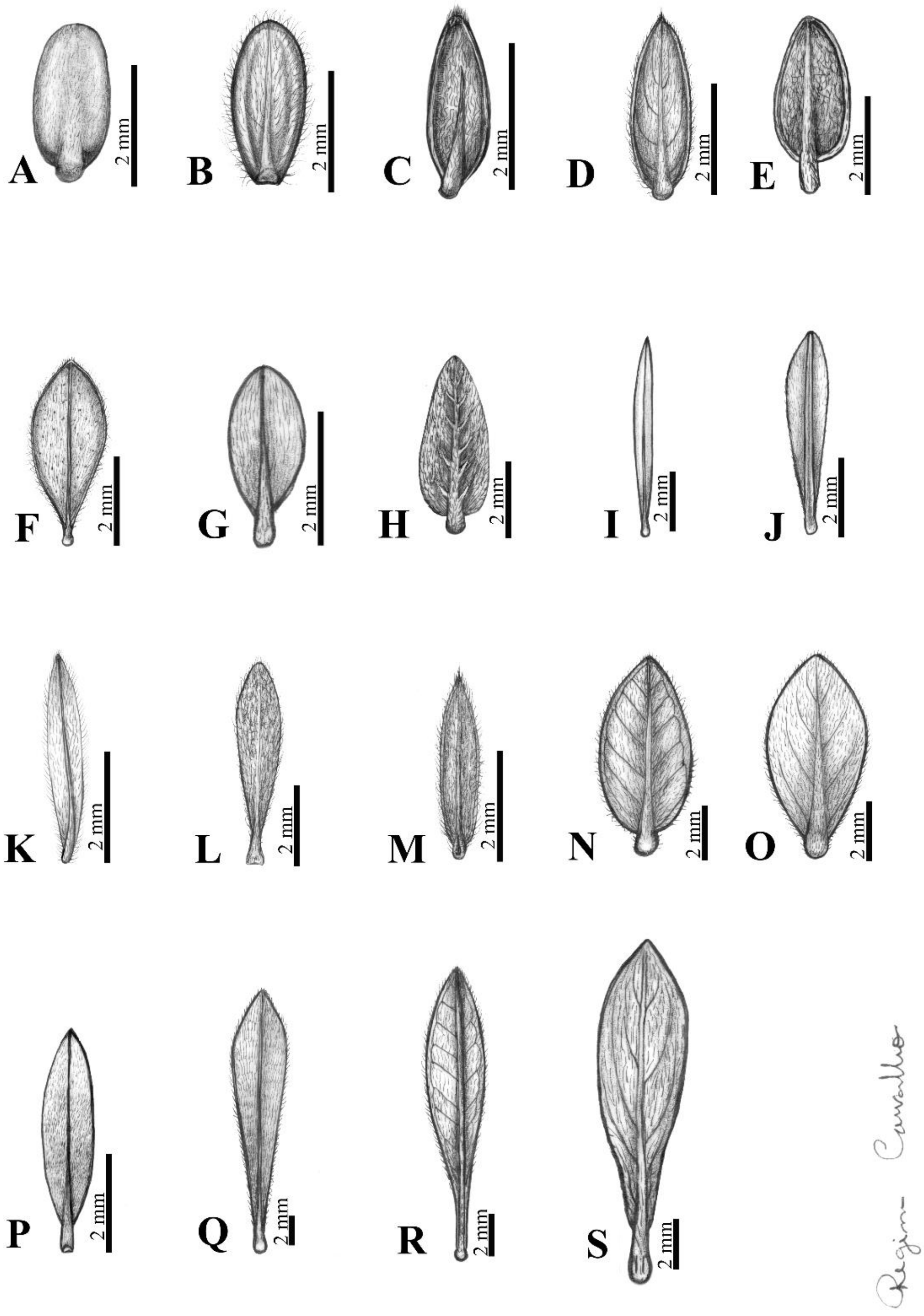

FIGURE 3. Leaf shape and abaxial surface for all *Piptolepis* species organised from smaller to larger size. **A.** *P. glaziouana*. **B.** *P. leptospermoides*. **C.** *P. corymbosa*. **D.** *P. imbricata*. **E.** *P. speciosa*. **F.** *P. buxoides*. **G.** *P. redacta*. **H.** *P. procumbens*. **I.** *P. ericoides*. **J.** *P. riparia*. **K.** *P. pilosa*. **L.** *P. elaeoda*. **M.** *P. fulgens*. **N.** *P. campestris*. **O.** *P. schultziana*. **P.** *P. pseudomyrtus*. **Q.** *P. gardneri*. **R.** *P. monticola*. **S.** *P. oleaster*. Drawings by Regina Carvalho.

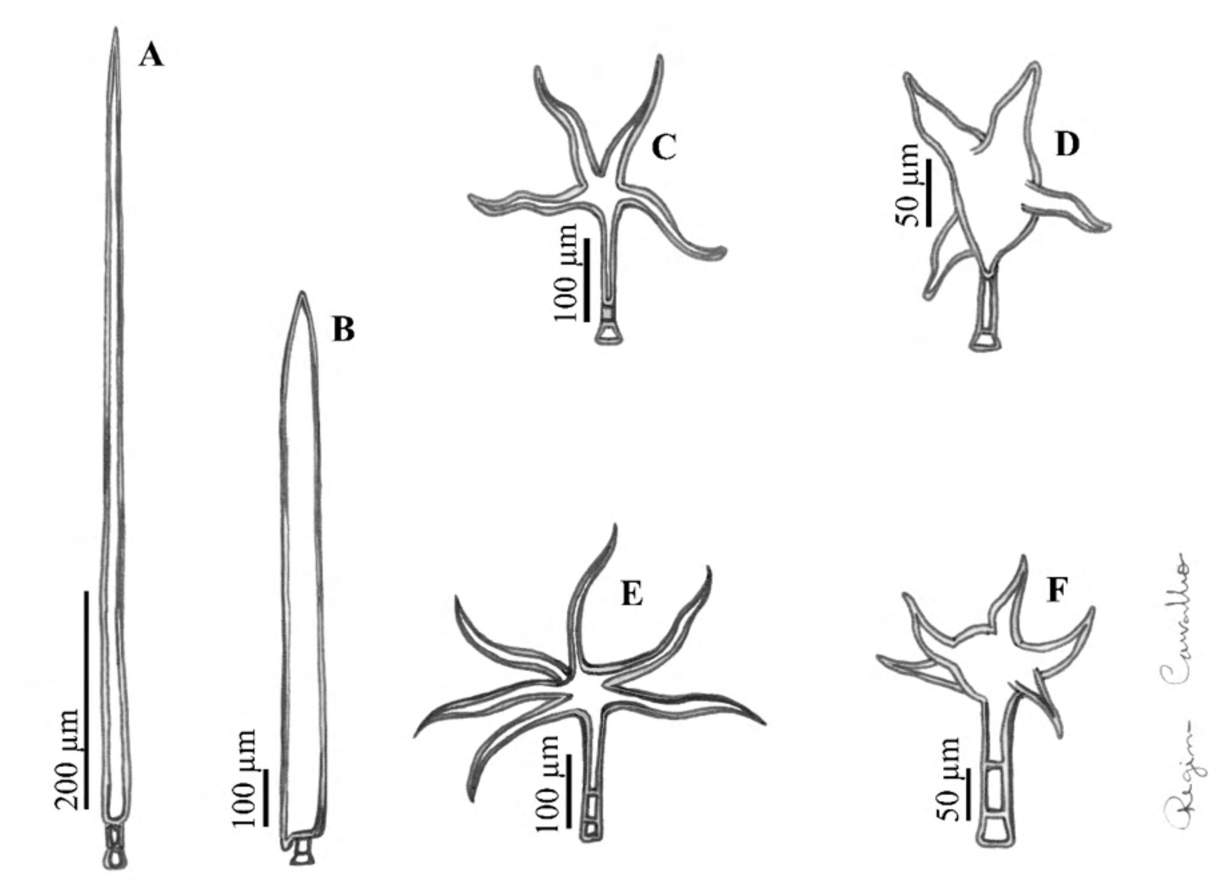

FIGURE 4. Trichomes in *Piptolepis*. **A.** unbranched, long and thin (*P. riparia*). **B.** unbranched, long, thin with top cell enlarged above stalk—auriculate (*P. monticola*). **C.** branched, 3- to 5-armed (*P. schultziana*). **D.** branched, 3- to 5-armed, bladder-like (*P. monticola*). **E.** simple stellate (*P. schultziana*). **F.** stellate, bladder-like (*P. oleaster*). Drawings by Regina Carvalho. Based from Wagner *et al.* (2014).

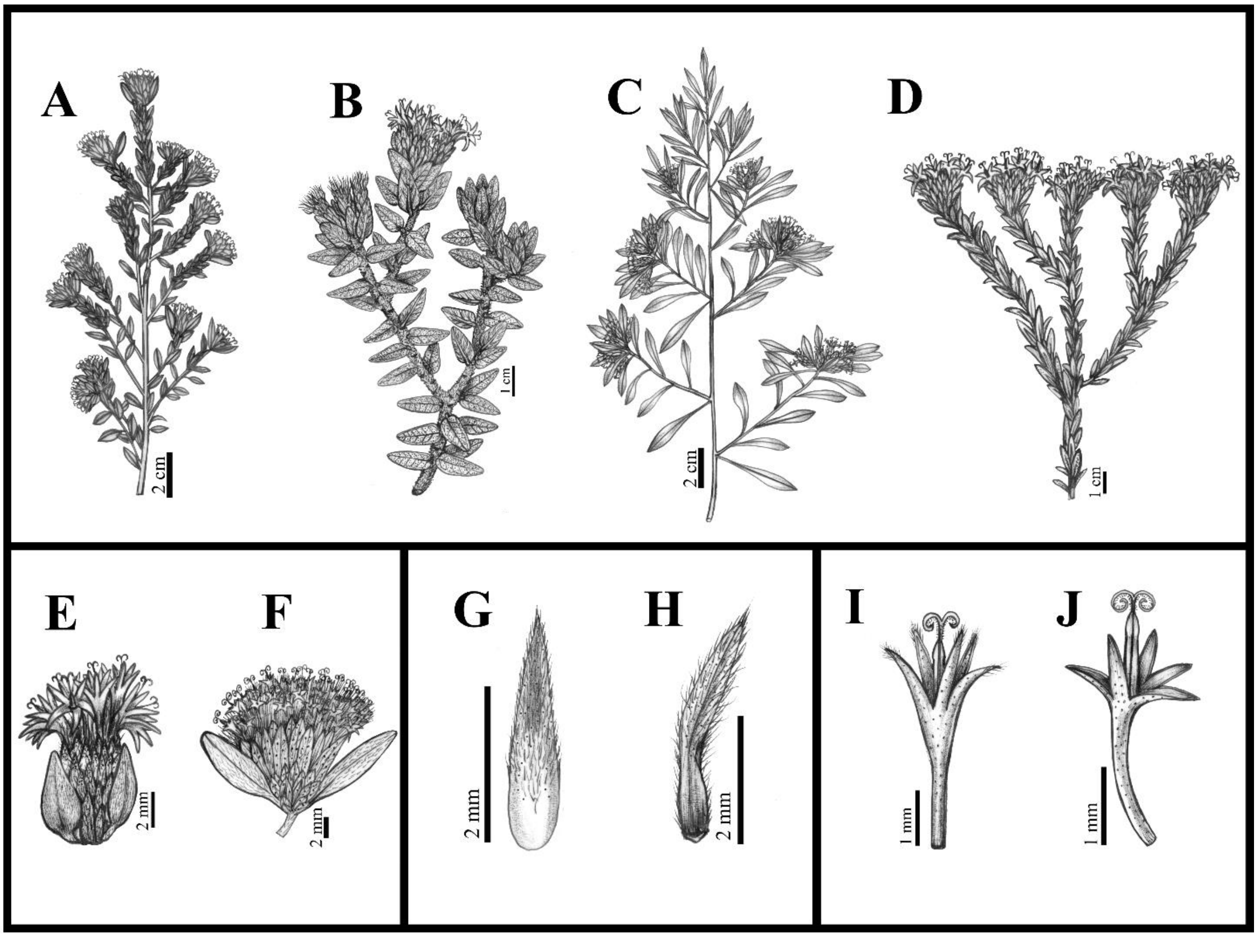

FIGURE 5. A–C. Inflorescences in *Piptolepis*. **A.** raceme of capitula (*P. pseudomyrtus*). **B.** pseudoglomerule of capitula (*P. procumbens*). **C.** raceme of pseudoglomerule (*P. gardneri*). **D.** corymb of capitula (*P. corymbosa*). **E–F.** Capitula. **E.** sessile, cylindrical (*P. procumbens*). **F.** pedunculate, campanulate (*P. pseudomyrtus*). **G–H.** Phyllaries. **G.** scarious (*P. elaeoda*). **H.** leaf-like upper half (*P. fulgens*). **I–J.** Florets. **I.** pubescent (*P. fulgens*). **J.** glabrous (*P. speciosa*). Drawings by Regina Carvalho.

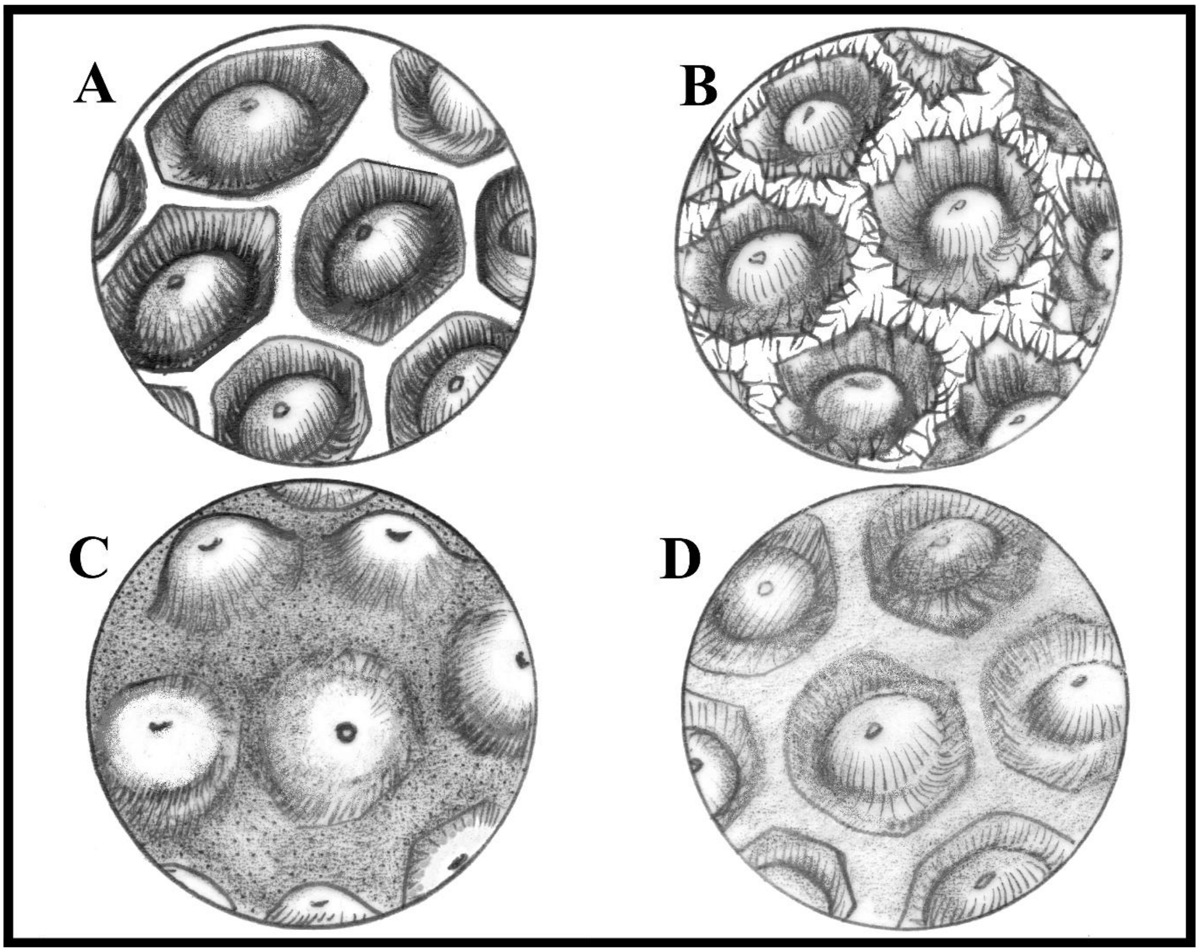

FIGURE 6. Receptacle surface in *Piptolepis*. **A.** areolate (*P. ericoides*). **B.** fimbrillate (*P. fulgens*). **C.** scrobiculate (*P. glaziouana*). **D.** foveolate (*P. leptospermoides*). Drawings by Regina Carvalho.

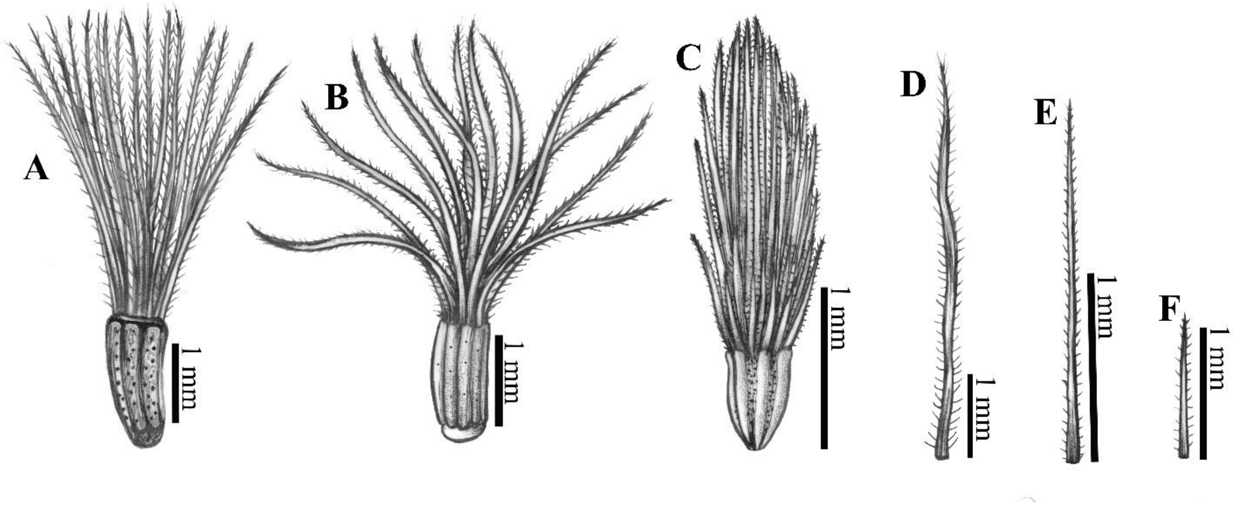

FIGURE 7. Cypselae and pappus in *Piptolepis*. **A–C.** Cypselae shape. **A.** prismatic (*P*. *pilosa*). **B.** cylindrical (*P*. *redacta*). **C.** turbinate (*P*. *fulgens*). **D–F.** Pappus elements. **D.** inner series, barbellate (*P*. *pilosa*). **E.** inner series, serrulate (*P*. *fulgens*). **F.** outer series, serrulate (*P*. *fulgens*). Drawings by Regina Carvalho.

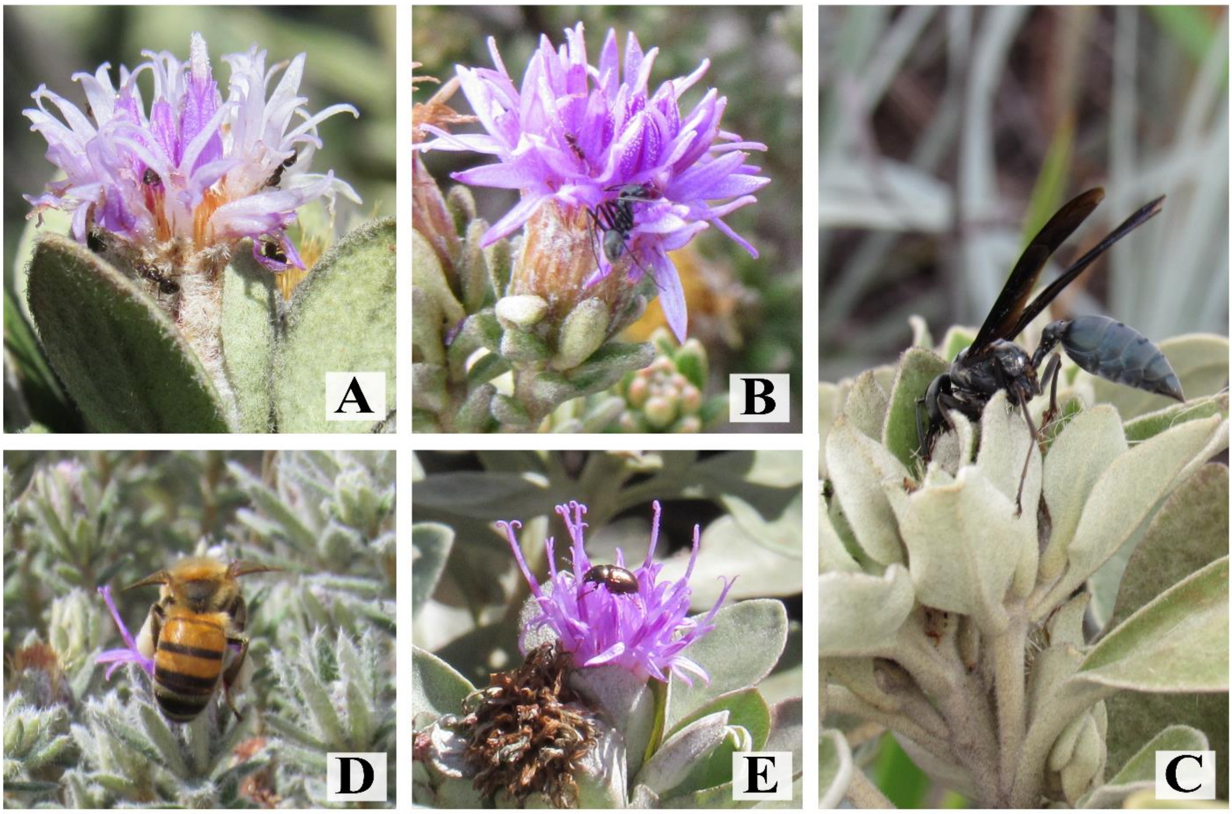

FIGURE 8. A–E. Visiting insects observed in *Piptolepis* flowers. **A.** Ants in *P. campestris* capitula. **B.** Ants in *P. glaziouana* capitula. **C.** Wasps in *P. oleaster* inflorescence. **D.** Bees in *P. pilosa* capitula. **E.** Beetle in *P. monticola* capitula. Photographs by J.B. Cândido.

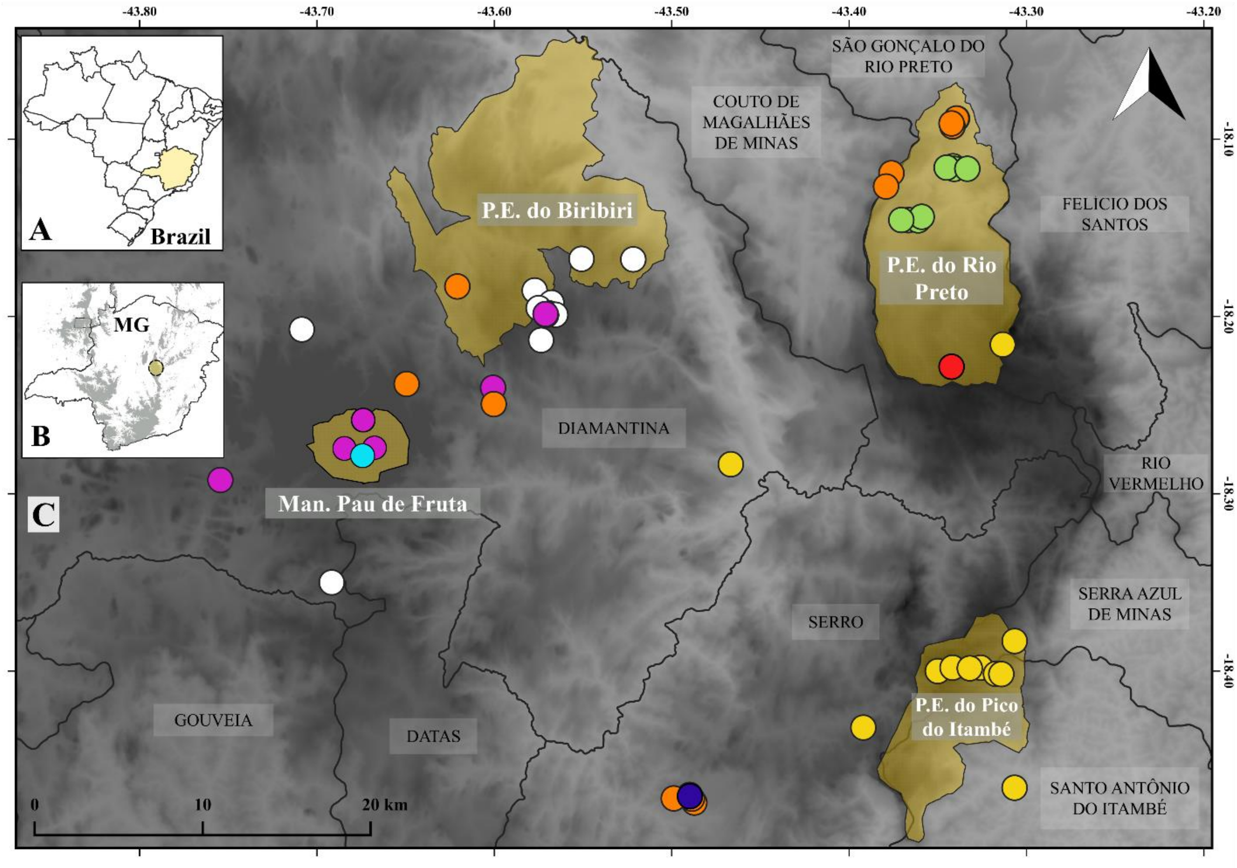

FIGURE 9. Map of protected areas. **A.** Brazil with the state of Minas Gerais in the spotlight. **B.** Regions of Highlighted Protected Areas. **C.** State and Municipality Protected Areas with *Piptolepis* species. *P. fulgens* (red circle), *P. glaziouana* (purple circle), *P. gardneri* (dark blue circle), *P. monticola* (yellow circle), *P. oleaster* (orange circle), *P. procumbens* (light blue circle), *P. riparia* (light green circle).

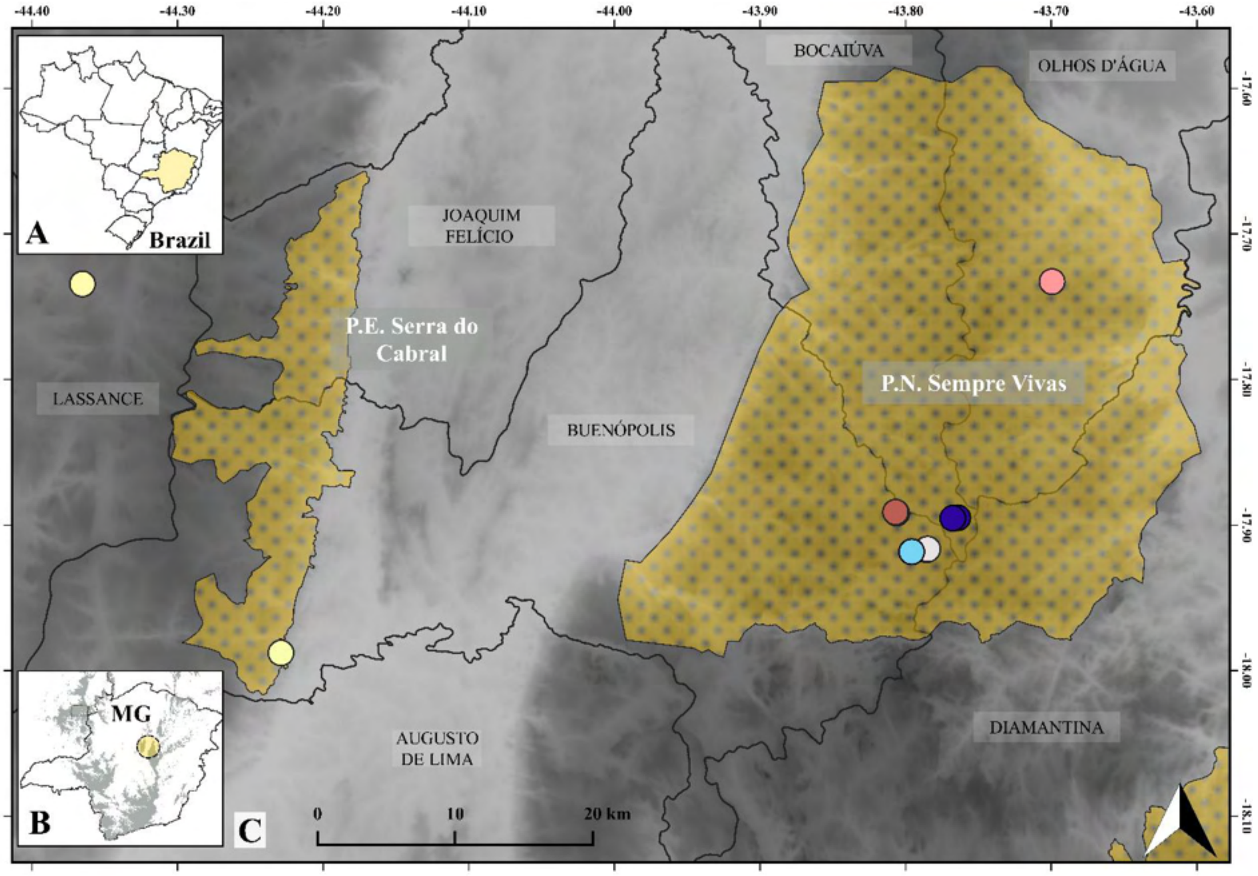

FIGURE 10. Map of protected areas. **A.** Brazil with the state of Minas Gerais in the spotlight. **B.** Regions of Highlighted Protected Areas. **C.** State and National Protected Areas with *Piptolepis* species. *P. corymbosa* (gray circle), *P. elaeoda* (light blue circle), *P. ericoides* (little yellow circle), *gardneri* (dark blue circle), *P. pilosa* (brown circle), *P. speciosa* (pink circle).

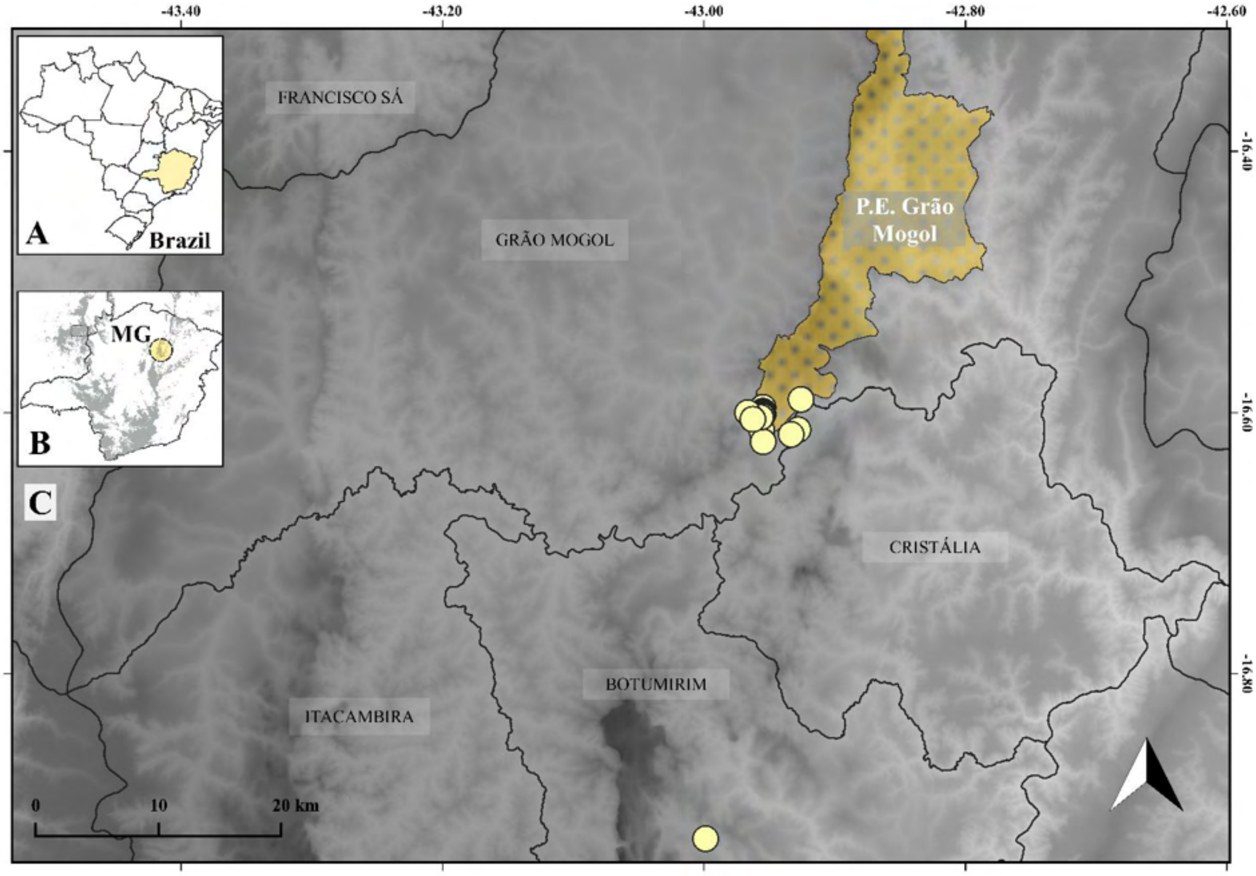

FIGURE 11. Map of protected areas. **A.** Brazil with the state of Minas Gerais in the spotlight. **B.** Regions of Highlighted Protected Areas. **C.** State Protected Areas with *Piptolepis ericoides* (little yellow circle).

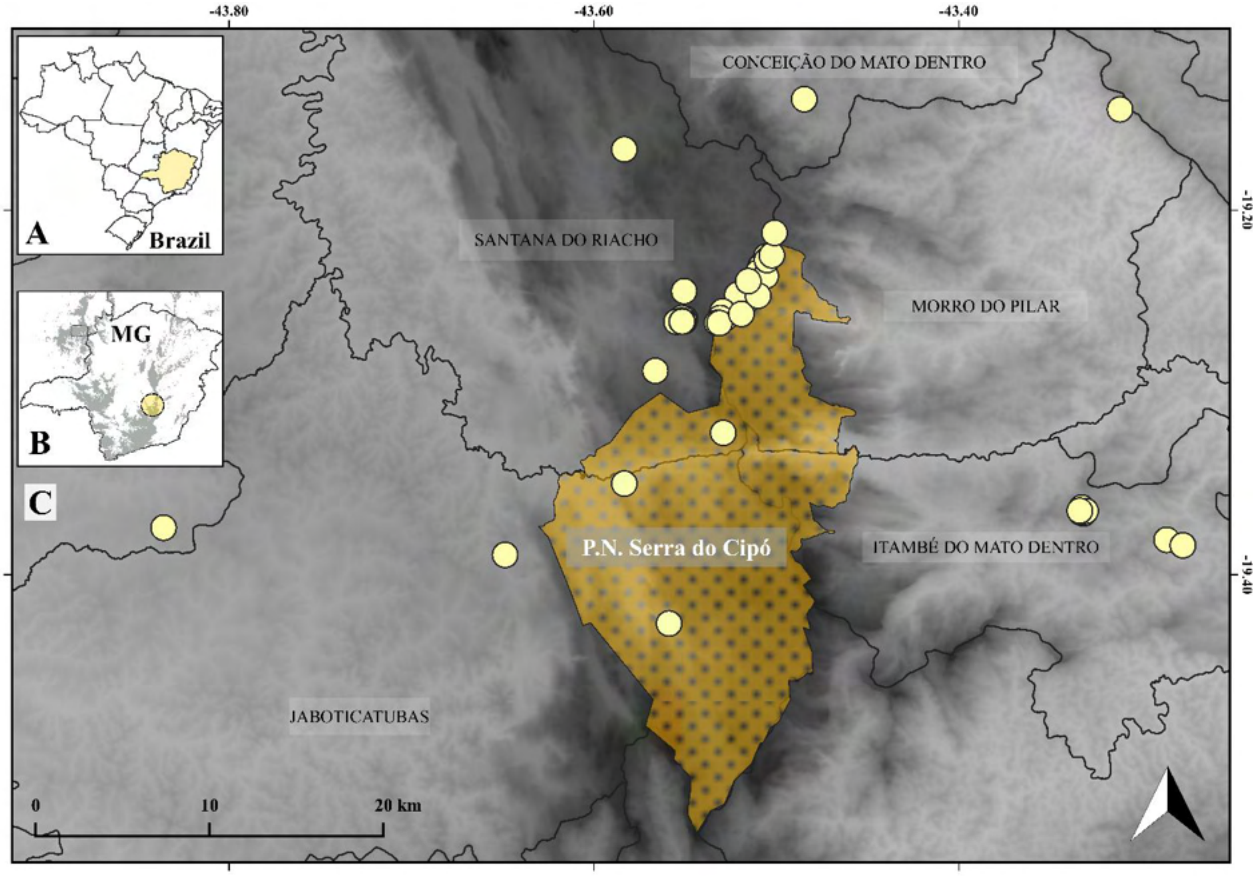

FIGURE 12. Map of protected areas. **A.** Brazil with the state of Minas Gerais in the spotlight. **B.** Regions of Highlighted Protected Areas. **C.** National Protected Areas with *Piptolepis ericoides* (little yellow circle).

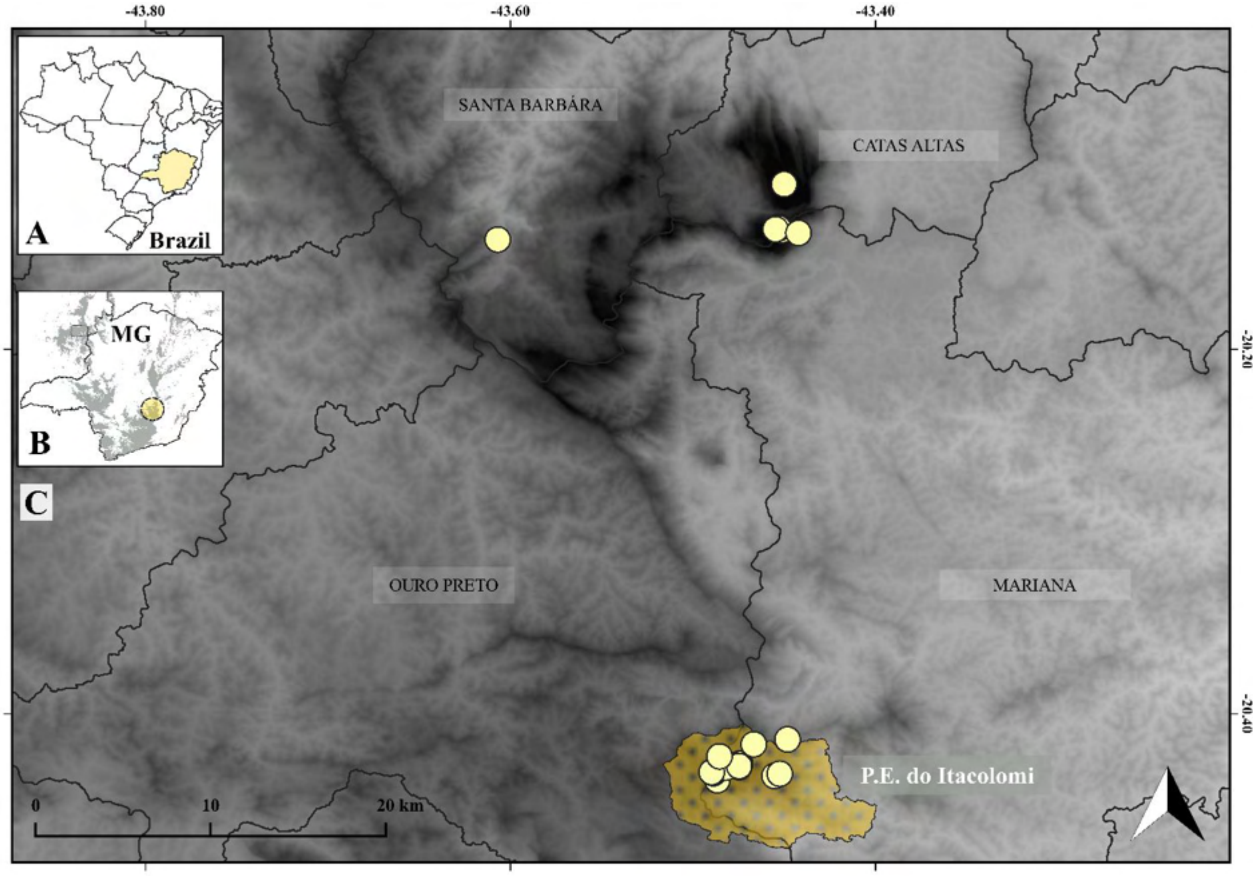

FIGURE 13. Map of protected areas. **A.** Brazil with the state of Minas Gerais in the spotlight. **B.** Regions of Highlighted Protected Areas. **C.** State Protected Areas with *Piptolepis ericoides* (little yellow circle).

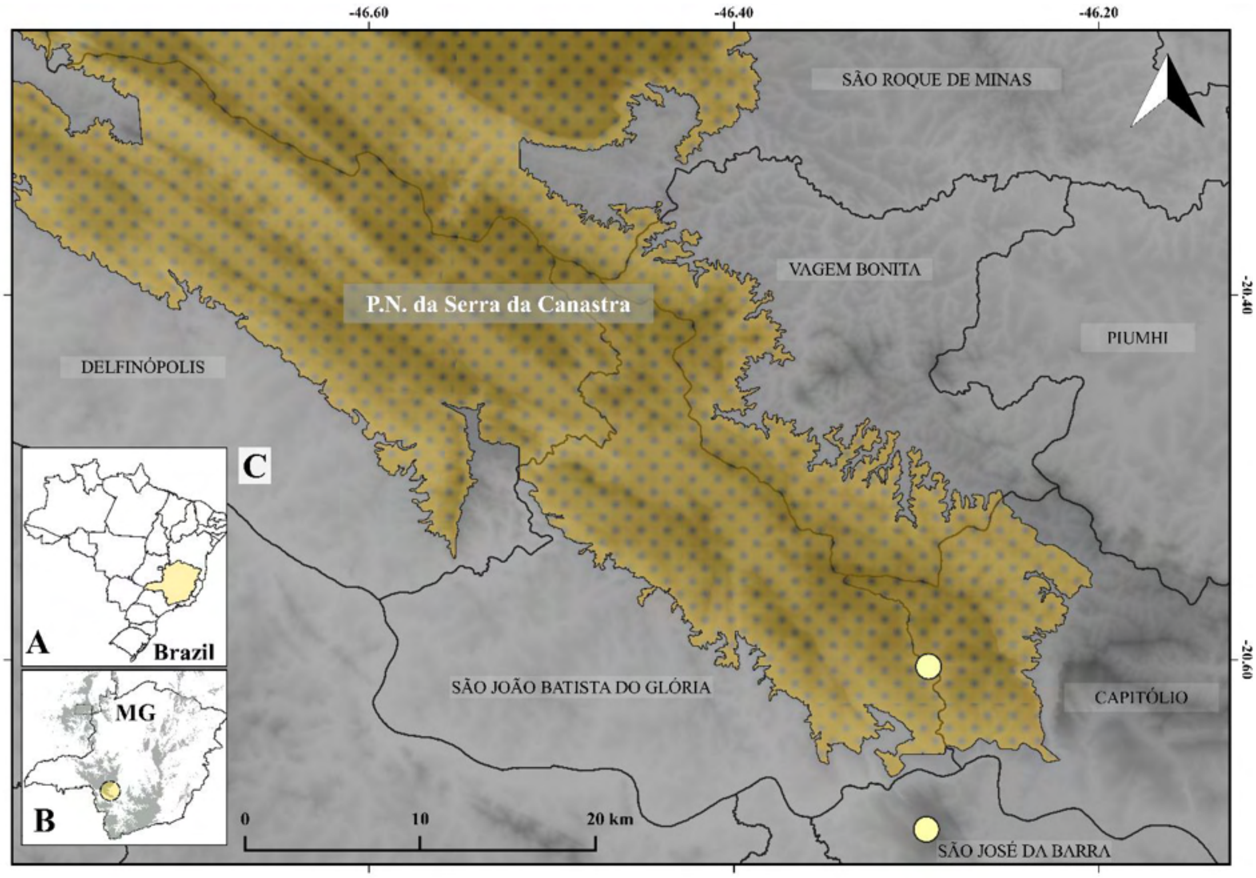

FIGURE 14. Map of protected areas. **A.** Brazil with the state of Minas Gerais in the spotlight. **B.** Regions of Highlighted Protected Areas. **C.** National Protected Areas with *Piptolepis ericoides* (little yellow circle).

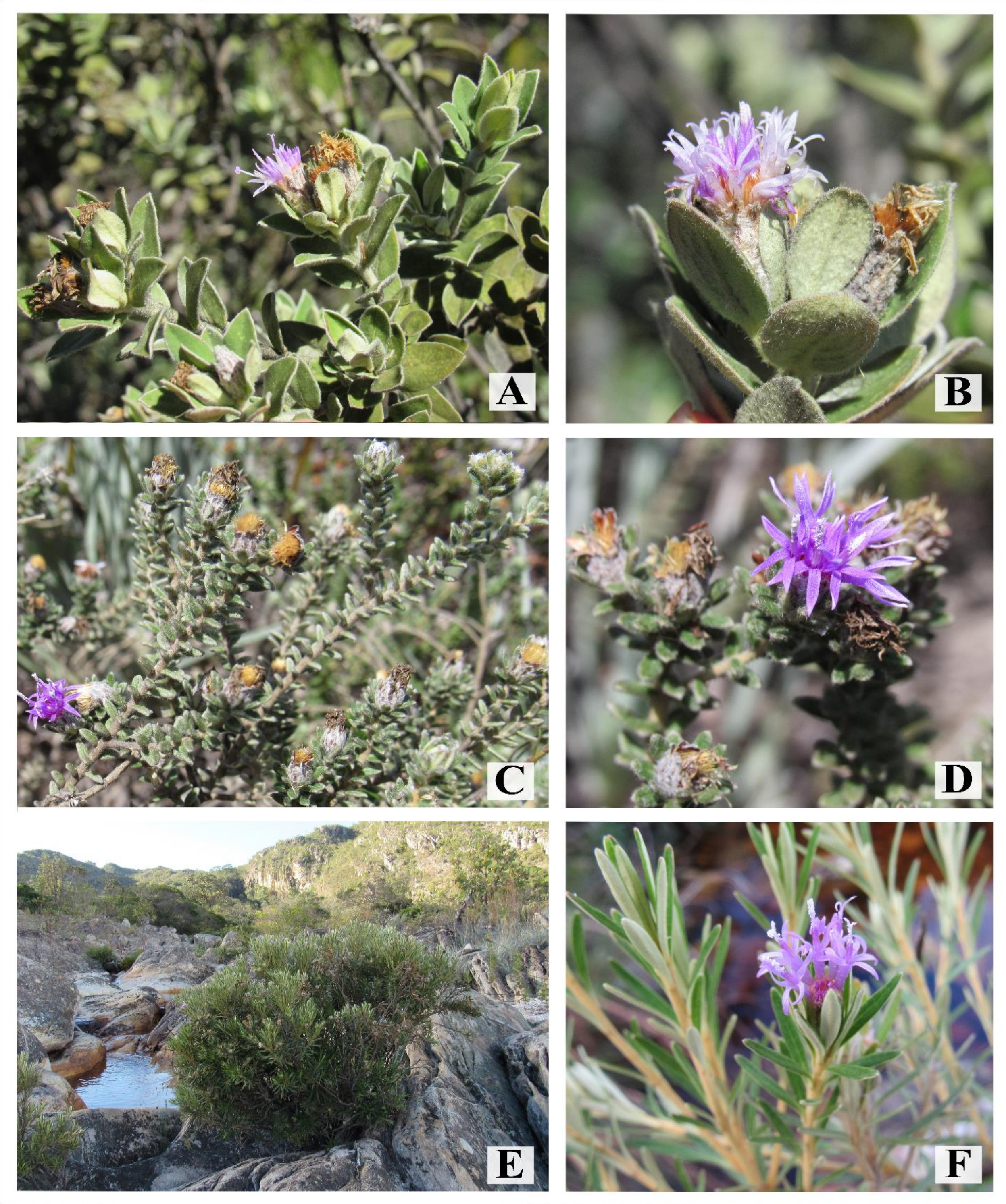

FIGURE 15. A–B. *Piptolepis campestris*. **A.** Leaf arrangement. **B.** Capitulum. **C–D.** *P. corymbosa*. **C.** Leaf arrangement and inflorescence. **D.** Capitulum. **E–F.** *P. ericoides*. **E.** Habit. **F.** Leaf arrangement and capitulum. **A–F.** Photographs by J.B. Cândido.

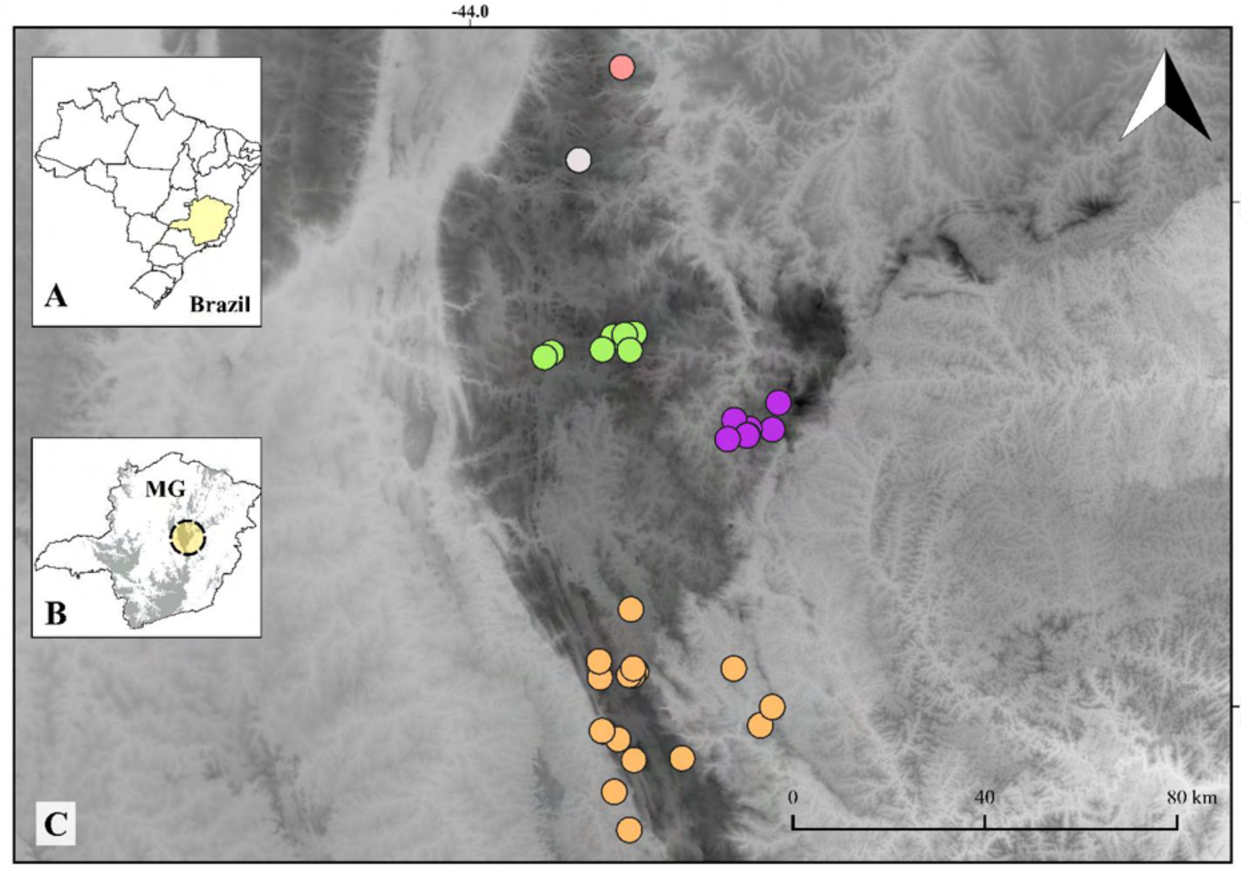

FIGURE 16. Distribution map. **A.** Brazil with Minas Gerais state highlighted. **B.** Espinhaço Range in Minas Gerais: Diamantina Plateau highlighted. **C.** Distribution of *Piptolepis campestris* (light green circle), *P. corymbosa* (gray circle), *P. imbricata* (purple circle), *P. schultziana* (orange circle), *P. speciosa* (pink circle) in Espinhaço Range of Minas Gerais.

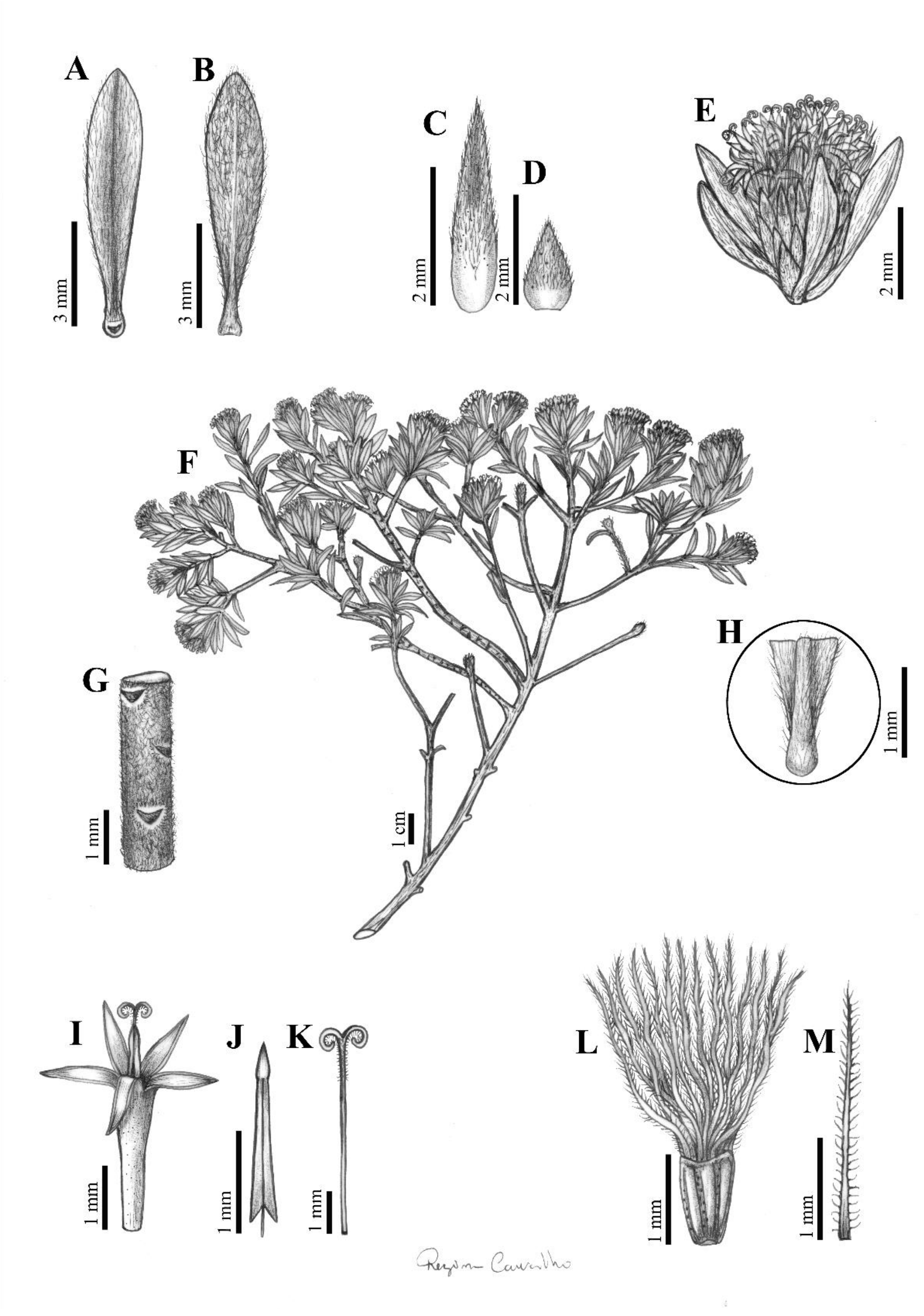

FIGURE 17. *Piptolepis elaeoda* sp. nov. **A.** Leaf, adaxial surface. **B.** Leaf, abaxial surface. **C.** Inner phyllaries. **D.** Outer phyllaries. **E.** Capitulum. **F.** Flowering branch with inflorescence in raceme. **G.** Stems with leaf scars. **H.** Pad-like leaf sheath. **I.** Corolla, androecium and style. **J.** Anther. **K.** Style. **L.** Cypsela. **M.** Pappus element. **A–M.** Drawings by Regina Carvalho.

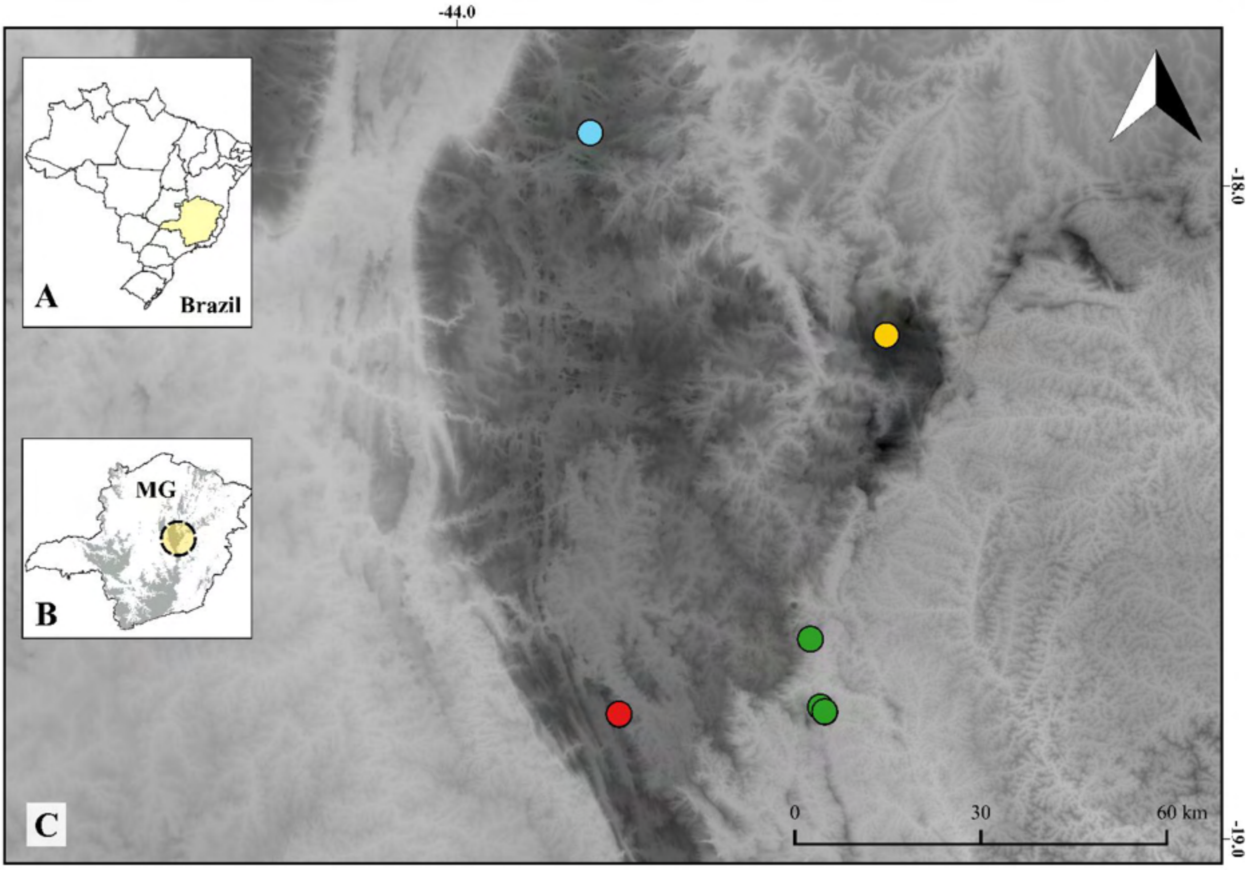

FIGURE 18. Distribution map. **A.** Brazil with Minas Gerais state highlighted. **B.** Espinhaço Range in Minas Gerais: Diamantina Plateau highlighted. **C.** Distribution of *P. fulgens* (yellow circle), *P. pseudomyrtus* (green circle), *P. redacta* (red circle), *P. elaeoda* (light blue circle) in Espinhaço Range of Minas Gerais.

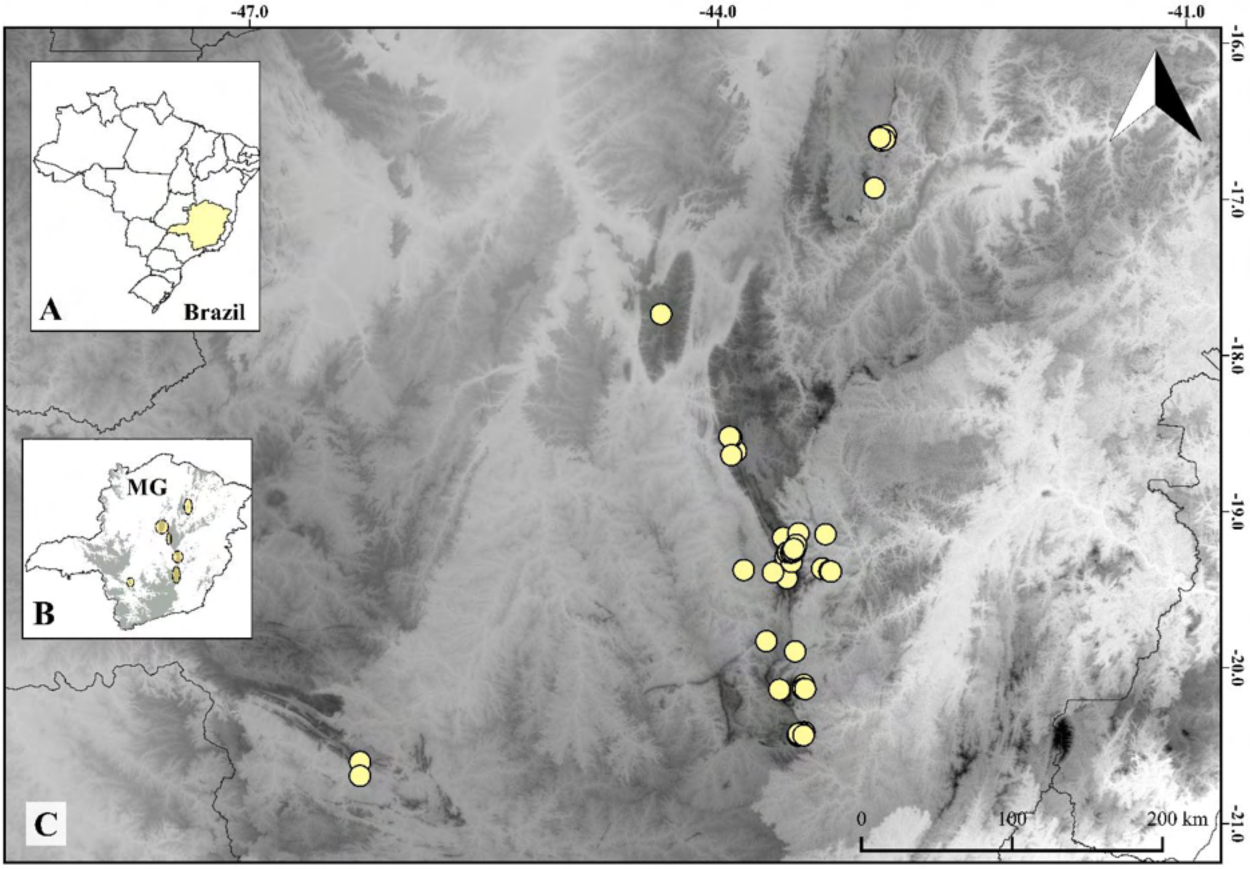

FIGURE 19. Distribution map. **A.** Brazil with Minas Gerais state highlighted. **B.** *Piptolepis ericoides* population highlighted in *campos rupestres* of Minas Gerais. **C.** Distribution of *Piptolepis ericoides* (little yellow circle) in mountains of Minas Gerais.

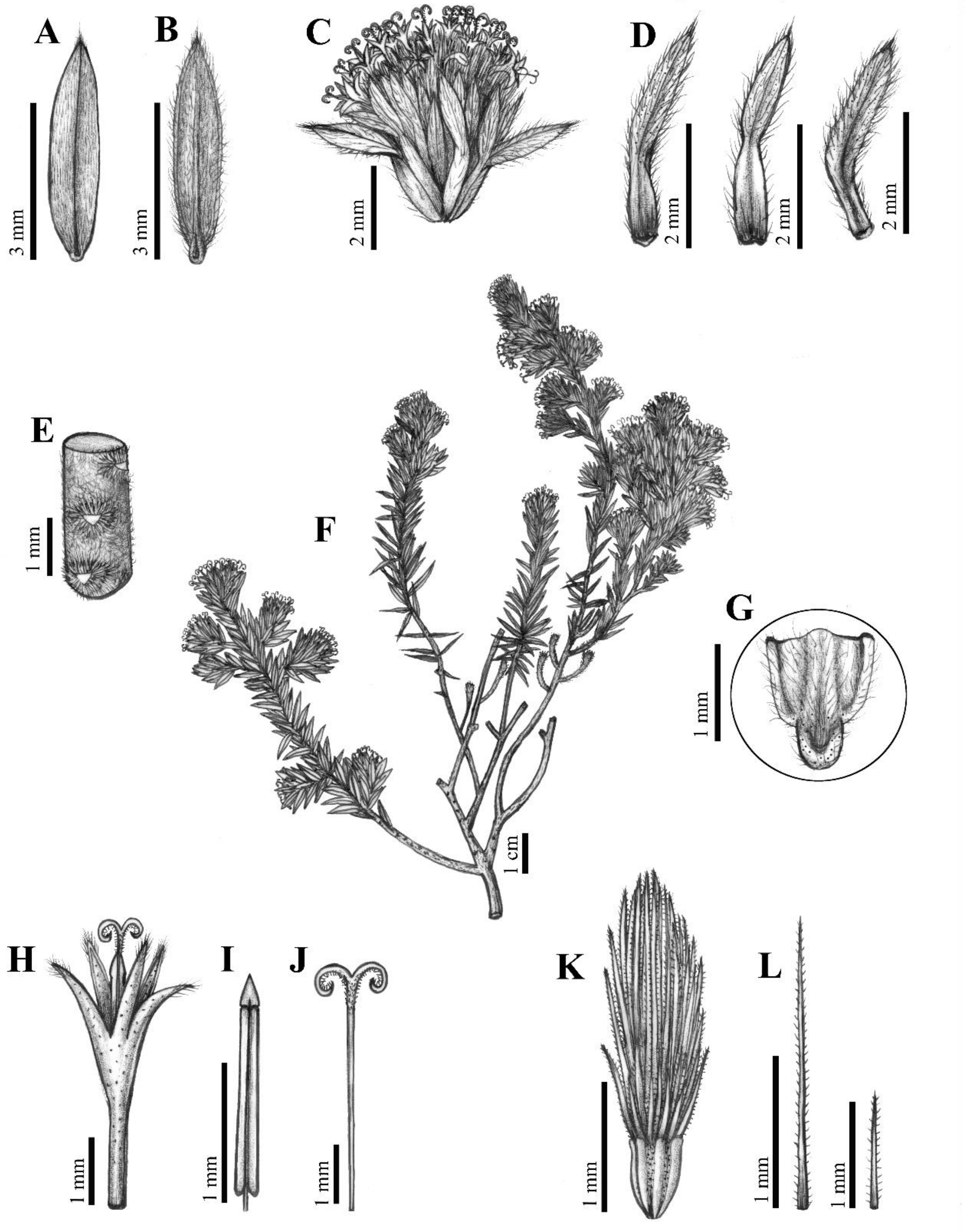

FIGURE 20. *Piptolepis fulgens* sp. nov. **A.** Leaf, adaxial surface. **B.** Leaf, abaxial surface. **C.** Capitulum. **D.** Outer and inner phyllaries. **E.** Stems with leaf scars. **F.** Flowering branch with inflorescence in raceme. **G.** Pad-like leaf sheath. **H.** Corolla, androecium and style. **I.** Anther. **J.** Style. **K.** Cypsela. **L.** Pappus elements. **A–L.** Drawings by Regina Carvalho.

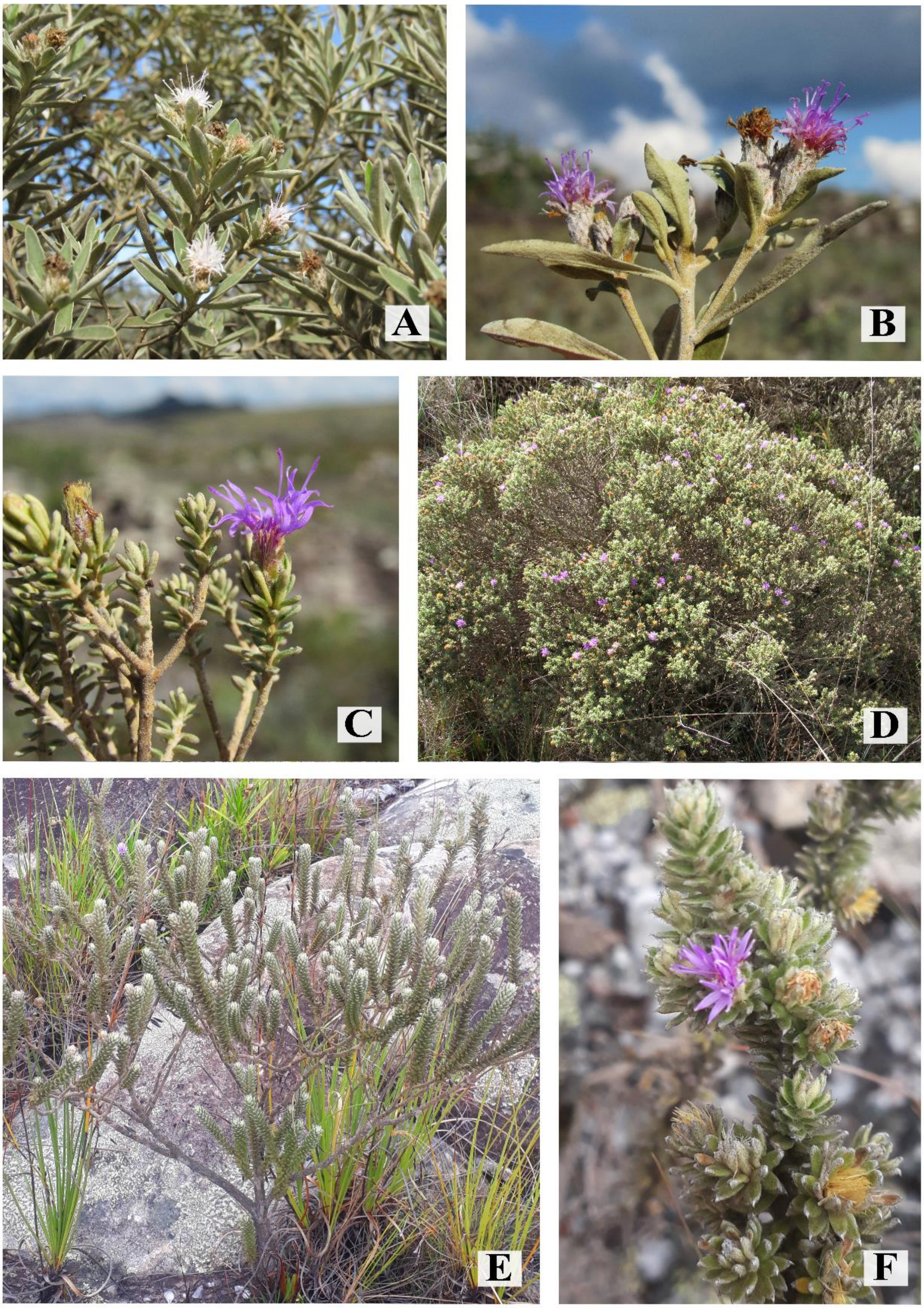

FIGURE 21. A–B. *Piptolepis gardneri*. **A.** Leaf arrangement. **B.** Capitulum in pseudoglomerules. **C–D.** *P*. *glaziouana*. **C.** Leaf arrangement and capitulum. **D.** Habit. **E–F.** *P*. *imbricata*. **E.** Habit. **F.** Inflorescence in short spike-like racemes. **A–F.** Photographs by J.B. Cândido.

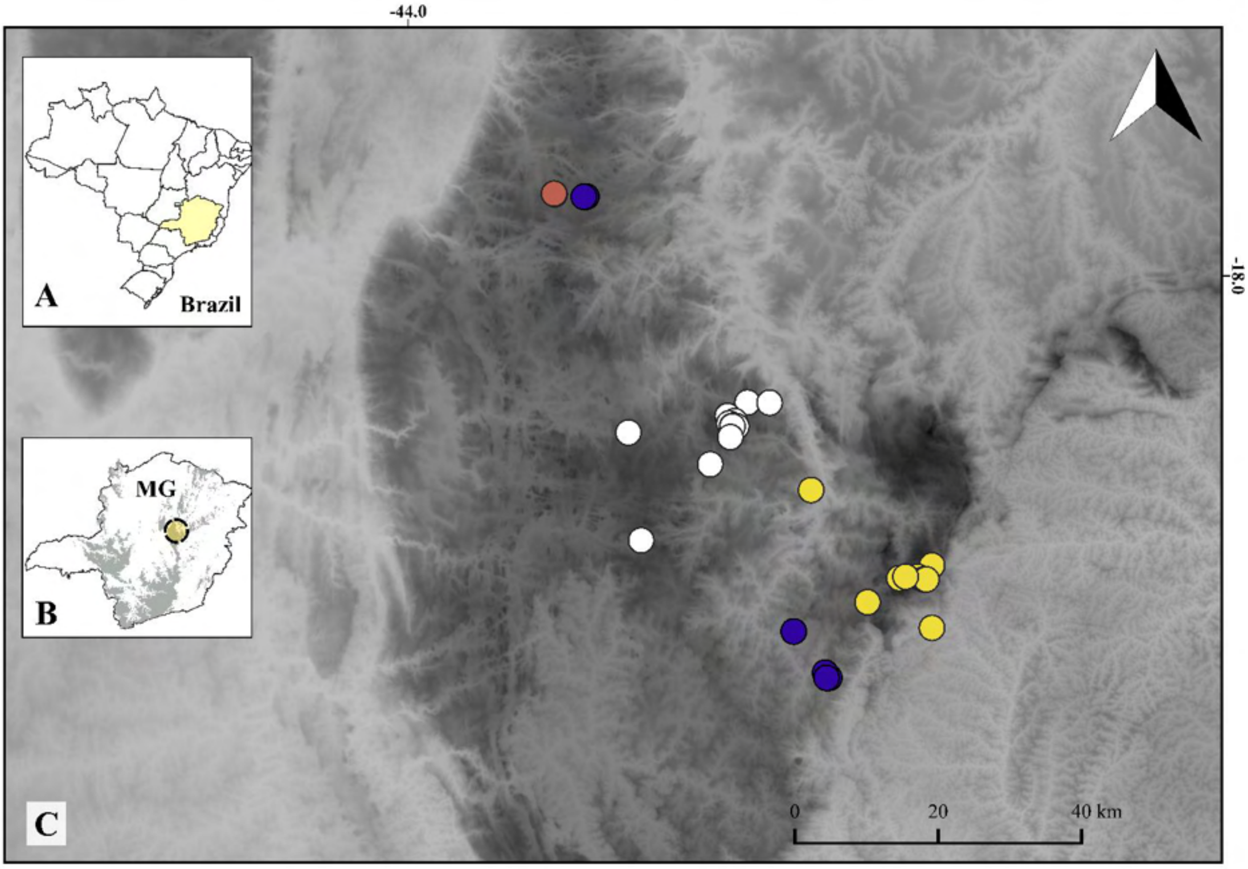

FIGURE 22. Distribution map. **A.** Brazil with Minas Gerais state highlighted. **B.** Espinhaço Range in Minas Gerais: Diamantina Plateau highlighted. **C.** Distribution of *Piptolepis gardneri* (dark blue circle), *P. leptospermoides* (white circle), *P. monticola* (yellow circle), *P. pilosa* (brown circle) in the Diamantina Plateau of the Espinhaço Range of Minas Gerais.

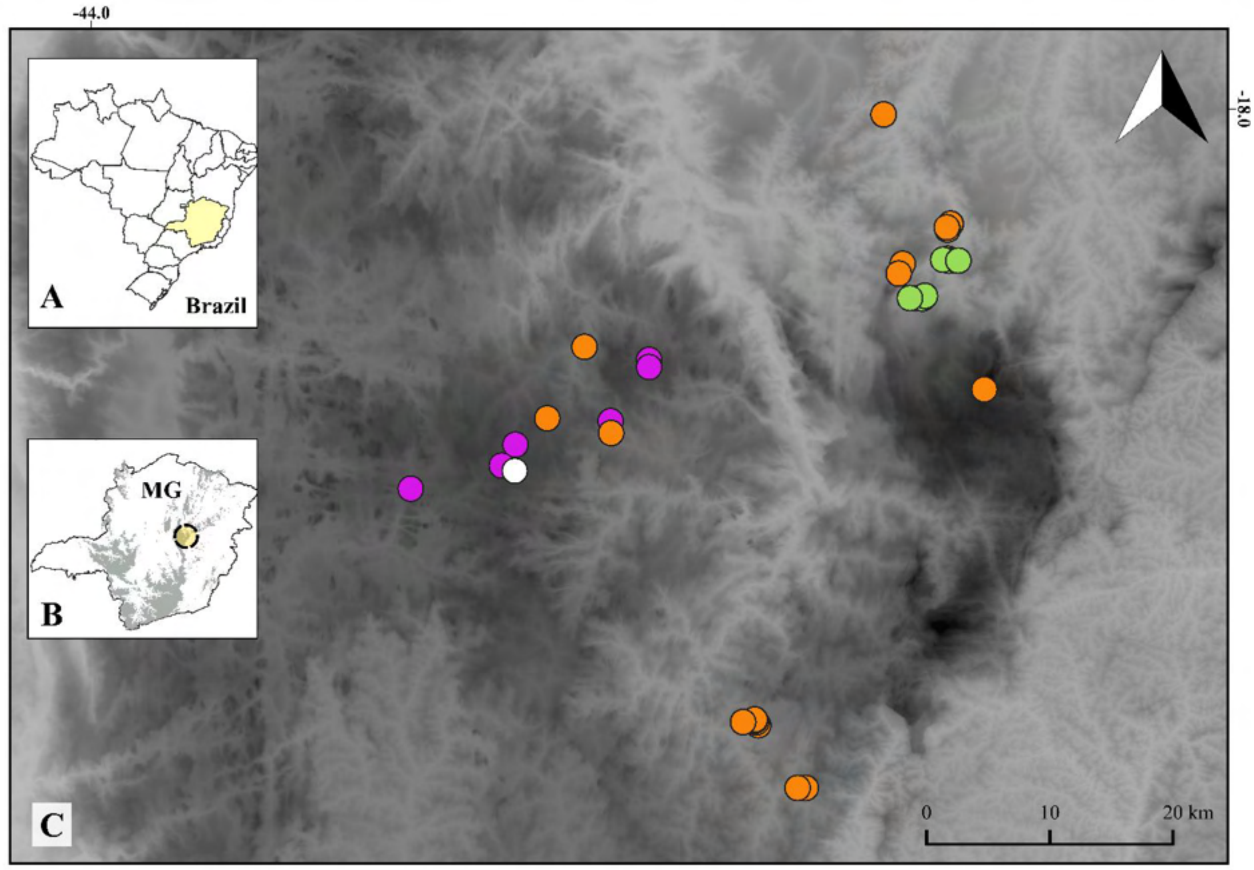

FIGURE 23. Distribution map. **A.** Brazil with Minas Gerais state highlighted. **B.** Espinhaço Range in Minas Gerais: Diamantina Plateau highlighted. **C.** Distribution of *Piptolepis glaziouana* (purple circle), *P. oleaster* (orange circle), *P. procumbens* (white circle), *P. riparia* (light green circle) in the Diamantina Plateau of the Espinhaço Range of Minas Gerais.

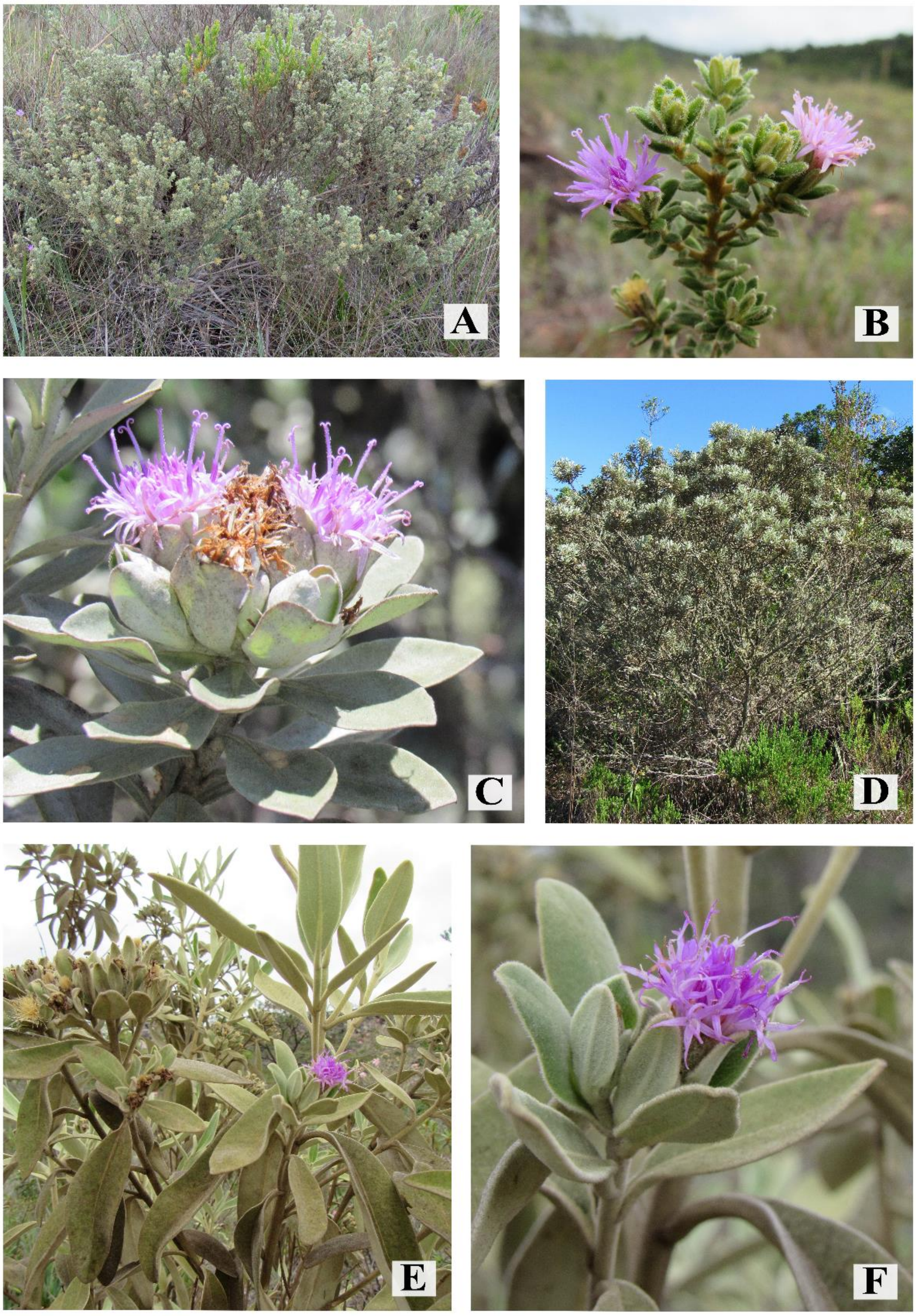

FIGURE 24. A–B. *Piptolepis leptospermoides*. **A.** Habit. **B.** Inflorescence in raceme. **C–D.** *P. monticola*. **C.** Inflorescence in pseudoglomerules. **D.** Habit. **E–F.** *P. oleaster*. **E.** Leaf arrangement. **F.** Capitulum. **A–F.** Photographs by J.B. Cândido.

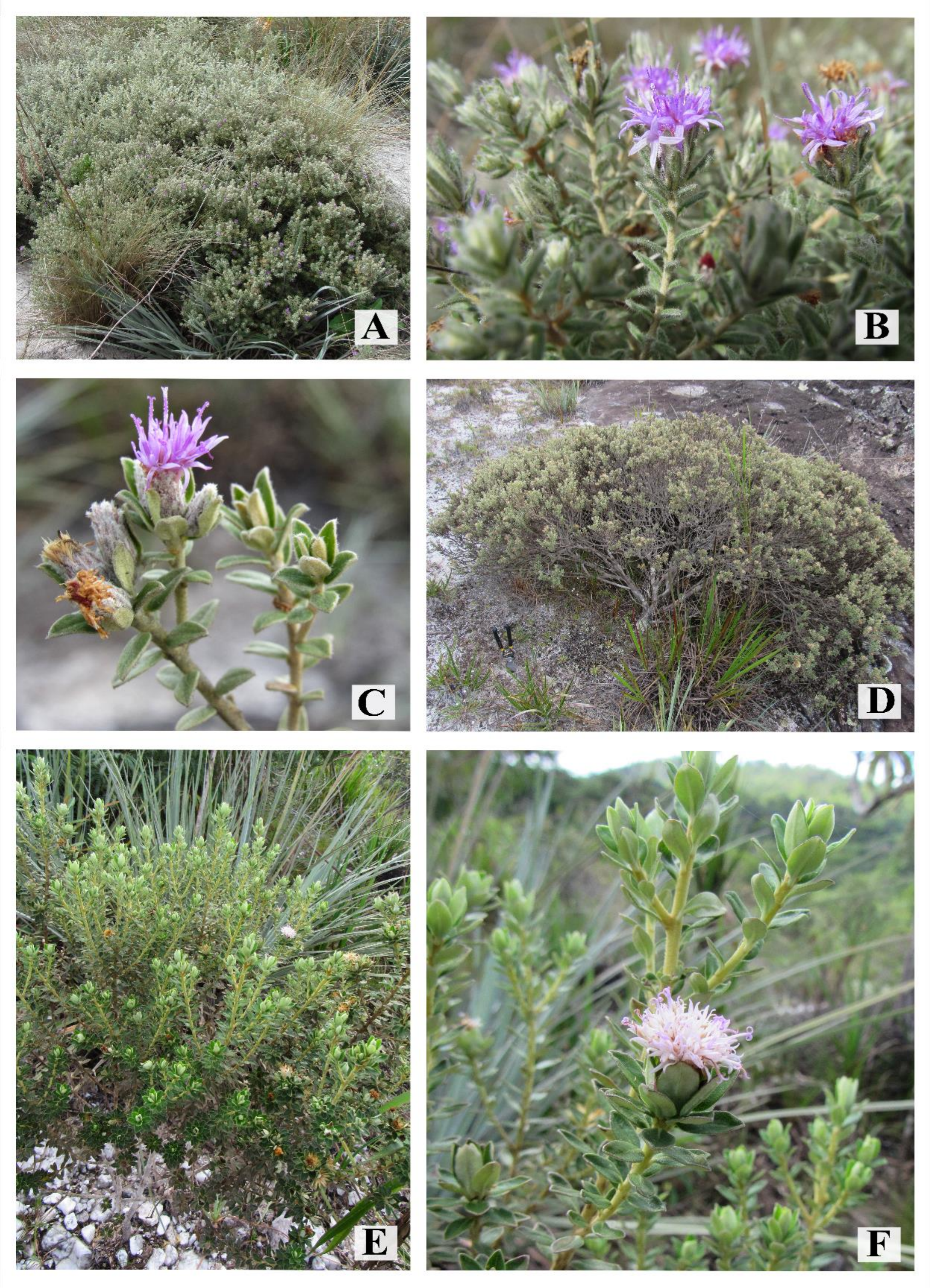

FIGURE 25. A–B. *Piptolepis pilosa*. **A.** Habit. **B.** Leaf arrangement and capitulum. **C–D.** *P. procumbens*. **C.** Inflorescence in pseudoglomerules. **D.** Habit. **E–F.** *P. pseudomyrtus*. **E.** Habit. **F.** Leaf arrangement and capitulum. **A–F.** Photographs by J.B. Cândido.

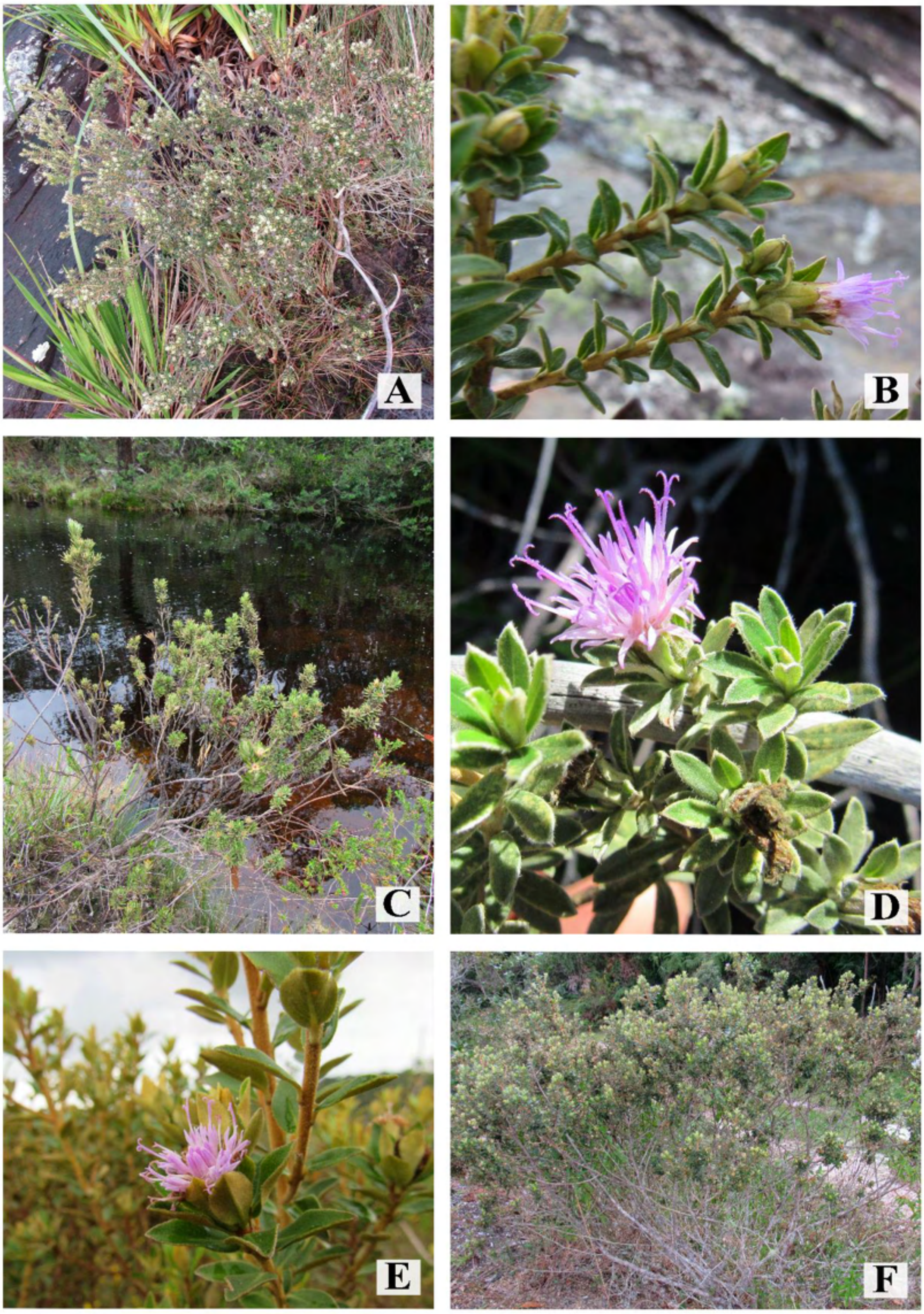

FIGURE 26. A–B. *Piptolepis redacta*. **A.** Habit. **B.** Leaf arrangement and capitulum. **C–D.** *P. riparia*. **C.** Habit. **D.** Capitulum. **E–F.** *P. schultziana*. **E.** Leaf arrangement and capitulum. **F.** Habit. **A–F.** Photographs by J.B. Cândido.

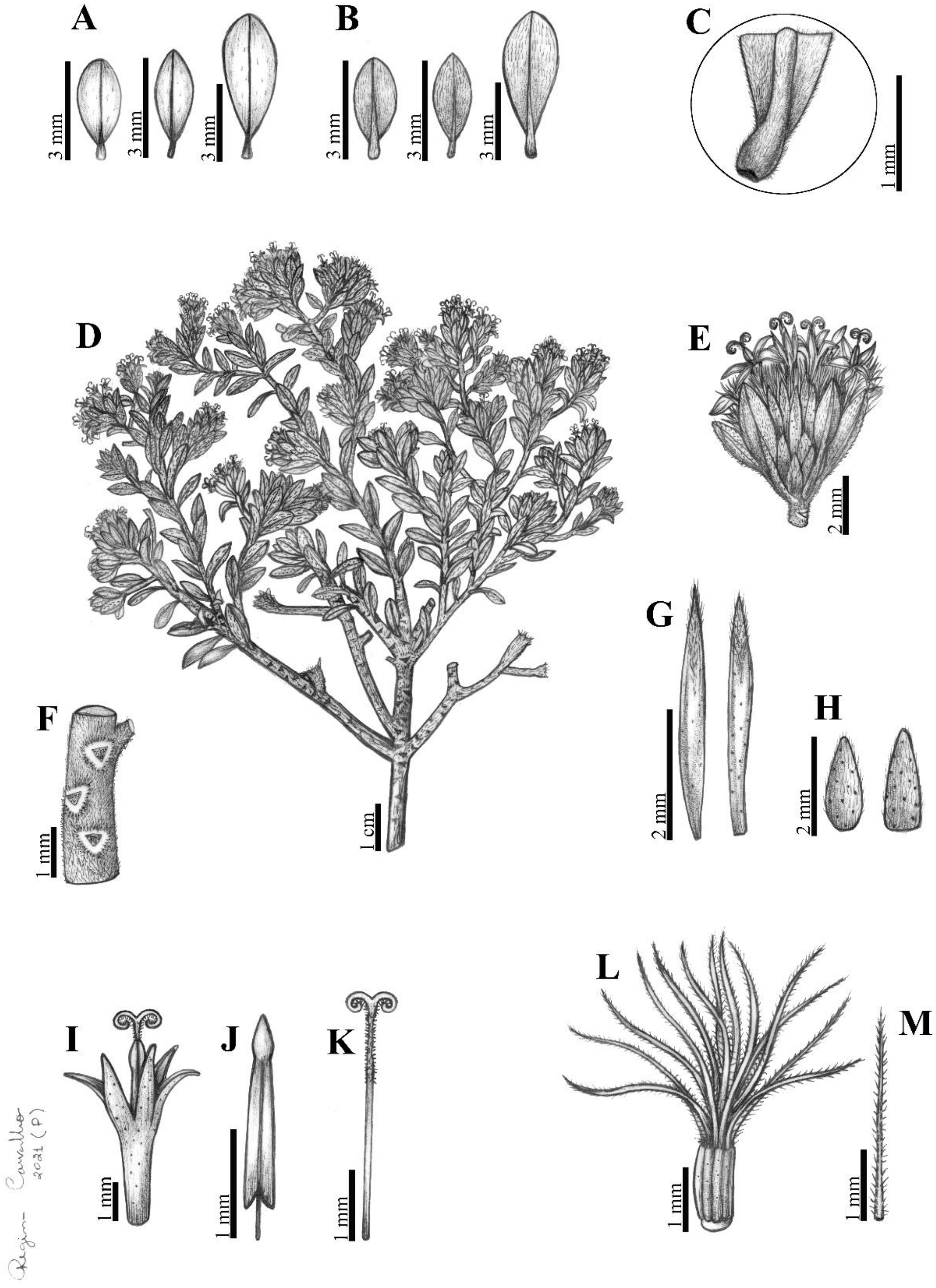

FIGURE 27. *Piptolepis redacta* sp. nov. **A.** Leaf, adaxial surface. **B.** Leaf, abaxial surface. **C.** Pad-like leaf sheath. **D.** Flowering branch with inflorescence in raceme. **E.** Capitulum. **F.** Stems with leaf scars. **G.** Inner phyllaries. **H.** Outer phyllaries. **I.** Corolla, androecium and style. **J.** Anther. **K.** Style. **L.** Cypsela. **M.** Pappus element. **A–M.** Drawings by Regina Carvalho.

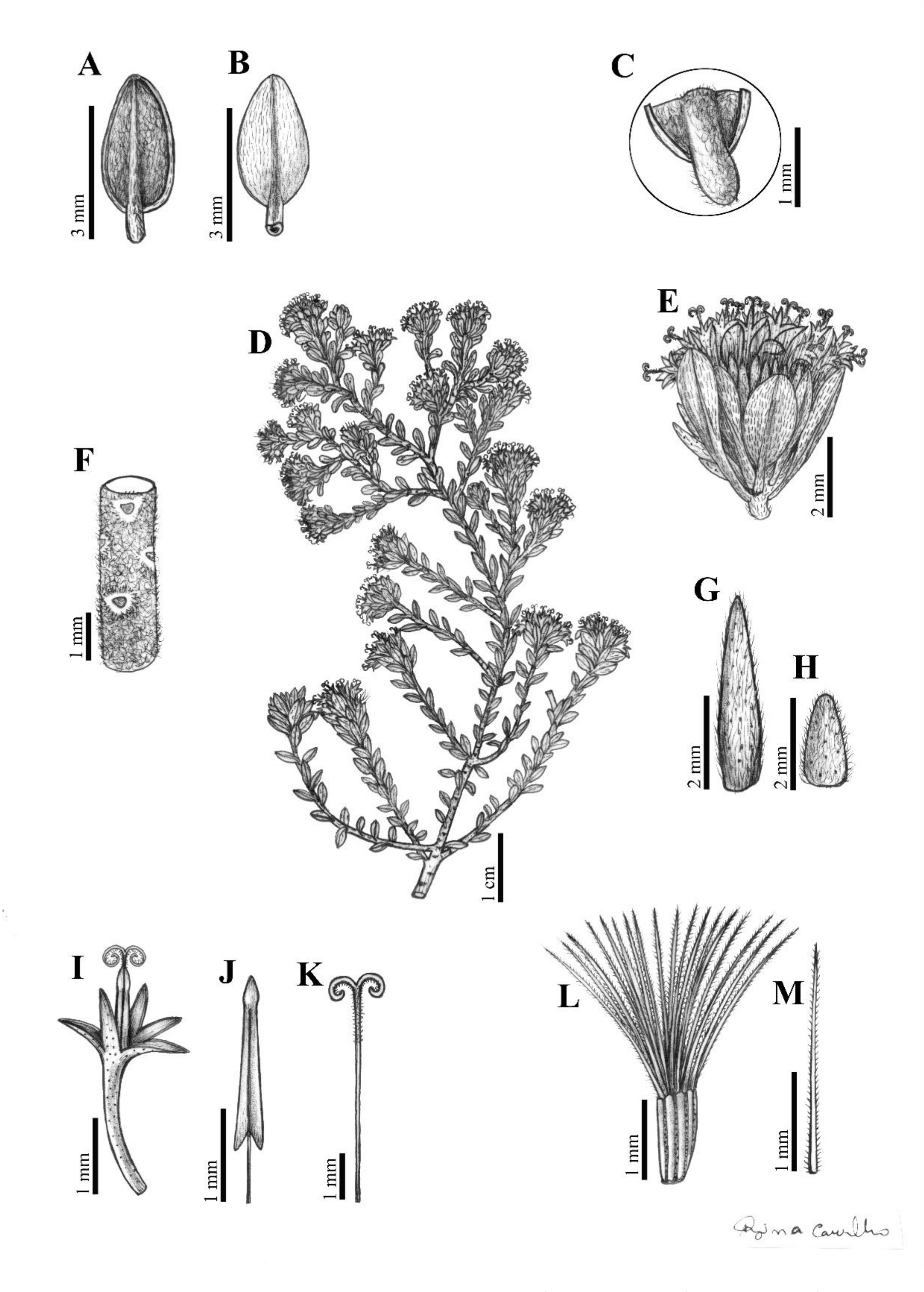

FIGURE 28. *Piptolepis speciosa* sp. nov. **A.** Leaf, adaxial surface. **B.** Leaf, abaxial surface. **C.** Pad-like leaf sheath. **D.** Flowering branch with inflorescence in raceme. **E.** Capitulum. **F.** Stems with leaf scars. **G.** Inner phyllaries. **H.** Outer phyllaries. **I.** Corolla, androecium and style. **J.** Anther. **K.** Style. **L.** Cypsela. **M.** Pappus element. **A–M.** Drawings by Regina Carvalho.

Table 1. *Piptolepis* species, their conservation status (CR − Critically Endangered, DD − Data Deficient, EN − Endangered, NT − Near Threatened) and protected areas where they occur.

Species	**Conservation Status**	**Populations inside of Protected Areas**	**Populations outside of Protected Areas**
1. *P. buxoides*	DD	unknown	unknown
2. *P. campestris*	CR		×
3. *P. corymbosa*	CR	Parque Nacional das Sempre Vivas	
4. *P. elaeoda*	DD	Parque Nacional das Sempre Vivas	
5. *P. ericoides*	NT	Parque Nacional da Serra do Cipó, Parque Estadual de Grão Mogol. Parque Estadual do Itacolomi, Parque Natural do Caraça, Parque Estadual da Serra do Cabral.	×
6. *P. fulgens*	DD	Parque Estadual do Rio Preto	
7. *P. gardneri*	CR	Parque Nacional das Sempre Vivas	×
8. *P. glaziouana*	CR	Área de Proteção Especial Manancial Pau de Fruta	×
9. *P. imbricata*	CR		×
10. *P. leptospermoides*	CR	Parque Estadual do Biribiri	×
11. *P. monticola*	EN	Parque Estadual Pico do Itambé, Parque Estadual do Rio Preto	
12. *P. oleaster*	EN	Parque Estadual do Rio Preto, Parque Estadual do Biribiri	×
13. *P. pilosa*	CR	Parque Nacional das Sempre Vivas	
14. *P. procumbens*	DD	Área de Proteção Especial Manancial Pau de Fruta	
15. *P. pseudomyrtus*	EN		×
16. *P. redacta*	DD		×
17. *P. riparia*	CR	Parque Estadual do Rio Preto	
18. *P. schultziana*	CR		×
19. *P. speciosa*	DD	Parque Nacional das Sempre Vivas	

4 ARTIGO II INVESTIGATING SPECIES MORPHOTYPES IN ANCIENT NEOTROPICAL MOUNTAINS

ARTIGO A SER SUBMETIDO AO PERIÓDICO FLORA – Morphology, Distribution, Functional Ecology of Plants.

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Abstract

The *campos rupestres* have environmental gradients that together with different evolutionary forces select plant traits that generate very narrow ecological niches for most species. *Piptolepis ericoides* Sch.Bip. is endemic to the *campos rupestres* and has a continuous distribution along the North-South cline of the Espinhaço Range in Minas Gerais State (Brazil). During field expeditions and study of herbarium specimens, different morphotypes were observed among populations of the species. Thus, we used multivariate analysis and environmental niche modeling to investigate the geographical and environmental factors acting in these populations and promoting morphological differentiation. Populations with longer leaf length and longer internodes were significatively different than those with shorter leaves and internodes. The edaphic-climatic variation in the areas where the populations occur may explain their morphological differences. Additionally, we did not support the idea of a large expansion of suitable niche in low altitude areas during the Last Glacial Maximum for *P. ericoides* and propose an alternative explanation.

Key words: Asteraceae, Compositae, *campos rupestres*, morphometric analysis, niche modeling

1. Introduction

The Last Interglacial (LIG, c. 120 ka) was characterized by the warmest global surface temperatures during the past 250 ka (ca. 2°C warmer globally). More recently, in the Last Glacial Maximum (LGM; c. 21 ka), the surface temperatures in the tropical region were 3.7 to 4.2°C cooler than the current temperatures, while precipitation varied across South America. During the Mid-Holocene (c. 6 ka), the climate became progressively hotter and more humid (Werneck et al., 2012; Barbosa and Fernandes, 2016; Tierney, 2020).

Some speciation models predict recurrent fluctuations in species geographic range during the Pleistocene, in theses hypotheses the current disjunct of areas of the *campos rupestres* would be a relict of an ancient wide distribution at lower elevation areas during the drier and colder glacial periods (LGM), then this vegetation would have suffer retraction during interglacial periods, warmer and wetter, confining populations in highlands, in top of mountains that acted as refugia (Barres et al., 2019; Dantas-Queiroz et al., 2021). Therefore, these events would have led to expansion and contraction of suitable habitats and variation in population connectivity (Flantua et al., 2019).

In contrast, Barbosa and Fernandes (2016) did not find significant expansion of the *campos rupestres* in their models during the MH and LGM, however the authors consider valid the interglacial refuges in which only some groups of plants present today in this vegetation were able to migrate to lower regions while others remained in highlands. Rapini et al. (2020), on the other hand, consider that the Pleistocene refugium hypothesis has been overemphasized, they proposed a new model, “escape-to-radiate”, in which the lineages are able to evolve and enter new biomes

In the context of climatic changes, the Brazilian *campos rupestres* (highland rocky grasslands) have been classified as old, climatically buffered, infertile landscape, or OCBIL (Hopper, 2009; Silveira et al., 2016; 2020), with high ecological stability climate during the LGM, and constant range of in different times of the past, which suggest that the *campos rupestres* probably remained in these highlands, regardless of Pleistocene climatic oscillation (Rapini et al. 2020).

The *campos rupestres* are found in the states of Bahia and Minas Gerais along the Espinhaço Range, in Iron Quadrangle southern of Espinhaço Range, Serra da Canastra, in the Distrito Federal in states of Goiás and Tocantins, all them in central Brazilian Plateau

(Fernandes, 2016). Within of the Espinhaço Range of Minas Gerais, there are three distinct regions (Echternacht et al. 2011, Bitencourt and Rapini 2013, Colli-Silva et al., 2018) classified by Colli-Silva et al. (2018), as Grão Mogol, Diamantina Plateau and Iron Quadrangle districts. Echternacht et al. (2011), in your work did not find any species shared between Grão Mogol district and the Iron Quadrangle district, highlighting that the geological, climatic and biotic conditions are very different between the northern, central and southern areas of the Espinhaço Range in Minas Gerais.

The diversity of habitat types is also enormous in vegetation type, the quartzitic grasslands, sandy, stony, and waterlogged grassland habitats, rocky outcrops, gallery forests, and relict hilltop forest patches, are the most common habitats (Fernandes, 2016). The *campos rupestres* are characterized by strong winds, seasonal fires, high irradiance, shallow, heavy drainage and/or leaching, and impoverished soils, originating from quartzite, sandstone, or ironstone, in elevations above 800 m a.s.l. (Fernandes, 2016). They display a high floristic diversity, housing 15% of the vascular flora of Brazil while covering only 1% of the country's territory, with significant levels of endemism (Gomes-da-Silva and Forzza 2020). Due to these features, that act as an important environmental filter (Fernandes, 2016), most species in the *campos rupestres* have very narrow ecological niches (Abrahão et al., 2018). The *campos rupestres* also show environmental gradients that together with different evolutionary forces select traits that determine the niche occupied by a certain plant species (Silvertown, 2004).

Piptolepis Sch.Bip. is a genus of Asteraceae (tribe Vernonieae, subtribe Lychnophorinae) that comprises 19 species. Its species are characterized by a variety of habit, ranging from spreading, straggling shrubs or rarely procumbent shrub or virgate treelets, with stems, marked by leaf scars, densely branched and arching, covered by a dense indumentum. The leaves are alternate, spiraled, discolorous, with a typical pad-like leaf sheath. The capitula are solitary, or organized in a terminal raceme, pseudoglomerule or rarely in a corymb. (Cândido and Loeuille, in prep.). The genus presents a high level of microendemism in *campos rupestres*, where the populations are frequently found on the banks of small streams, waterlogged grasslands or nearby peatland areas, at elevations between 700 and 2,050 m a.s.l. The center of diversity of *Piptolepis* is in the Diamantina Plateau in the Espinhaço Range in the state of Minas Gerais (Brazil), with 15 of the 19 species restricted to this area. *Piptolepis ericoides* Sch.Bip., the most widespread species of the genus, is the only species of the genus occurring in the North, South and Southwest of the Espinhaço Range (Fig. 1).

During field expeditions and study of herbarium specimens, we noticed that populations of *P. ericoides* display different morphotypes, with most morphological differences shown in vegetative characters (Fig. 2). Considering that speciation can be caused by different subpopulations of a more widely distributed ancestral species, which has undergone different adaptations that allowed it to survive different ecological niches or environmental filters, and that selection, depending on the environment, acts in different ways in different populations (Barraclough, 2019) and that the evolution of morphological and anatomical diversity in Lychnophorinae seems to have been directed by adaptive pressures derived from ecophysiological factors in xeric environments such as *campos rupestres* (Lusa et al. 2018), it is important to investigate the geographical and environmental factors that promote morphological differentiations in these populations.

Mattos et al. (2021) found that the evolutionary history of some plant lineages at Serra do Cipó, in the south-central Espinhaço Range, is strongly marked by environmental filters, such as edaphic factors, elevation and other microenvironmental aspects. Chaves et al. (2019) found that distribution patterns of Asteraceae in the *campos rupestres* in the Diamantina Plateau are mainly determined by geographical and environmental parameters, such as exchangeable bases, soil texture, and geomorphology. This suggests that other plant lineages in different regions of the Espinhaço Range might share a similar evolutionary history.

Therefore, we analyze the morphological variation of *P. ericoides* in relation to differences in environmental variables, considering that environmental niche modeling can be a useful tool to investigate the diversification history of a given lineage, clarifying processes that led to its current distribution pattern (e.g., Magalhães et al., 2021), the combination of ecological approaches with morphological analysis can clarify the influence of abiotic factors on the geographical distribution and phenotypic variation found in *P. ericoides* (Vogel Ely et al., 2018; Ferrero, 2020).

In this context, we predict that: (i) there are significative vegetative morphological differences among populations of *P. ericoides* from the northern and southern Espinhaço Range in Minas Gerais State; (ii) temperature, precipitation and soil variables such as density, pH, coarser fragments and nutrients influence specific in morphological differences among the populations; (iii) *P. ericoides* had a wider suitable niche when the climate was cooler; which decreased during warmer periods; and (iv) the morphological similarities seen between the geographically distant Grão Mogol and Capitólio populations can be explained by the existence of an ancient corridor. To test these hypotheses, we integrated morphometric analysis with ecological niche modelling to clarify the biogeographic pattern of geographical distribution and phenotypic variation currently observed in *P. ericoides*.

2. Materials and Methods

2.1. Morphometric Analysis

We seek to include individuals from all known populations for *P. ericoides*, at least 20 individuals by population were choose (whenever possible, since some smaller populations haven't this number of gathering available) of herbarium samples with vegetative characters in good conservation and that contained information in the label, such as coordinate geographic and environmental information (e.g., vegetation, elevation and soil). The measurements were made standardizing from 5th to the 7th node of the branches (from apex towards to base) and for each exsiccate, the vegetative character was measure three times in different branches and then an arithmetic average was calculated. Therefore, a database was built with eleven populations [Supplementary Material S1] and performed morphometric analysis with multivariate analysis using only the arithmetic average. (Legendre and Legendre, 2012).

After studying the morphological variation in those samples, reproductive characters were rejected because they were homogeneous at this taxonomic level. We decided to focus only on vegetative characters, which are the main source of difference among *P. ericoides* populations. We built a matrix containing the following vegetative measurements for each specimen: leaf length (LL), leaf width (LW), distance from leaf midrib to margin (DMM), petiole length (PL), leaf sheath length (LSL), and internode length (IL) [Supplementary Material S1]. Measurements were taken with a digital caliper rule from 71 dried specimens deposited in the herbaria ALCB, BHCB, ESA, HUEFS, HUFU, R, RB, SPF and UEC (acronyms according to Index Herbariorum; Thiers, continuously updated), and from samples collected in the Espinhaço Range in the state of Minas Gerais in May and July 2019, and deposited in the herbarium UFP.

All statistical analysis were performed using the software Past v.3.13 (Hammer et al., 2001). Initially, we carried out a principal component analysis (PCA) (Hotelling, 1933) as an exploratory investigation of the general structure of the data and to evaluate possible discontinuities along the principal component axes, detect outliers and determine the morphological variation among populations of *P. ericoides*. Additionally, we carried out an ANOSIM with 9999 permutations to verify statistical similarities and differences between each population.

We used a non-metric multidimensional scaling (NMDS) analysis with 13 abiotic variables (Table 2) to investigate morphological variations in relation to environmental and climatic variables (e.g., precipitation, temperature, seasonality, elevation, and soil) that can influence the phenotypic variation of the specimens, applying the Bray-Curtis distance to detect possible morphological groups congruent with certain climatic indices.

2.2. Ecological Niche Modelling (ENM)

We used the modleR v.0.0.0.9000 package (Sánchez-Tapia et al., 2018) in RStudio v.1.3.1056 (RStudio Team, 2020) with R v.3.6.3 (R Core Team, 2020) to organize the geographical occurrence dataset and select ENM bioclimatic variables. We built a database containing georeferenced records of *P. ericoides* by gathering information from field collections, speciesLink (2019) and the Global Biodiversity Information Facility (GBIF, 2019). The recorded data were filtered to remove misidentified specimens, records in areas where the species does not occur, absences and geospatial information errors and record inaccuracy, to prevent biases and ensure greater result reliability. The filtering of data from the 121 resulting records was performed manually and automatically in a two-stage approach (Panter et al., 2020), using the arguments "clean_dupl", "clean_nas" and "clean_uni" of the "setup_sdmdata()" function in modleR to eliminate duplicate records, remove records outside the study area (circumscribed by a raster layer) and keep only one record per pixel [~4.5 km^2] (linked to the raster layer), respectively (Sánchez-Tapia et al., 2020).

The *P. ericoides* ENM was carried out in the software Maxent 3.4.4 (Phillips et al., 2021). The "ENMevaluate" function of the ENMeval package (Kass et al., 2021) was used to select the best parameters for the feature classes and regularization multiplier. The options used for the modelling process were: response curve parameters, bioclimatic variable importance measure, linear and quadratic feature classes, regularization multiplier value of 3.1, random seed and cross validation replication. Model performance was assessed using the area under the curve (AUC) of the receiver operating characteristics (ROC) curve, where values close to 1 represent more descriptive models with higher performance (Peterson et al., 2008; Phillips, 2017; Wang et al., 2020).

We gathered 19 bioclimatic variables with 2.5 min spatial resolution (~4.5 km at the Equator) from WorldClim version 1.4 (Hijmans et al., 2005), using the Model for Interdisciplinary Research on Climate-Earth System Model (MIROC–ESM) Global Climate Model (GCM) (Watanabe et al., 2011). Soil variables bulk density, coarse fragment volumetric, clay content, nitrogen, soil pH in H_2O and sand content were obtained, in the same scale of the climatic variables, from ISRIC–World Soil Information (https://maps.isric.org/). All variables were selected using the “select_variables” argument of the “setup_sdmdata()” function available in modleR, keeping only non-correlated variables, i.e., those that do not present collinearity, to avoid model overfitting (Table 2) (Sánchez-Tapia et al., 2020). The ENM was carried out for the present (1960–1990) and projected to the Last Interglacial (LIG, ~120 ka – 140 ka), the Last Glacial Maximum (LGM, ~22 ka), Mid-Holocene (MH, ~6 ka), using data from Otto-Bliesner et al. (2006), and future (2070), with the Representative Concentration Pathway (RCP) 8.5 scenario, to estimate niche dynamics over time in an OCBIL perspective and the impacts on the species distribution.

We calculated the environmental suitability areas (km^2) present in the ENM models and the percentage of niche gains and losses among different analyzed periods by binarizing the models, assigning 0 and 1 values to areas with absence and presence, respectively, of environmental suitability, as defined by threshold values obtained with the Minimal Predicted Area (MPA) approach using 90% of species records, to ensure process reliability. This process was carried out with the “ecospat.mpa” and “ecospat.binary.model” functions of the ecospat package (Broennimann et al., 2021). The binarized models allowed the identification of climatically stable areas through the intersection of niche areas, carried out with QGIS 3.16.1 (QGIS Development Team, 2020).

Distribution maps for all species of *Piptolepis* and species of Asteraceae with exclusive occurrence in *campos rupestres* were made in QGIS 3.16.1 (QGIS Development Team, 2020). Georeferenced records were obtained in SpeciesLink (2019), the Global Biodiversity Information Facility (GBIF, 2019) and from field collections. Asteraceae species from *campos rupestres* were selected by using search filters in the Flora do Brasil (2020) online database. The record data were cleaned and organized using the same methodology explained above.

3. Results

3.1. Morphometric and environmental variation within Piptolepis ericoides

The principal component analysis (PCA) suggested there are two groups of populations (Fig. 3). The first two PCA components accounted for 98.55% (95.90% and 2.64%, respectively) of the variation. Axis 1 separate specimens with longer leaf length (0.98) which appear in the right quadrant (Group 1: populations from Grão-Mogol, Capitólio, Cristália, Santana de Pirapama and Gouveia municipalities) from those with smaller leaves, which appear in the left quadrant (Group 2: populations from Ouro Preto, Itambé do Mata Dentro, Santa Bárbara and Conceição do Mato Dentro municipalities). Specimens from the Serra do Cipó population show overlap with Group 1 and 2 populations, therefore being interpreted as a morphological intermediate between the two groups. The Catas Altas population, which has small leaves and short internode length, appears as an isolate group close to Group 1 and the Serra do Cipó population. Axis 2 emphasizes differences in internode length (0.94) (Table 1). The ANOSIM analysis of morphological characters shows significant differences among populations (global R: 0.53; p = 0.0001) [Supplementary Table S2].

Bioclimatic and soil variables were analyzed with the morphometric data to investigate if specific environmental variables would be correlated with the morphotypical variation of each population. A bi-dimensional solution was produced by NMDS ordination (stress = 0.06693), explaining 97% of the total variation of the distance matrix (Fig. 4). The first axis explains 96% of the variation and contains all of the variables that were significant (Table 2). Morphological variation along axis 1 is mainly determined by bulk density (-0.70), soil pH (-0.68), minimum temperature of coldest month [BIO 6] (-0.55), coarse fragments volumetric (0.74), nitrogen (0.56), annual precipitation [BIO 12] (0.50), precipitation of warmest quarter [BIO 18] (0.51) and precipitation of coldest quarter [BIO 19] (0.60). These results suggest that in Group 1 populations, the presence of longer leaves is influenced by denser soils, higher pH and higher temperature values, while in Group 2, smaller leaf size is associated with coarser soils, higher nitrogen content and higher precipitation.

Group 1 occurs in *campos rupestres* in the northern, central-western and southwestern Espinhaço Range in Minas Gerais State (Fig. 1). The climate is drier (annual mean precipitation 969–1573 mm) and hotter (8.1–11.6°C minimum temperature in the coldest month) in these regions, when compared to the eastern and southern Espinhaço Range (1426–1645 mm annual mean precipitation and 6.9–10.8°C minimum temperature in the coldest month). Additionally, our data indicate that areas where Group 2 populations occur have less dense, coarser soil, with higher nitrogen and acidity, than the northern and western populations (Group 1). The Serra do Cipó population shows intermediate values to the two other groups [Supplementary Material S3]. Additionally, the analysis associating morphologic characters with climate and soil data presented significant difference among populations (ANOSIM global R = 0.99; p = 0.0001).

3.2. Ecological Niche Modelling

The AUC values (>0.98) indicate that the predictive accuracies of ENMs were good. Jackknife tests [Supplementary Material S5] indicate that the minimum temperature of the coldest month (BIO 6) shows higher contribution in predicting the current and past distribution of *P. ericoides*. The minimum temperature of the coldest is the highest gain variable in isolation, i.e., it has the most useful information by itself, suggesting a stronger occurrence of the species in areas with colder days over the winter. Besides, BIO 6 is also the environmental variable that most reduced gain when omitted, appearing to have information that is not present in other variables.

Our ENMs indicate that between 120 and 140 ka ago, in the Last Interglacial Maximum (LIG), suitable areas for *P. ericoides* were found only in sparse fragments in the Iron Quadrangle and Serra da Mantiqueira (Fig. 5). Models show that a wide range expansion in habitat suitability occurred in the Last Glacial Maximum (LGM, ~ 22 ka), including almost all the state of Minas Gerais, southwestern Bahia and northern São Paulo (Fig. 5). The Mid-Holocene models (MH ~ 6 ka) show a substantial reduction of ca. 75% of the LGM area, with higher suitability values in Grão-Mogol, southern Bahia, Diamantina Plateau, Iron Quadrangle and Serra Mantiqueira (Fig. 5). The current distribution inferred for *P. ericoides* was similar to the known records, but also includes predicted distribution in areas where there are no records of the species (i.e., in Serra da Mantiqueira, Serra da Bocaina, Serra da Canastra, Alto Paranaíba and Diamantina). The current predicted suitable area for the species is ca. 26% smaller than the distribution in the MH (Fig. 5). Finally, the future projection (2070) shows a reduction of approximately 78% in the *campos rupestres* area in the most pessimistic scenario, with remaining suitable areas for species concentrated in the Diamantina Plateau, Iron Quadrangle and Serra da Mantiqueira (Fig. 5). Our analysis shows that the Iron Quadrangle and Serra Mantiqueira are the main areas of stability since the LIG (Fig. 5).

4. Discussion

4.1. *Morphological and environmental variation within* Piptolepis ericoides

The PCA separated two groups based on leaf and internode length. Vegetative structures are usually considered the most plastic characters in plants, less conserved than reproductive structures, in particular flowers. Nonetheless, vegetative characters are also more immediately affected by environmental changes than reproductive structures. Plants can change aspects of leaf morphology to avoid or mitigate the effects of abiotic extremes, allowing us to understand how a determinate taxon responds to different environments (Schmid, 1992; Taiz et al., 2017).

Biotic and abiotic soil properties affect plant performance in small scales and can be considered selective factors (Jesus et al., 2009). *P. ericoides* generally occurs in dystrophic litholic neosols, which are shallow, very acid, moderately to excessively drained, oligotrophic and with low organic carbon content. They are composed of quartzite gravel and rocks and characterized by a moderate A horizon overlying a coarse textured mineral layer up to 50 cm deep (FEAM, 2010; Schaefer et al., 2016).

Comparing soil attributes of the areas where the populations are distributed, we observed that Group 1 populations grow in relatively less acidic soils, with pH ~ 5 (Soilgrids, 2021), than Group 2, with pH ~ 3.5−4.3 (Andrade et al., 2012). According to Taiz et al. (2017), soil pH affects the availability of all mineral nutrients, with their availability decreasing to critical levels in very acidic (< 5) and very basic soils (> 7). Most mineral nutrients are available between pH levels of 4.5 and 6.5, which could indicate that Group 2 populations might be under nutritional or pH stress, resulting in less robust growth for the plant.

The Group 2 and the eastern part of the Serra do Cipó population occupy a vegetation mosaic in the ecotone between the Cerrado and Atlantic Forest (Coelho et al., 2016; Messias et al., 2017). These regions have higher precipitation, likely related to the barrier effect created by the mountain ranges along the southeastern Brazilian coast, trapping the moisture from the Atlantic Ocean and creating an area of stationary nebulosity. These climatic characteristics create conditions for the establishment of an extensive region of Atlantic Rainforest around the eastern range limits of Group 2 and Serra do Cipó populations, with annual precipitation of 1426–1645 mm (Sant'Anna Neto, 2005; Lorenzon, 2011; Coelho et al., 2016; Pacifico et al., 2021).

In contrast, Group 1 populations are in areas surrounded by Cerrado vegetation, except for the Grão Mogol population, which is in the ecotone between the Cerrado and Caatinga domains. Consequently, the climate is markedly drier and hotter than in the southern Espinhaço Range (Pirani et al., 2003), thus creating drier conditions for Group 1 populations throughout the year (annual precipitation 969–1573 mm). Furthermore, Group 2 populations occur on coarser and slightly less clayey soils than Group 1, which can result in less rainwater retention, with faster draining and increased nutrient leaching, affecting plant growth. Nutrient leaching is higher in acidic soils, as many mineral elements form soluble compounds in more acid pH (Weil and Brady, 2016; Taiz et al., 2017).

In this context, the more imbricate and smaller leaves displayed in Group 2 populations may function as an adaptation to drought stress, as individuals with these features would be more metabolic effective under drought conditions than broad-leaved plants. Narrow leaves have higher cell wall elasticity, indicating greater ability to maintain leaf turgor when the relative water content of the leaf tissue declines (Pfitsch, 1994; Semir et al., 2011). Reconstructions of ancestral states of the characters suggest that the stems of the Lychnophorinae most recent common ancestor hypothetically featured longer internodes (absence of shorter internodes) and that this taxon inhabited a mesic environment, as it was not observed any xeric features, currently commonly found in derivative lineages from this subtribe. Moreover, it seems likely that adaptations to seasonally dry environments and with periodic fire events have had an important role in the diversification of species of Lychnophorinae (Lusa et al. 2018).

Additionally, Group 2 populations are usually found at higher elevations (800–2060 m) than Group 1 (650–1255 m) [Supplementary Material S1]. There is evidence that individuals of a same species often have smaller organs in high elevations than in low elevations (Schmid, 1992). Previous studies have shown that elevational variation can influence the chemical composition and genetic diversity among populations of other species of Asteraceae in different regions of Espinhaço Range, where *P. ericoides* is also found (Jesus et al., 2001; Portella et al., 2021).

The Grão Mogol (northern Espinhaço Range in Minas Gerais State) and Iron Quadrangle (southern region of Minas Gerais State, close to Espinhaço Range) populations represent two morphological extremes, with significant difference in leaf size, longer and shorter, respectively. Within the *campos rupestres* of the Espinhaço Range, “Grão-Mogol” and “Iron Quadrangle” are two bioregions recognized as different districts of the “Southern Espinhaço” province (Colli-Silva et al. 2019). These plateaus stand as inland archipelagos, naturally fragmented by a matrix of lower elevation areas with different soils from those found in the *campos rupestres* plateaus. This low elevation matrix act as a barrier restricting gene flow among mountain-top populations, which consequently have particular evolutionary histories and geobiotic scenarios (Jesus et al., 2001; FEAM, 2010; Campos et al., 2016; Colli-Silva et al., 2018; Barres et al., 2019; Alves and Loeuille 2021). These natural barriers may contribute to the strong isolation between the northern and southern regions of the Espinhaço Range and increase the morphological differentiation between populations of *P. ericoides*.

Another important aspect of the Iron Quadrangle area is the substrate that originates from ferruginous rocky grasslands. These soils have high iron levels, leading to the selection of tolerant individuals (Porto and Silva, 1989) that can grow in high oxidized iron and low water retention conditions, thus generating a vegetation with anatomical, morphological, physiological, and reproductive adaptations that enable survival in this harsh environment (Schaefer et al., 2016; Silveira et al., 2016). However, the most of the iron found in the soil with neutral pH is Fe3+, which is insoluble and not available to plants (Schaefer et al., 2016), happens that acid soils, such as those found in Group 2 areas, can increase the solubility of the ferric (Fe+3) state, reducing it to the ferrous (Fe2+) state, which has greater solubility for the plants (Taiz et al., 2017). This indicates that seasonal reducing conditions occur in these areas, increasing the amount of Fe^{2+} released from Fe-oxide dissolution (Schaefer et al., 2016), which can cause dwarfism in plant species found in these ferrous soils, and lead to retention of high metal concentrations in plant tissues (Porto and Silva, 1989).

Thus, Group 2 populations might be more likely to absorb soluble iron forms, since they occur in more acidic and ferrous soils, generating smaller morphotypes (dwarfs) in comparison to populations outside this area. Among the populations that are part of the Iron Quadrangle (Caeté, Catas Altas, Ouro Preto and Santa Bárbara municipalities), the smallest morphological extremes are found in Catas Altas and Ouro Preto. All these factors combined may contribute to the growth limitations seen in Group 2 populations, even if they occur in environments with higher precipitation, milder temperatures, and soils with lower bulk density and higher amounts of nitrogen, the latter being one of the most limited nutrients in OCBILs (Hopper, 2009; Silveira et al., 2016; 2020).

Serra do Cipó has a north-south orientation and marks the division between the Cerrado and Atlantic Rainforest. The western side has calcareous, claystone and sandstones soils, with patches of shrubby Cerrado and *campos rupestres* vegetation. In the eastern side the soil consists of quartzites and litholic neosols, where *campos rupestres* are found, a transition zone of haplic cambisol, and red yellow latosol-oxisol, covered by ombrophilous forest (Valente, 2009; Coelho et al., 2016). The intermediate morphotypes of *P. ericoides* from Serra do Cipó can be linked to their habitat, in this area of ecologic tension with intermediate vegetational, physical and chemical characteristics, combined with its location between the two population groups (Fig. 1).

Lastly, phenotypic variation has been used in systematics to separate taxa, most often without knowledge of the corresponding genotypic variation, which can lead to taxonomic problems and possibly the creation of more species complexes in the future (Schmid, 1992). Thus, based on our results, we decided not to separate the Grão Mogol population as a different species, as further phylogeographic, anatomical and genetic information is required to support the observed morphological differences. However, we conclude that environmental variables are influencing specific morphological differentiation among *P. ericoides* populations.

4.2. *Ecological Niche Modelling*

In view of the specific adaptations of plants in *campos rupestres* and their low dispersal capability, usually being unable to colonize new, distant habitats (Conceição et al., 2016; Oliveira et al., 2016; Silveira et al., 2020), the low elevation matrix could represent a strong barrier to gene flow, and impose a strong physiological contrast for the highly specialized *campos rupestres* vegetation. The reproductive biology of *Piptolepis* has never been studied. Hummingbirds have already been reported as visit of *P. ericoides* in Serra do Cipó (Espinhaço Range), nonetheless, Asteraceae is rarely used as a food resource by hummingbirds (Rodrigues and Rodrigues, 2014). In the literature, solitary bees are generally accepted to be the primary pollinators of family in much of the world (Lane, 1996). In relation to dispersion in this species, is occurs by anemochory, however the pappus efficacy dispersal role is not so clear, mainly when it has modifications that make it difficult to disperse over long distances by the wind, such as paleaceous, antrorsely oriented and serrulate bristles (Stuessy and Garver, 1996), features found in *P. ericoides*.

Moreover, significant expansion of the geographical limits of rock outcrops and sandy soils is not expected during climatic oscillations, although they could sporadically become more continuous (Conceição et al., 2016; Rapini et al., 2020; Silveira et al., 2020). Barbosa et al. (2015) suggested that some plant groups found today in the *campos rupestres* could have dispersed to lower regions, as many South American montane ecosystems had their limits shifted ca. 1 km downhill during the LGM. However, the absence of paleovegetation and paleoclimate evidence makes it challenging to show this process happened for *campos rupestre*s vegetation (Barbosa and Fernandes, 2016).

Thus, a large expansion of suitable niche for *P. ericoides* seems unlikely, as shown in the LGM model. Previous studies also projected wider suitable areas for *campos rupestres* in the LGM (e.g., Bonatelli et al., 2014; Barbosa et al., 2015; Barres et al., 2019; Danta-Queiroz et al., 2021; Magalhães et al., 2021). However, this *campos rupestres* expansion in the ENMs were considered biased by Rapini et al. (2020), who suggested that including elevation and soil variables could reduce the suitable area outside the Espinhaço Range during the last glacial cycle. In our model, the use of soil variables did not result in relevant differences in the suitable niche range for *P. ericoides* when compared only to climatic variables [see Supplementary Figure S4].

Other parameter combinations could influence the modeling projection, such as the number of occurrences used in the modeling (e.g., Rapini et al. (2020) used a large database with 16,323 records). Different methodologies could also have an impact: Fiorini et al. (2019) used only 191 occurrences, however included elevation and pseudo-absence occurrences for areas below

800 m a.s.l. Barbosa and Fernandes (2016) included terrain slope and soil variables in addition to elevation (see also Barbosa 2012). The size of the area established for modeling is also important. Barbosa and Fernandes (2016) and Fiorini et al. (2019), for example, delimited possible areas of *campos rupestres*. All these studies found stable suitable areas for *campos rupestres* in the LGM through different methodological approaches, which can imply that specific methodological choices need to be made when assembling prediction models for Neotropical OCBILs, to achieve more homogeneous ENM results, as highlighted by Corlett and Tomlinson (2020). However, models do not need to be perfect or complete to be useful. Even with a small amount of inaccuracy, niche models are still the best tools available, containing valuable information for conservation and understanding evolution (Warren, 2012).

Based on species distribution patterns previously reported for *campos rupestre*s (Inglis and Cavalcanti, 2018, Alves and Loeuille, 2021), on phylogeographic studies (Collevatti et al., 2012; Perez et al., 2016; Barres et al., 2019; Carvalho et al., 2020), and on the current occurrence data for different endemic groups (e.g., Ribeiro et al., 2014; Inglis and Cavalcanti, 2018; Barres et al., 2019; Carvalho et al., 2020), a "U" shape occurrence pattern emerges for species that exclusively occur in *campos rupestre*s. This "U" shape encompasses the Chapada Diamantina in the state of Bahia, the Espinhaço Range and Serra da Canastra in Minas Gerais State, the Goiás Plateau and the State of Tocantins (e.g., the current distribution pattern for Asteraceae that exclusively occur in *campos rupestres* in Fig. 6). This shared distribution pattern could represent an ancient pattern of the biogeographic history of *campos rupestre*s, where species would have dispersed to areas between adjacent mountain ranges via occupation of intermediate lowland areas that acted as ecological corridors, rather than dispersing over longer distances within a matrix of different edaphic-climatic characteristics.

Additionally, studies have been shown that populations of species that occur in *campos rupestres* in the State of Tocantins experience gene flow with populations in the Goiás Plateau, but not with those in the Chapada Diamantina (state of Bahia) (Collevatti et al., 2012, Perez et al., 2016; Inglis and Cavalcanti, 2018; Barres et al., 2019), probably due to the São Francisco River valley acting as a geographic barrier between the Goiás and Chapada Diamantina plateaus (Inglis and Cavalcanti, 2018; Barres et al., 2019; Magalhães et al., 2021). This reinforces the hypotheses that dispersal of species from *campos rupestres* over long distances in central Brazil is unlikely.

Therefore, it seems more likely that *P. ericoides* dispersed over short distances, occupying regions in-between *campos rupestres* (ecotone zones) in lower altitudes, according to the "escape to radiate" model (Rapini et al., 2020), later colonizing and establishing in high-altitude rock outcrops and disappearing from the intermediate zones due to different ecological factors, persisting in small fragments for a long time, a common feature of the OCBIL biota (Hopper, 2009). These transition zones probably had the best conditions for *P. ericoides* adaptation during the LGM, as our models showed that colder and drier conditions were more favorable for *P. ericoides*, as well as for other *campos rupestres* species (e.g., Collevatti et al., 2009; Barbosa and Fernandes, 2016; Barres et al., 2019).

P. ericoides was probably the first species of the genus, originated ~200 ka (confidence interval: 0.125–1.4408 Ma) (Alves and Loeuille, in prep.) in the Iron Quadrangle region, during the LIG (Fig. 5). The Iron Quadrangle is considered a species cradle (Bitencourt and Rapini, 2013; Conceição et al., 2016) and is also a zone of stability in our model. From there, the *Piptolepis* lineage likely migrated along *campos rupestres* fragments towards the north of Minas Gerais State, to the Espinhaço Meridional and Septentrional, and towards to the Brasília Arc (or Canastra arc), arriving in the Serra da Canastra, in Capitólio municipality (Inglis and Cavalcanti, 2018; Alves and Loeuille, 2021). However, more studies are needed to corroborate our findings and to better understand the patterns and processes involved in the diversification and dispersal of *campos rupestre*s species.

Regarding the environmental influence over morphological features and our proposed hypothesis for the current distribution of *P. ericoides*, the hypothesis that Capitólio and Grão Mogol present morphological similarities due to previous contact in an old ecological corridor was not corroborated. The existence of an ancient corridor directly connecting these two populations seems unlikely and we favor the hypothesis that these morphological similarities were generated by similar adaptive responses to specific environmental conditions, as discussed above.

P. ericoides, as well as other species restricted to *campos rupestre*s, tends to have a more suitable niche in drier and colder periods, corroborating our hypothesis (iii), that morphological adaptations allowed the species to survive in these cooler environmental conditions (Barbosa and Fernandes, 2016). Therefore, we also detected a trend of decrease in the niche area of *P. ericoides* in hotter and more humid climates, as seen in the LIG and MH models, which could lead to extinction in extremely hot and dry climates, as predicted for 2070 (Fig. 5).

The Cerrado is becoming hotter and drier: from 1990 to 2019, the Espinhaço Range region had an increase in temperature from 1.5 to 2.5°C and 10 to 15% decrease in relative humidity. This creates hotter nights, when the temperatures do not cool enough to reach dew point, which is the main source of water for numerous Cerrado plant species during the dry season (Hofmaan et al., 2021). This local climate change was caused by anthropogenic activities, such as greenhouse effect, loss of natural habitat, intentional fires, mining, and creation of pastures and farmlands (Fernandes et al., 2018). This scenario predicts that several species with restricted distribution and small populations can be easily and stochastically eliminated (Vasconcelos et al., 2020), eventually leading to species extinction (Rapini et al., 2020). For instance, Brazilian governmental authorities predict scenarios of desertification for the Grão Mogol region in the next 20 years (Barbosa and Fernandes, 2016). *Campos rupestres* lineages are highly vulnerable to disturbances and their conservation deserves special attention (Conceição et al., 2016).

Among *campos rupestres* areas, the Iron Quadrangle and Mantiqueira mountains are considered climatically stable areas by many authors (e.g., Fernandes et al., 2018; Barres et al., 2019; Danta-Queiroz et al., 2021; Magalhães et al., 2021; Pacifico et al., 2021). According to Fernandes et al. (2018), these stable areas will likely remain climatically suitable until the end of this century, making them primary targets for conservation of biodiversity and ecosystem services.

5. Conclusion

Our findings indicate that morphological variation in vegetative characters of *P. ericoides* are influenced by local environmental conditions in each population. Thus, we do not recommend splitting some populations as distinct species, as their differences are likely to be only phenotypic variations. Additional phylogeographic, anatomical and genetic studies would allow a more accurate decision.

ENM analysis indicated a large expansion of suitable niche in low altitude areas during the LGM. However, we hereby propose that *P. ericoides* dispersed over short distances in the LGM, occupying intermediate regions between mountain ranges, following the "escape to radiate" model (Rapini et al., 2020). Periods for which the projections show hotter and more humid climates (LIG, MH and future) have a decrease in suitable niche, as our models show that colder and drier conditions are more favorable for the species. This suggests that *P. ericoides* is highly vulnerable to climate changes, such as greenhouse effect.

The morphological differences observed in *P. ericoides* populations can represent the first steps of a microevolutionary pattern. Edaphic-climatic factors greatly influence the adaptation and decrease of gene flow among *campos rupestres* populations, making these areas a cradle for new and microendemic species. Information on the biogeographical history and dispersal patterns is essential to increase our understanding of this peculiar vegetation. Thus, genetic and palaeogeographical studies would be essential, as well as environmental niche models for small groups and biologically restricted environments.

Acknowledgements

The first author thanks Instituto Estadual de Florestas - Minas Gerais and ICMBio for issuing collection permits; Fabiane Nepomuceno da Costa from Universidade Federal do Vale do Jequitinhonha e Mucuri (UFVJM) for kindly hosting the author and providing logistic support during fieldwork in the state of Minas Gerais, and the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (Finance Code 001) for the granted fellowship (CAPES/PROEX).

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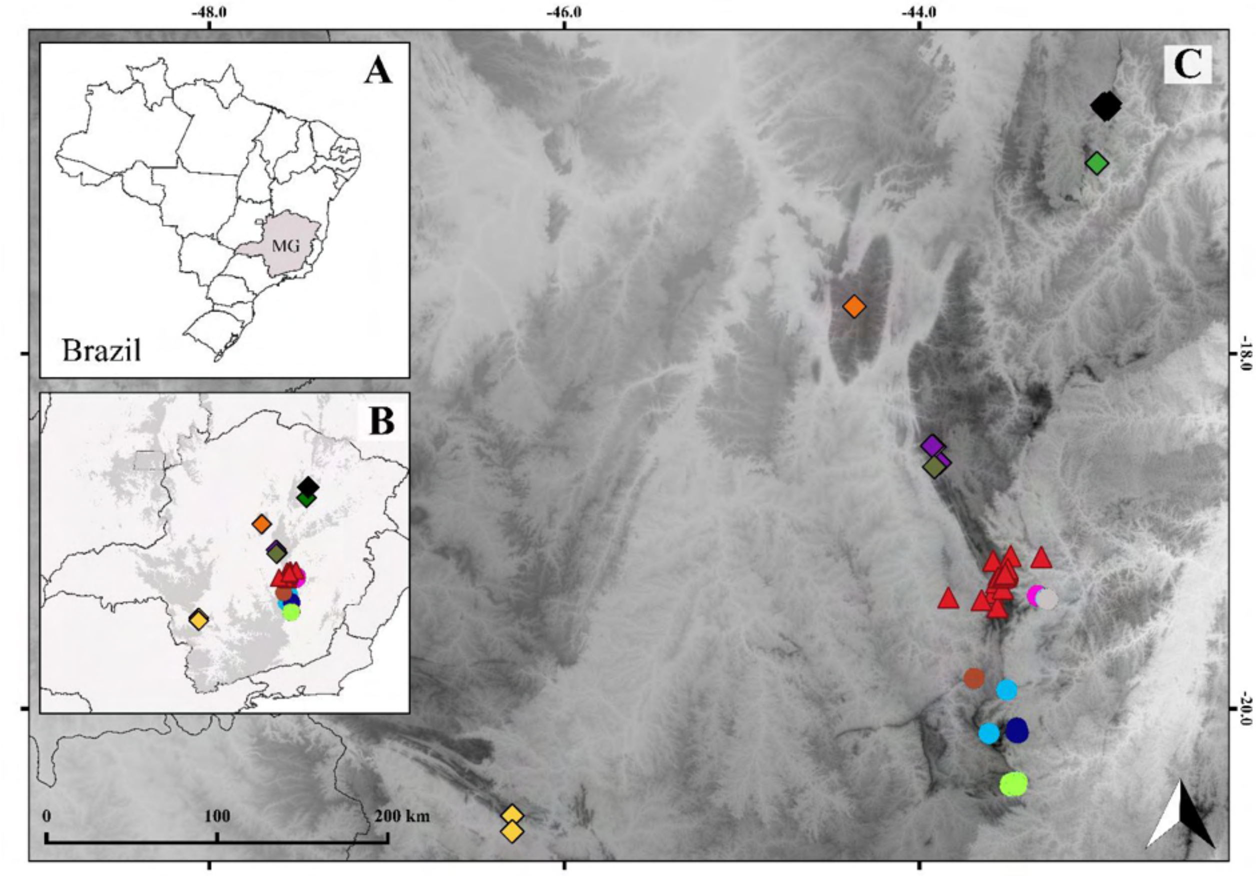

FIG. 1. A. Brazil with the state of Minas Gerais highlighted. **B.** *Campos rupestres* in Minas Gerais with the distribution of *Piptolepis ericoides* overlayed. **C.** Distribution of *Piptolepis ericoides* populations, Group I [diamonds: Grão Mogol (black), Cristália (dark green), Serra do Cabral (orange), Gouveia (purple), Santana do Pirapama (olive) and Capitólio (yellow)], Serra do Cipó (red triangle) and Group II [circle: Conceição do Mato Dentro (pink), Itambé do Mato Dentro (gray), Caeté (brown), Santa Barbara (light blue), Catas Altas (dark blue), Ouro Preto (light green)].

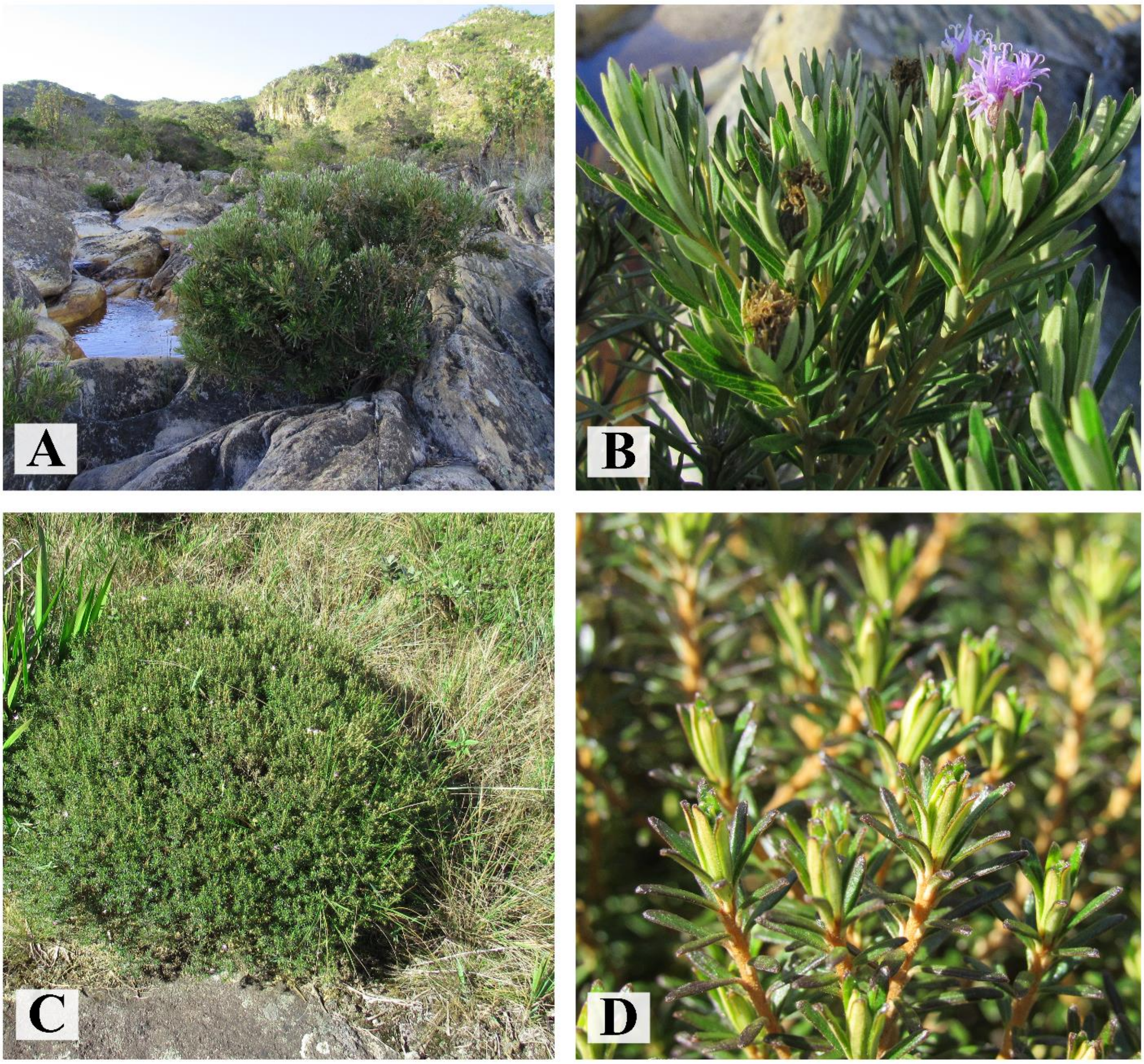

FIG. 2. Morphological extremes of *Piptolepis ericoides*. **A–B.** Grão Mogol population (North). **A.** Habit. **B.** Leaf arrangement. **C–D.** Ouro Preto population (South). **C.** Habit. **D.** Leaf arrangement. A–D by J.B. Cândido.

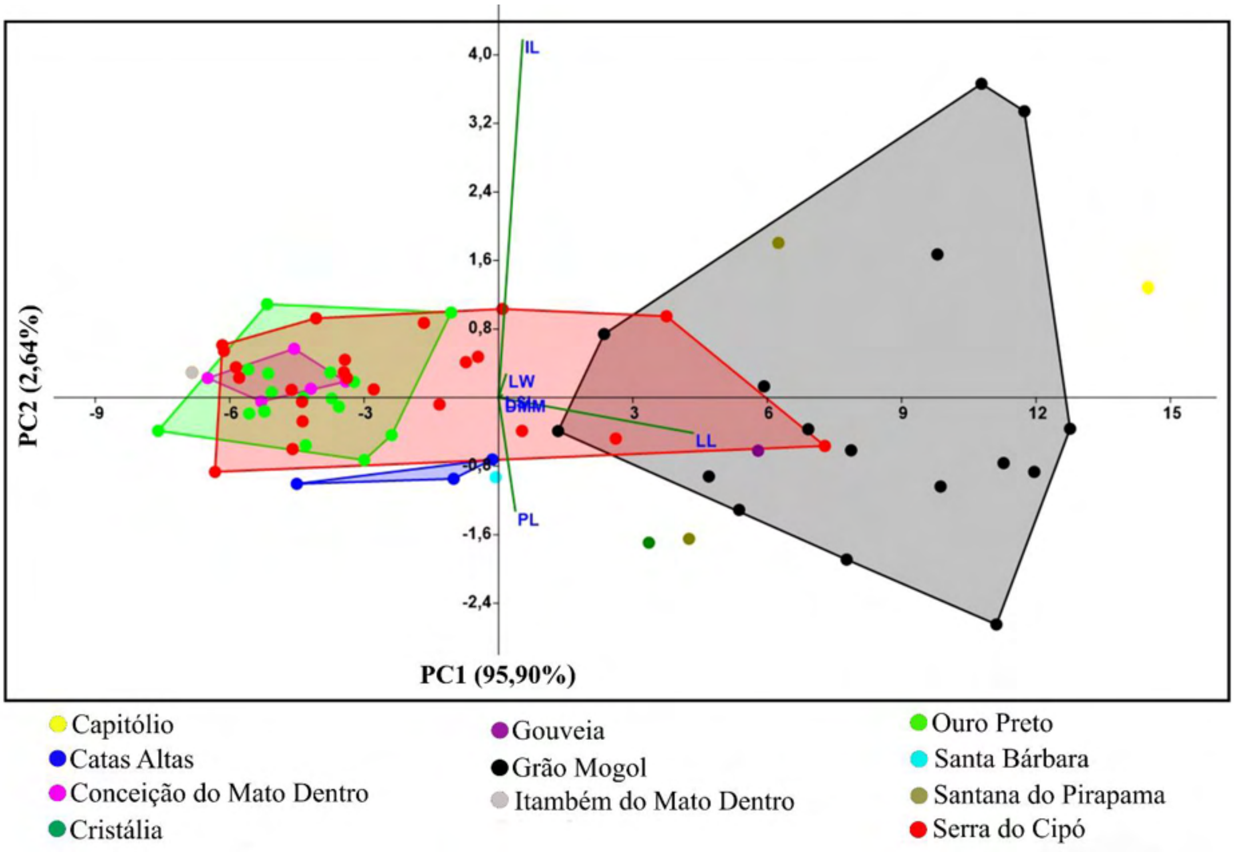

FIG. 3. Morphological Principal Component Analysis (PCA) for *Piptolepis ericoides*: diagram of the first two axes (PC1 and PC2). The percentage of total variance associated to each PC is provided in parentheses. Colored circles represent specimens of each population. Arrows indicate the contribution of morphological characters to the first two axes. Numbers correspond to the morphological characters listed in Table 1.

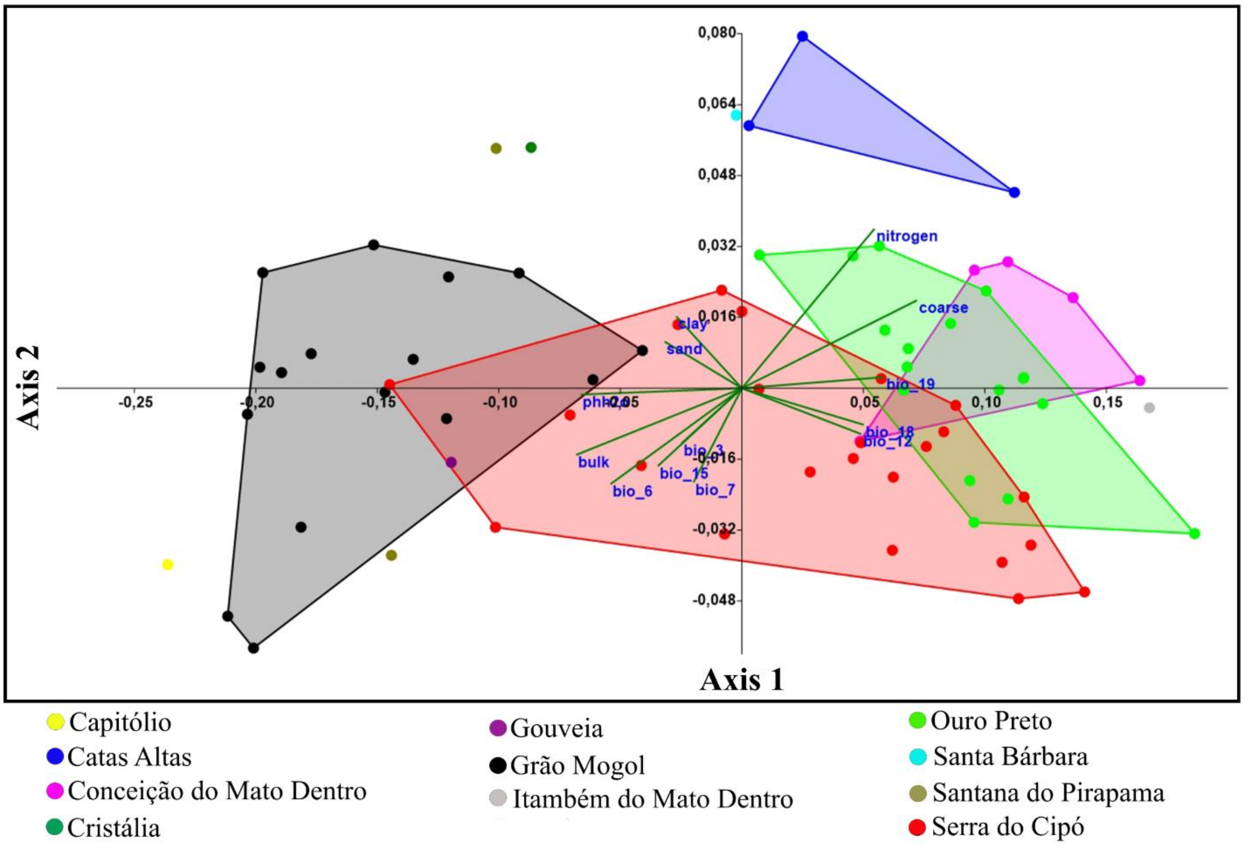

FIG. 4. Bioclimatic and soil variables with morphometric characters for *Piptolepis ericoides* populations used in Non-Metric Multidimensional Scaling (NMDS): diagram of the first two axes (PC1 and PC2), based on 13 bioclimatic and soil variables. The percentage of total variance associated to each PC is provided in parentheses. Colored circles represent specimens of each population. Arrows indicate the contribution of bioclimatic and soil variables to the first two axes. Numbers correspond to the bioclimatic and soil variables listed in Table 2.

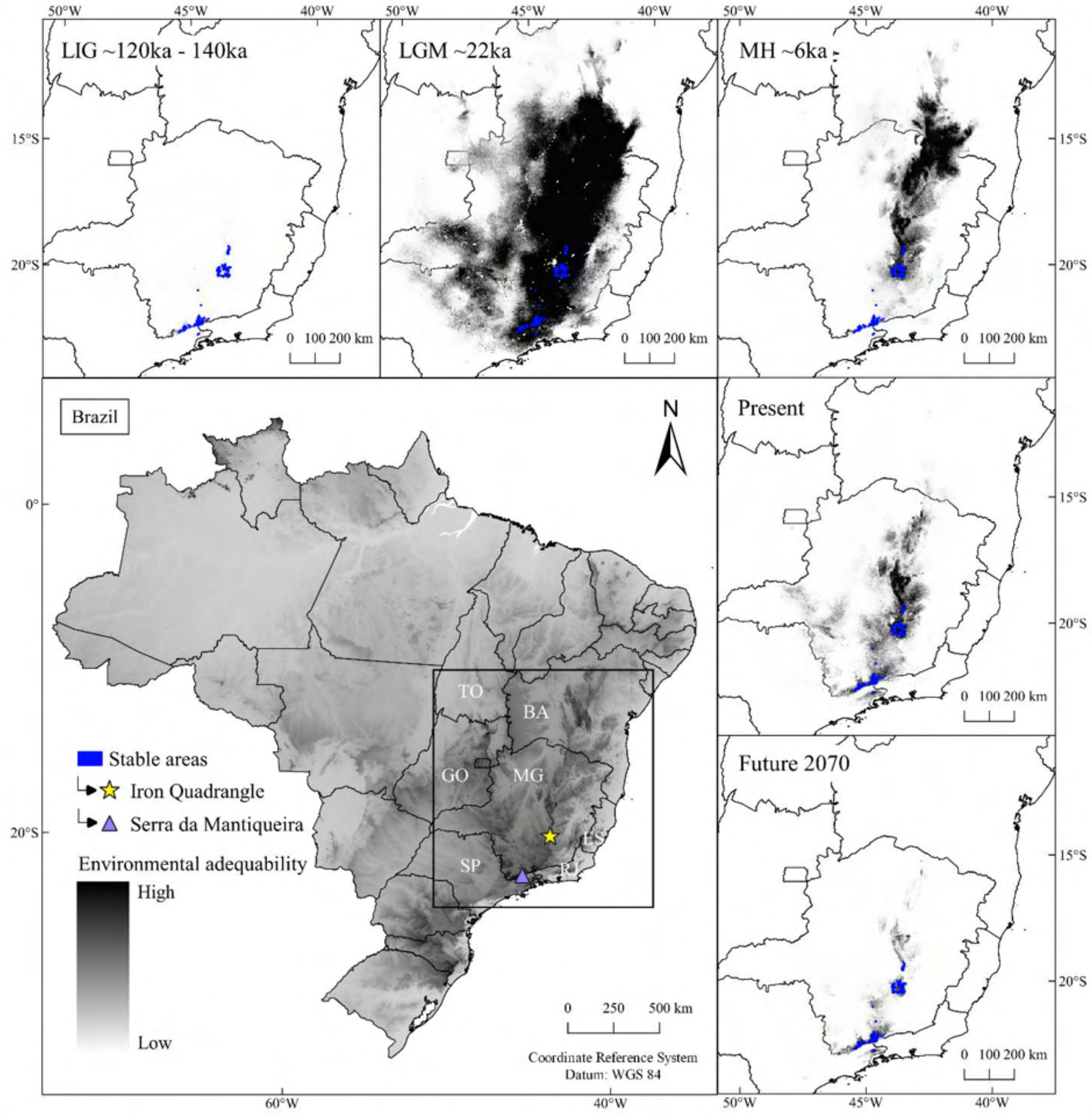

FIG. 5. Ecological niche model maps for *Piptolepis ericoides* in *campos rupestres* in the Last Interglacial, Last Glacial Maximum, Middle Holocene, Present and Future (2070) projected from models using climate variables with soil variables. In blue color, projected areas of niche stability.

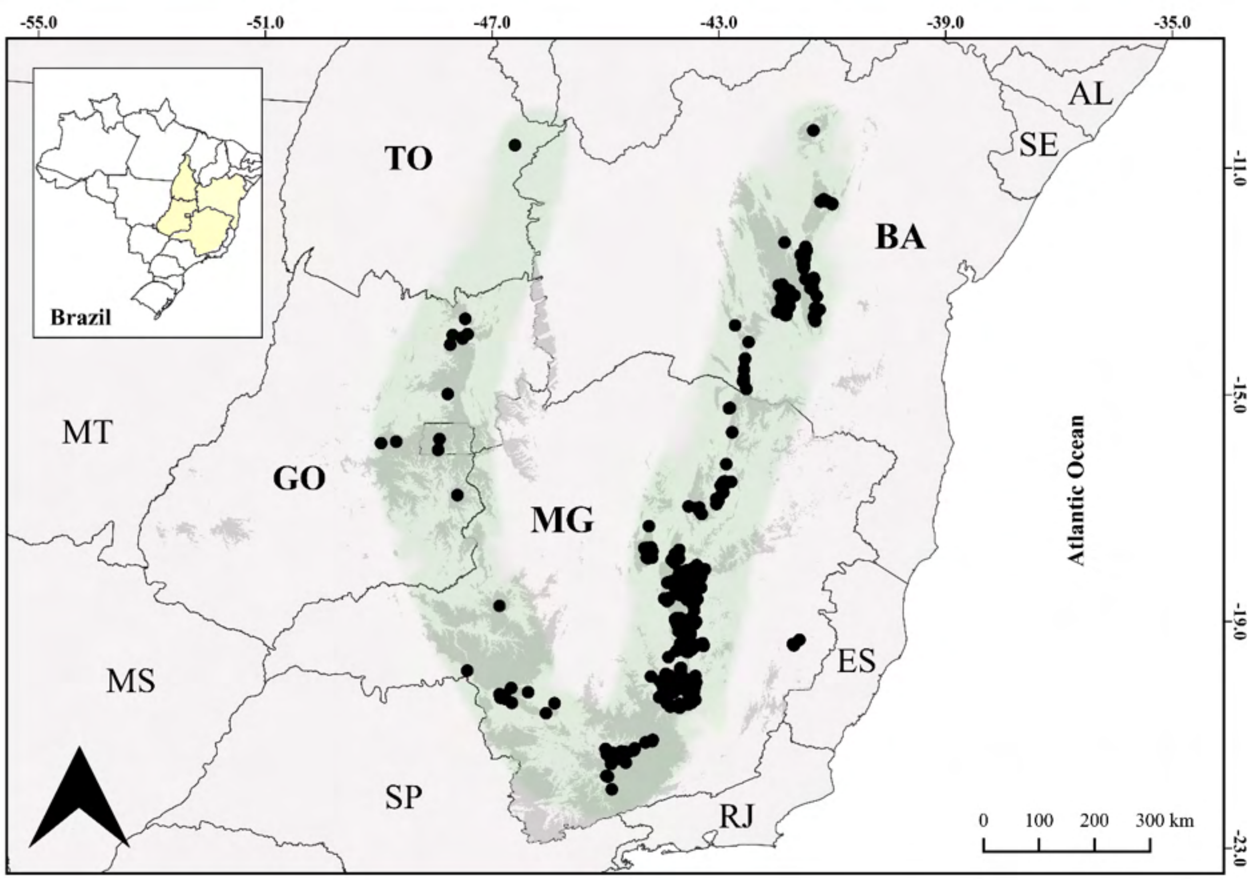

FIG. 6. Distribution map of species of Asteraceae (black dots) that currently occur exclusively in *campos rupestres*. The highlight shows a possible ancient dispersal pattern that occurred during the biogeographic history of *campos rupestres*.

Supplementary Material 1. Database with *Piptolepis ericoides* occurrences, respective herbarium vouchers, morphometric measurements, coordinates and elevation for each specimen.

Supplementary Table 2. Analysis of similarities - ANOSIM (using Bray-Curtis similarity test) showing differences among populations. **Mean rank within**: 717,9, **mean rank between**: 1383, **R**: 0,5353, **p**: 0,0001, **Permutation**: 9999. In bold coefficient of similarity ≤ |α 0.05|, considered significant.

Supplementary Material 3. Values of the Ecological Niche Modelling layers for each bioclimatic and soil variable in each population specimen.

Supplementary Figure 4. Maps of ecological niche models for *Piptolepis ericoides* in campos rupestres during the Last Interglacial, Last Glacial Maximum, Present and Future (2070), projected from models using only climate variables, without soil variables.

Supplementary Material 5. Results of the ENM for LIG, LGM, MH, Present and Future, using climatic and soil variables, exported from Maxent.

Disponíveis em: https://1drv.ms/u/s!AlDTBb7C4-PR3Q1ULXx0vgK0xyte?e=iwWLyg

Table 1. Factor loadings on the first two principal components axis for morphological quantitative characters used in the principal component analysis. In bold, correlations ≥ |0.5|, considered significant.

Variables (mm)	PCA 1	PCA 2
	Eigenvalue = 36.1309	Eigenvalue = 0.997447
	% variance = 95.907	% variance = 2.6477
Leaf length (LL)	**0.98**	-0.09
Leaf width (LW)	0.03	0.06
Petiole length (PL)	0.08	-0.30
Leaf sheath length (LSL)	0.02	0.01
Distance from leaf midrib to margin (DMM)	0.02	-0.01
Internode length (IL)	0.12	**0.94**

Table 2. Correlations of each bioclimatic and soil variable used in environmental niche modeling to the two NMDS axis to the morphometric variable. In bold, correlations ≥ |0.5|, considered significant.

Environmental variables	Axis 1	Axis 2
	% variance = 96.93	% variance = 0.011
Bulk density	**-0.70**	-0.16
Clay content	-0.28	0.18
Coarse fragment volumetric	**0.74**	0.20
Nitrogen	**0.56**	0.37
Soil pH in H2O	**-0.68**	-0.01
Sand content	-0.32	0.11
BIO3 = Isothermality	-0.25	-0.13
BIO6 = Min Temperature of Coldest Month	**-0.55**	-0.23
BIO7 = Temperature Annual Range	-0.20	-0.22
BIO12 = Annual Precipitation	**0.50**	-0.10
BIO15 = Precipitation Seasonality	-0.35	-0.19
BIO18 = Precipitation of Warmest Quarter	**0.51**	-0.08
BIO19 = Precipitation of Coldest Quarter	**0.60**	0.03

5 CONCLUSÃO

O desenvolvimento deste trabalho, em campo e estudando amostras de diversos herbários, levou a descrição de sete novas espécies (*P. corymbosa*, *P. elaeoda*, *P. fulgens*, *P. pilosa*, *P. procumbens*, *P. redacta* e *P. speciosa*) e o reestabelecimento do nome *P. pseudomyrtus*. Reforçando a importância dos trabalhos *in loco* e o alto nível de endemismo e diversidade dos campos rupestres, que ainda necessitam de estudos para um melhor conhecimento de sua flora. A maioria das espécies de *Piptolepis* estão restritas a uma região (Platô Diamantina) e são microendêmicas com populações pequenas, esta informação apontada neste trabalho poderá servir de subsídios para futuras medidas de conservação e manutenção dos táxons endêmicos e fortemente ameaçados dentro das áreas de *campos rupestres*.

O artigo dois, por sua vez, trouxe informações sobre as diferenças morfológicas entre as populações de *P. ericoides* e apontou como diferentes fatores ambientais de cada população podem estar envolvidas nesse processo, além disso, a modelagem permitiu analisar o nicho adequado dessa espécie desde o último interglacial até os dias atuais, levantando hipóteses de como sua distribuição ocorreu ao longo do tempo. Todos esses dados, podem contribuir para um melhor entendimento sobre a ecologia e evolução das pequenas e naturalmente fragmentadas populações dos campos rupestres.

Todavia, para além dos trabalhos apresentados aqui, inúmeros outros ainda se fazem necessário para melhor entendimento não só do grupo de estudado, mas das demais Lychnophorinae e dos campos rupestres como um todo (ex: estudos fitogeográficos, anatômicos, genéticos, paleogeográfico). Atualmente, ainda como fruto deste doutorado dois manuscritos estão em desenvolvimento: uma análise filogenética do gênero *Piptolepis* utilizando sequenciamento de nova geração de DNA (NGS) e um estudo anatômico comparativo entre *Piptolepis, Lychnophorella* e nas espécies *Lychnophora harleyi*, *L. brunioides, L. souzae* e *L. albertinioides*, os quais devem trazer mais alguns esclarecimentos necessários e complementares a esta tese.

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APÊNDICE A – A NEW SPECIES OF *PIPTOLEPIS* (LYCHNOPHORINAE, VERNONIEAE, ASTERACEAE) FROM THE BRAZILIAN CENTRAL PLATEAU

ARTIGO PUBLICADO NO PERIÓDICO PHYTOTAXA 399 (4): 271–278, 2019.

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Abstract

Piptolepis rosmarinifolia, a new species from Brazil, is here described and illustrated, and its conservation status assessed. The new species is endemic to the Maranhão River Plateau in the state of Goiás, Brazil. *Piptolepis rosmarinifolia* is closely related to *P. pabstii* but differs by its smaller and linear to very narrow elliptic densely spiraled leaves, solitary terminal syncephalium, a higher number of heads per syncephalium and triseriate pappus.

Key words: campos rupestres, Cerrado, Compositae, endemism, rock outcrop

Introduction The Brazilian campos rupestres (highland rocky fields) is a tropical, fire-prone vegetation with grassy and shrubby physiognomies in a mosaic arrangement, which occurs at elevations between 900 and 1,500 m, on oligotrophic soils with rock outcrops of quartzite, sandstone or ironstone (Harley 1995, Giulietti *et al.* 1997, Conceição *et al.* 2007, Jacobi *et al.* 2007, Rapini *et al.* 2008, Conceição *et al.* 2016, Silveira *et al.* 2016). Campos rupestres are mostly found in several mountain ranges and isolated mountains in the states of Bahia, Goiás and Minas Gerais (Silveira *et al.* 2016). Their high diversity and endemism of vascular plants is notoriously known (Rapini *et al.* 2008, Echternacht *et al.* 2011), being the Brazilian vegetation type with the highest percentage of endemism, where ca. 40% of a total of 4,928 species are endemic (BFG 2015). Asteraceae is one of the most diverse families in campos rupestres, accounting for almost 30% of the Brazilian species of the family (627 spp.) (Flora do

Brasil 2020 under construction). Some lineages of this family are highly adapted to the ecological features of the campos rupestres, with 24 genera endemic to this environment (Pirani *et al.* 2003, Conceição *et al.* 2007, Jacobi *et al.* 2007, Silveira *et al.* 2016, Flora do Brasil 2020 under construction). *Piptolepis* Schultz-Bipontinus (1863: 380) is one of the endemic genera of the campos rupestres vegetation, comprising 11 species (Loeuille *et al.* 2019). The genus is recognized by its unique combination of a subshrubby to treelet habit, pad-like leaf sheath, indumentum composed of 3- to 5-armed trichomes, terminal inflorescence, heads with weakly imbricate caducous to deciduous phyllaries, and pappus usually biseriate with setose to paleaceous setae (Loeuille *et al.* 2012, Esteves *et al.* 2017, Loeuille *et al.* 2019). This genus occurs mainly in Espinhaço Range in the state of Minas Gerais, with only one species, *Piptolepis pabstii* (Barroso 1964: 173) Loeuille *et al.* (2019), being endemic to Serra dos Cristais in the municipality of Cristalina in the state of Goiás, therefore displaying a disjunct distribution in the Brazilian Central Plateau (Loeuille 2018, Loeuille *et al.* 2019). This species was formerly assigned to genus *Eremanthus* Lessing (1829: 317) section Chresta (Velloso ex Candolle 1836: 85) Baker (1873: 166) by Barroso (1964), due to the combination of subshrubby habit with the presence of syncephalium (heads fused in a secondary order inflorescence). The species was just recently transferred to *Piptolepis*, based in phylogenetic studies with molecular and morphological data, and being further supported by sharing with this genus the pad-like leaf sheath, 3 to 5-armed, bladder-like trichomes and biseriate pappus (Loeuille *et al.* 2015, Loeuille *et al.* 2019).

Collection expeditions made in the Maranhão River Plateau, in the state of Goiás, in a region called Serra Geral do Paranã, located south of Chapada dos Veadeiros and north of Distrito Federal Plateau, brought to light a new species of *Piptolepis* from the Brazilian Central Plateau.

Material & Methods

Morphological features of the specimens were analyzed with a 10–60 × magnification stereomicroscope. Measurements of only fully mature structures were made using a digital caliper rule. Terminology follows Hickey (1973) for leaf shape and Beentje (2010) for general morphology. Assessment of conservation status followed the IUCN (2017) criteria and was also performed using the GeoCAT Tool (Bachman *et al.* 2011), with the IUCN default for Area of Occupancy (AOO) analysis (cell size of 2 km2). The distribution map was produced in QGIS version 2.6.1 (QGIS Development Team 2015). Geographic coordinates were obtained from herbarium specimens.

Taxonomic treatment

Piptolepis rosmarinifolia Bringel, J.B. Cândido & Loeuille, **sp. nov.** Type:—BRAZIL. Goiás: Água Fria de Goiás, estrada para torre repetidora do Roncador, início da estrada ca. 20 km S. de São João d'Aliança, ponto de coleta ca. 2,5 km L. do entroncamento com a rodovia GO-118, 14°53'08"S, 43°33'17"W, 14 May 2017, *J.B.A. Bringel Jr. et al. 1329* (holotype: CEN!; isotypes: HUFU!, K!, MBM!, NY!, RB!, SPF!, UFP!, US!) (Fig. 1, 2 A–D, 3).

Species Piptolepi pabstii primo aspectu maxime similis, sed foliis linearibus ad angustissime elliptica (non anguste oblongis), parvioribus (9–18 × 0.8–1.5 mm, non 26–38 × 2.2–2.6 mm), capitulis in syncephalo solitario (non cymis syncephalorum), capitulis syncephalo 30–64 (non 16–21) et series pappi 3 (non 2) differt.

Subshrub 15–35 cm tall, caespitose, sparsely branched towards the apex; with xylopodium. Stems cylindrical, flattened and furrowed towards the apex, ochreous to argenteous lepidote, dark-greyish and glabrescent with age, leaf scars semicircular following leaf fall. Leaves alternate, simple, densely spiraled, sessile, with pad-like leaf sheath 1–1.5 mm long; blade linear or very narrow elliptic, 9–18 × 0.8–1.5 mm, strongly discolorous, venation hyphodromous, adaxially light green (dark-grey in sicco), glabrous, abaxially light-greyish, lepidote, tomentum of branched, 3 to 5-armed, bladder-like trichomes, coriaceous, margins entire, flat or sometimes slightly conduplicate, apex acute, base attenuate or sometimes truncate. Capitulescence of fused capitula in a terminal solitary syncephalium (secondary order inflorescence) at apex of branches. Syncephalium 6.8–14.45 mm tall, 8–18.55 mm in diam., hemispherical, with capitula slightly adpressed at base, peduncle 2.5–12 cm long; bracts 5–20, 6.5–13 × 0.5–1.2 mm, leaf-like; secondary bracts lorate or very narrow elliptic, rarely linear, 3.5–9 × 0.4–1.1 mm, light greyish lepidote. Capitula 30–64, homogamous, discoid, sessile; involucre 5–7 mm tall × 1.5–2.5 mm diam., turbinate to cylindrical; phyllaries 5–6 seriate, weakly imbricate, scarious, deciduous, margins entire, outer phyllaries ovate to oblong, 2–3.5 × 0.4–0.5 mm, apex acute, purplish, lanulose, inner phyllaries oblong to lanceolate, 5.5–6 × 0.5–0.6 mm, apex cuspidate, purplish, sparsely lanulose; receptacle flat, naked. Floret 1 per capitulum, bisexual, fertile; corolla actinomorphic, deeply 5-lobed, seldom 6-lobed, white to pale lilac, densely glandular-punctate, 6.2–8.0 mm long., corolla tube 3–4 × 1.4–1.6 mm, corolla lobes 2.8–3.9 × 0.8–1 mm, apex acute; anthers whitish to pale lilac, apical appendages trullate, acute, anther base sagittate, obtuse; style shaft 4–7 mm long, whitish to pale lilac, glabrous throughout except for pubescent upper 1–1.5 mm beneath style-arms, style-arms 2–3 mm long, apex acute, pubescent outside, hairs acute, style-base glabrous, lacking basal node. Cypsela turbinate, 2.3–2.8 ×1.0–1.3 mm, 10-ribbed, tomentose, light reddish glandular-punctate, base attenuate; carpopodium annular, minute; pappus setae 3-seriate, unequal, purplish to stramineous, subpaleaceous, narrowed, serrulate, outermost series 0.5–1 mm long, straight, persistent, innermost series 2.1–5.2 mm long, frequently slightly twisted, deciduous.

Distribution and habitat:—The new species occurs in vegetation islands of campos rupestres and campo limpo associated with sandstone outcrops in Maranhão River Plateau (Serra Geral do Paranã) in the state of Goiás (Brazil), at elevations above 1,100 m (Fig. 3, 4).

Conservation status:—This species is known from only two localities. The southernmost of these two localities (Planaltina de Goiás) is clearly under anthropogenic influence, with the surrounding area displaying the vegetation drastically changed by agriculture and affected by erosion and cattle ranching; while the other locality is well preserved (Fig. 4). According to results obtained with the GeoCAT tool analysis, *Piptolepis rosmarinifolia* should be considered Critically Endangered, as it has an area of occupancy (AOO) of 8 km2, and a null area of extent (EOO) because the species is known from only two locations. Although the northern part of Goiás Central Plateau is included in an integral conservation unit, the Chapada dos Veadeiros National Park, with an area of 2,405.86 km^2 that was recently expanded, the southernmost region in Maranhão River Plateau does not contain any relevant conservation units, and has other occurrences of endemic species such as *Diplusodom grahamae* Cavalcanti (2007: 810), *Calea nervosa* Barroso (1975: 109, Silva 2016), *Manihot gabrielensis* Allem (1989: 653), *M. congesta* Mendonza & Cavalcanti (Mendoza *et al.* 2018: 919), *M. incisa* Mendoza & Cavalcanti (Mendoza et al. 2018: 922), and *M. pinatiloba* Mendoza & Cavalcanti (Mendoza *et al.* 2018: 925).

Etymology:—The epithet *rosmarinifolia* refers to the leaves resembling those of rosemary (*Rosmarinus* Linnaeus 1753: 23, Lamiaceae).

Phenology:—*Piptolepis rosmarinifolia* has been found with flowers in the beginning of the dry season, in May.

Additional specimens examined (paratypes):—BRAZIL. Goiás: Água Fria de Goiás, rod. GO-118, subida para a Torre Repetidora de Roncador, 8 May 2000, *G. Hatschbach et al. 70631* (BHCB!, CESJ, ESA!, HUEFS!, MBM!, SP!, UPCB!, US!); ibid., início da estrada para Fazenda Bom Jesus, 1.5 km em estrada de terra, 14°53’08”S, 43°33’17”W, 14 July 2018, *J.B. Cândido & J.B.A. Bringel Jr. 251* (CEN!, K!, RB!, SPF!, UFP!, US!); ibid. Ca. 2,2 km da GO 118 para Estação Repetidora Telebrasília de Roncador, e entrando, ca. 15 m SO (lado direito), 22 April 2016, *J. M. Mendoza F. et al. 5184* (CEN). Planaltina de Goiás, estrada vicinal a W da GO-118, com início a cerca de 28,5 km N de São Gabriel, 14°58’52’’S, 47°42’05’’O, 1185 m, 12 February 2015, *J.B.A. Bringel Jr. et al. 1201* (CEN!); ibid., 14°58’53’’S, 47°37’41’’W, 1156 m, 14 May 2017, *J.B.A. Bringel Jr. et al. 1324* (CEN!, UFP!).

Notes:—*Piptolepis rosmarinifolia* is morphologically similar to *P. pabstii*, both species displaying a similar subshrubby habit, narrow leaf blades (linear to narrow-oblong), heads fused in a syncephalium and only one floret per head. This resemblance explains why the first collection of *P. rosmarinifolia* (*Hatschbach et al. 70631*) was identified as *P. pabstii*. However, *Piptolepis rosmarinifolia* differs from *P. pabstii* by its densely spiraled (vs. laxly) leaves, the shape of the leaves (linear to very narrow elliptic vs. narrow-oblong), smaller leaf blades (9–18 × 0.8–1.5 mm vs. 26–38 × 2.2–2.6 mm), capitulescence composed by a solitary terminal syncephalium (vs. cymose capitulescence composed by 1–5 terminal syncephalia, Fig. 2F), secondary bracts lorate or very narrow elliptic, rarely linear (vs. lanceolate to linear), a higher number of heads per syncephalium (30–64 vs. 16–21) and a higher number of pappus series (3 vs. 2) (Table 1). To the moment, both species are not found in sympatry: *P. rosmarinifolia* is only known from Serra Geral do Paranã, whereas *P. pabstii* is endemic of Serra dos Cristais, ca. 200 km to the south (Fig. 3).

Acknowledgments

The authors thank Regina Maria Alcântara de Carvalho for the line drawing, Moises Mendoza for help in collection expedition and Carolina Siniscalchi for helpful comments on the manuscript. J.C.B. thanks Coordenação de Aperfeiçoamento de Pessoal de Nível Superior for the fellowship granted (CAPES/PROEX).

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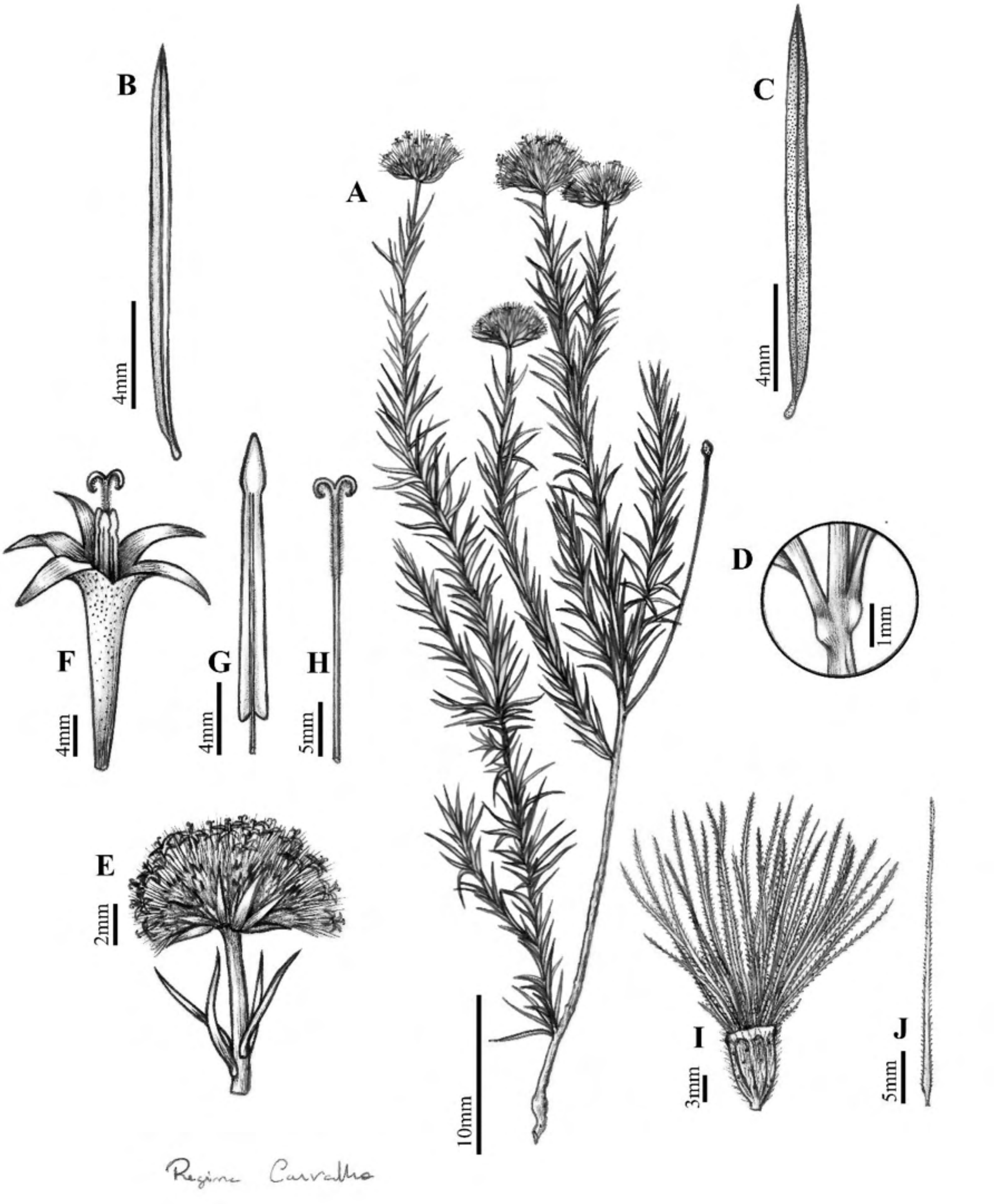

FIGURE 1. *Piptolepis rosmarinifolia*. **A.** Habit. **B.** Leaf, adaxial surface. **C.** Leaf, abaxial surface. **D.** Pad-like leaf sheath. **E.** Syncephalium. **F.** Corolla, androecium and upper part of style. **G.** Anther. **H.** Style. **I.** Cypsela. **J.** Pappus setae. **A.–I.** *Bringel Jr. et al. 1329* (UFP).

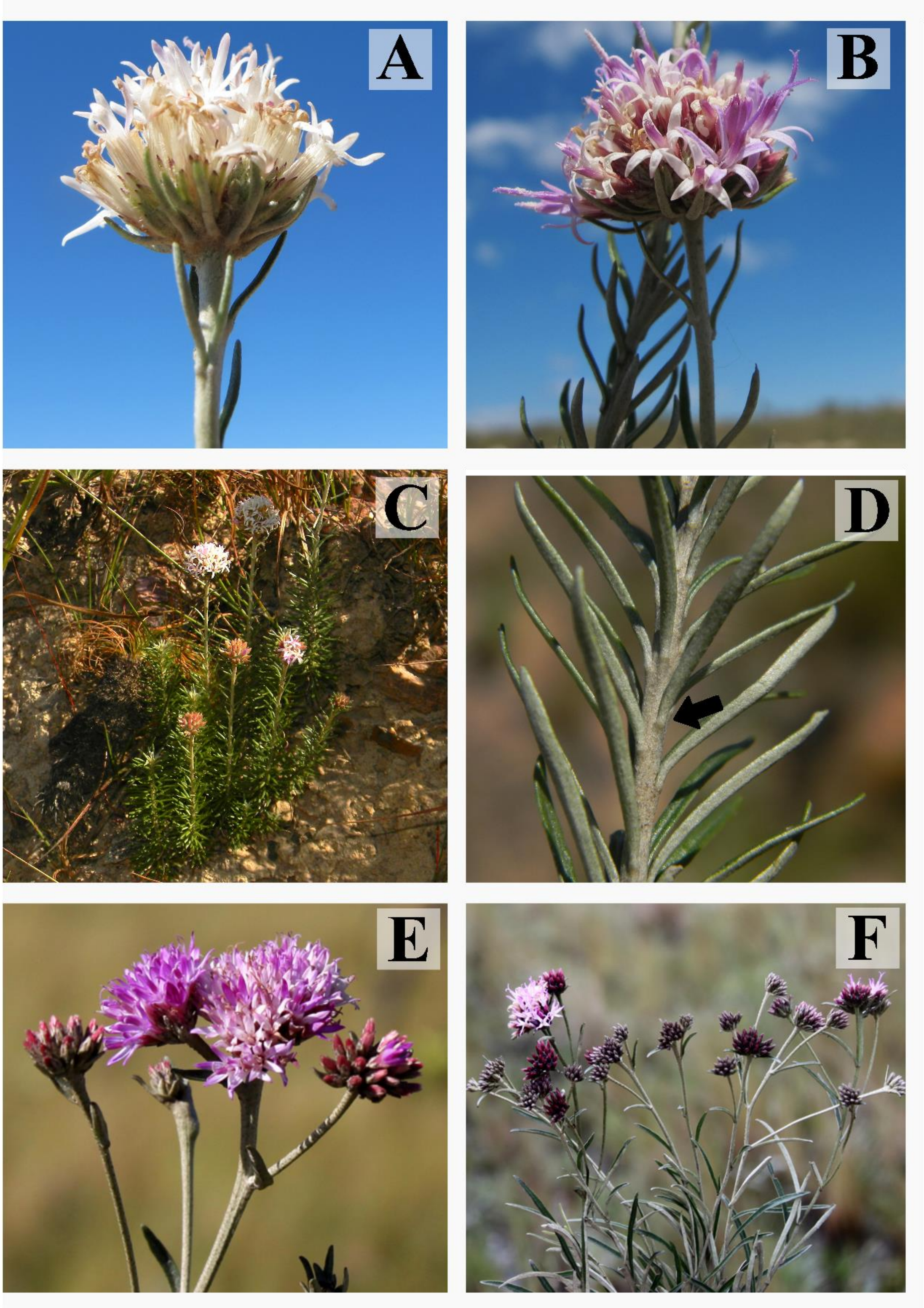

FIGURE 2. *Piptolepis rosmarinifolia*. **A.–B.** Syncephalia. **C.** Habit. **D.** Leaf arrangement and pad-like leaf sheath (black arrow). *Piptolepis pabstii*. **E**. Syncephalium. **F.** Capitulescence. **A.–E.** by Loeuille. **F.** by Henrique J. C. Moreira.

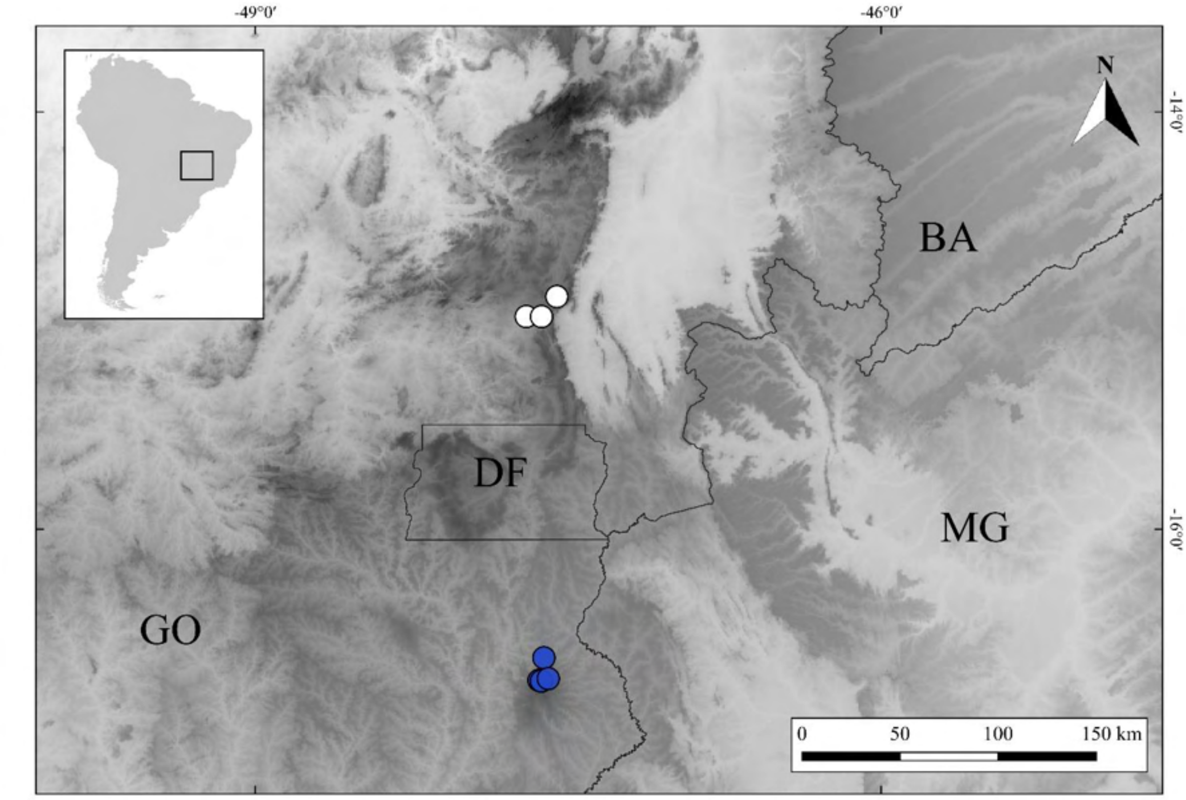

FIGURE 3. Distribution of *Piptolepis rosmarinifolia* (white circle) and *P. pabstii* (blue circle).

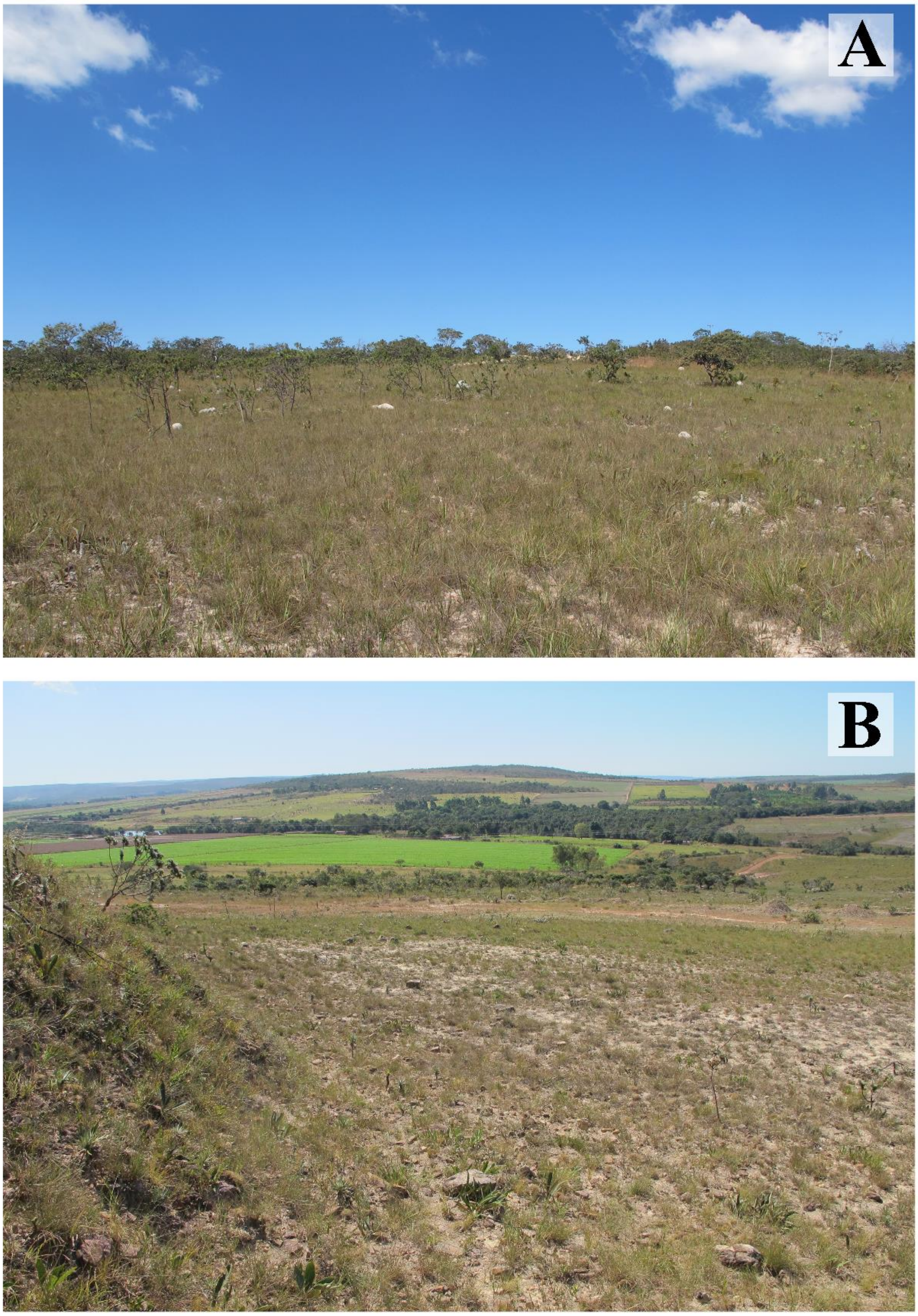

FIGURE 4. Habitats of *Piptolepis rosmarinifolia*. **A.** *Campo limpo* (at foreground) in Água Fria de Goiás. **B.** *Campo rupestre* (left) and anthropized *campo limpo* (right) in Planaltina de Goiás. **A.–B.** by Loeuille.

Table 1. Comparison of morphological characters between *Piptolepis rosmarinifolia* and *P. pabstii*.

Morphological characters	*P. rosmarinifolia*	*P. pabstii*
Leaf arrangement	densely alternate spiral	laxly alternate spiral
Leaf blade	Linear or very narrow elliptic	narrow-oblong
Leaf size	9–18 × 0.8–1.5 mm	26–38 × 2.2–2.6 mm
Capitulescence	unbranched (solitary syncephalium)	1–5-branched
Secondary bracts	lorate or very narrow elliptic, rarely linear	lanceolate to linear
Number of heads per syncephalium	30–64	16–21
Number of pappus series	three	two

APÊNDICE B – TWO NEW SPECIES OF *LYCHNOPHORELLA* (ASTERACEAE, VERNONIEAE) FROM CHAPADA DIAMANTINA, BAHIA, BRAZIL

ARTIGO PUBLICADO NO PERIÓDICO SYSTEMATIC BOTANY, 45(2): 379-386, 2020.

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Abstract

Lychnophorella comprises eight species previously placed in *Lychnophora*. It is characterized by the presence of a pad-like leaf sheath, strongly imbricate persistent phyllaries, glabrous corolla lobes and anther appendage constricted at the base. The genus is restricted to the highland rocky grassland vegetation in Chapada Diamantina, Bahia state, Northeastern Brazil. *Lychnophorella hindii* sp. nov. is morphologically similar to *L. santosii*, however the new species differs from *L. santosii* by its treelet habit (*vs.* shrubby), elliptic or ovate leaf blades (*vs.* spathulate or obovate), eucamptodromous venation (*vs.* brochidodromous), rounded base (*vs.* acute) and stramineous pappus (*vs.* reddish). *Lychnophorella saxicola* sp. nov. differs from *L. leucodendron* by its canescent stems (*vs.* lanate), densely sericeous leaves (*vs.* tomentose), and leaf blades measuring 19–30 × 5–7 mm (*vs.* 25–50 × 10–25 mm), dichasium of syncephalia (*vs.* dichasium of glomerules), cypsela prismatic to obconic (*vs.* cylindrical). These new species are described and illustrated, their affinities discussed and an updated key for the genus is provided.

Key words: Campo rupestre, Compositae, Endemism, Lychnophorinae

Introduction

The Cerrado domain in Northeastern Brazil occurs in the western part of the state of Bahia, associated with the hillsides of the Chapada Diamantina, commonly between 800-1000 m elevation (Rocha *et al.* 2005). One phytophysiognomy of the Cerrado are the campos rupestres which are a shrubby-herbaceous vegetation associated to high altitude (mainly found above 900

m) rock outcrops characterized by shallow, oligotrophic soils that are mainly composed of quartzite and display high levels of aluminium (Fernandes 2016, Colli-Silva *et al.* 2019).

Campos rupestres present a high diversity and high level of endemism of vascular plants, comprising more than 5,000 species, nearly 15% of the Brazilian plant diversity (Silveira *et al.* 2016). It is also the vegetation type with the highest percentage of endemism in Brazil, with ca. 40% of species being endemic (BFG 2015). Approximately 118 genera and 626 species of Asteraceae have been documented in campos rupestres, being one of the most diverse families in this physiognomy, accounting for almost 30% of the Brazilian species of the family (2099 spp.) (Flora do Brasil 2020 under construction 2019). Approximately 75 species of Astereaceae are endemic to Chapada Diamantina in Bahia (Roque *et al.* 2016).

Vernonieae is one of the major tribes of Asteraceae with ca. 1100 species placed into 129 genera (Keeley *et al.* 2007, Keeley & Robinson, 2009). They are distributed into two main biodiversity centers (Brazil and Africa) and are very variable in habit (from small herbs to large trees), bearing leaves generally alternate and discoid capitula with white, blue or purple florets (rarely red or yellow) (Keeley & Robinson 2009).

Among the 21 subtribes currently recognized in Vernonieae, Lychnophorinae is nearly endemic to Brazil (three species occur abroad) and contains 19 genera and 117 species. Several species are restricted to campo rupestre areas in the highlands of southeastern and northeastern Brazil and to the Cerrado (Loeuille *et al*. 2019).

The Chapada Diamantina flora has been intensely studied in specific areas, such as Mucugê (Harley & Simmons 1986, Watanabe *et al.* 2009, Silva & Wanderley 2013, Roque *et al*. 2016, Pataro *et al.* 2017), Pico das Almas (Stannard 1995), Catolés (Zappi *et al.* 2003) and Morro do Chapéu (Staudt *et al.* 2017). This effort has provided insights about the flora of campos rupestres, showing it is extremely rich in endemic species, and highlighting that there are still several poorly collected areas.

Lychnophorella Loeuille, Semir & Pirani (2019: 73) is a genus of the subtribe Lychnophorinae that comprises nine species. The genus is characterized by the presence of a pad-like leaf sheath, second-order syncephalia or heads congested in a dichasium, strongly imbricate persistent phyllaries, glabrous corolla lobes and anther appendage constricted at the base. The genus is restricted to the campos rupestres of Chapada Diamantina, the northern sector of the Espinhaço range of mountains, in the State of Bahia (Loeuille *et al.* 2019).

Extensive efforts to study the campos rupestres flora and its distribution patterns have revealed two new species of *Lychnophorella*, which are hereby described and illustrated and their affinities discussed.

Materials & Methods

This study was based on literature review, fieldwork observations and analyses of herbarium collections. Morphological features of the specimens were analyzed with an 8–40 × magnification stereomicroscope. Measurements were taken using a digital caliper rule and optical graticule attached to the microscope. Maps were prepared with Quantum GIS version 3.0 (QGIS Development Team 2015). Morphology terminology follows Small (1919) for pappus and receptacle forms, Hickey (1973) for leaf shape, Harris & Harris (2001) and Beentje (2010) for general morphology.

Taxonomic treatment

Lychnophorella hindii J.B.Cândido & Loeuille, **sp. nov.**

TYPE:—BRAZIL. Bahia: Chapada Diamantina, Ibicoara, Serra da Batava, [-13.317777°, -41.290833°], 1,186 m, 23 June 2012, *H. A. Ogasawara & G. B. Siqueira 220* (holotype: ALCB!).

Species Lychnophorellae santosio simile, sed habitu (arbuscula, non frutice), foliis ellipticis vel ovatis (non spathulatis vel obovatis), venatione eucamptodroma (non brochidodroma), basi rotundata (non acuta) et pappo stramineo (non rubello) differt.

Treelet up to 1.8 m tall, erect, twisted, branched towards the apex. Stems cylindrical, furrowed, velutinous, brown, old stems becoming glabrescent, rugose, manicate, dark grey, leaf scars flattened, deltate. Leaves alternate, simple, densely spiraled, sessile, pad-like leaf sheath deltate, 2–4 mm long; blade elliptic or ovate, 15–28 × 6.5–12 mm, strongly discolorous, coriaceous, venation eucamptodromous, midrib prominent abaxially, adaxial surface glaucous, glabrous to pubescent, abaxially light green, lanulose, margins entire, flat, apex rounded, base rounded. Capitula fused in a terminal, solitary, rarely two, syncephalium (secondary order inflorescence) at apex of branches. Syncephalium 3–4.1 cm tall, 1.4–2.3 cm in diam, hemispherical, with capitula adpressed at base, on retained peduncle following flowering, peduncle 3.5–8.6 cm long; secondary bracts 12–21 × 7–13 mm, leaf-like, base rounded to attenuate. Capitula 15–26, homogamous, discoid, sessile, interspersed by leaf-like subinvolucral bracts; involucre 7.4–8.3 mm tall × 3.2–4.3 mm diam, 5–6 seriate, turbinate; phyllaries imbricate, scarious, margins entire, apex acute, lanate only at apex, outer phyllaries ovate to deltoid, 2.1–3.2 × 1–1.5 mm, stramineous, inner phyllaries narrowly obtrullate, 5.8–6.2 × 1.2–1.4 mm, stramineous with brown middle line, glandular-punctate; receptacle flat, fimbrillate. Florets 5, bisexual, fertile; corolla actinomorphic, deeply 5-lobed, pale lilac to lilac, glabrous, glandular-punctate, 5.8–7.0 mm long., corolla tube 3–3.5 × 1.0–1.2 mm., corolla lobes 2.8–3.0 × 0.9–1 mm, apex acute;

anthers lilac, apical appendages acute, anther base sagittate; style shaft 3.5–6 mm long, pale lilac, glabrous throughout except for pubescent upper 2–2.5 mm beneath style-arms, style base glabrous, lacking basal node, with nectariferous disc, style arms 1–1.8 mm long, apex acute, short pubescent outside throughout. Cypselae prismatic, 2.5–3 × 1.0–1.3 mm, 8-ribbed, glabrous, glandular-punctate, brown, base attenuate; carpopodium annular, minute; pappus setae biseriate, equal to subequal, stramineous, paleaceous, narrowed, serrulate, series 4–4.5 mm long, straight, caducous. Fig. 1, 2 A–C.

Distribution and Habitat:— The new species occurs in campos rupestres vegetation (highland rocky grasslands – 1186 m alt.) on the basal plateau of Chapada Diamantina, at Serra do Batava, in the state of Bahia (Fig. 3).

Conservation status:— The species is known from a single locality and population, which is situated inside a protected area, being approximately 800 m distant from the southern limit of Chapada Diamantina National Park. Nonetheless, this single sampling of the species does not provide a confident evaluation of its conservation status through GeoCAT analysis (Bachmann *et al.* 2011). Thus, we suggest this species should be classified in the Data Deficient category (DD), according to the IUCN Red List Categories and Criteria (IUCN 2017).

Etymology:— This species is named in honor of D.J. Nicholas Hind, a renowned British botanist who has studied and described several new species of Asteraceae from the campos rupestres in Bahia.

Phenology:— The flowering and fruiting holotype was collected in June.

Notes:— *Lychnophorella hindii* is morphologically similar to *L. santosii* Loeuille, Semir & Pirani (2019: 78), both species displaying similar strongly discolorous leaves, with an abaxially prominent midrib, light green and lanulose adaxial surface, entire and flat margins, and rounded apex; the cypsela in both species is prismatic. However, the new species differs from *L. santosii* by its treelet habit (vs. shrubby), elliptic or ovate leaf blades (vs. spathulate or obovate), eucamptodromous venation (vs. brochidodromous), rounded base (vs. acute) and stramineous pappus (vs. reddish).

The southern part of Chapada Diamantina divides into two branches: Serra das Almas in the west and Serra do Sincorá in the east. *Lychnophorella hindii* is currently known only from Serra do Sincorá in the region of Ibicoara, while *L. santosii* occurs in the western side of Chapada Diamantina, at Serra das Almas and Serra do Barbado.

Lychnophorella bishopii Loeuille, Semir & Pirani (2019: 75) occurs sympatrically with the new species in Ibicoara, however it is easily distinguished by its not ericoid leaves (vs. ericoid), elliptic or ovate (vs. linear) and bigger leaf blades (15–28 × 6.5–12 mm vs. 8–15 × 1 mm), with flat margins (vs. revolute), eucamptodromous venation (vs. hyphodromous), rounded base (vs. attenuate to decurrent), glabrous cypsela (vs. with strigose hairs) and equal to subequal series of pappus setae (vs. unequal).

Several species in Chapada Diamantina are rare, therefore vulnerable due to their restricted distribution (microendemics) or low frequency, thus common species in one area may be absent in a nearby area. Due to this fragmentary distribution, each locality (mountain range) has unique diversity characteristics, making the selection of areas for conservation difficult (Rocha *et al.* 2005). Therefore, the discovery of new species improves the knowledge about the regional flora and can stimulate the creation of new conservation areas in the future or promote the extension of the ones already delimited (Siniscalchi *et al.* 2016).

Lychnophorella saxicola J.B.Cândido & Loeuille, **sp. nov.**

TYPE: — BRAZIL. Bahia: Chapada Diamantina, Rio de Contas, Pico do Itobira, [-13.370555°, -41.884444°], 1,918 m, 23 October 2018, *J.B. Cândido & F. Gomes-Silva 272* (holotype: UFP!, isotypes: ALCB!, K!, US!).

Species Lychnophorellae leucodendro simile, sed caulibus pilosis (non lanatis), foliis dense sericeis (non tomentosis), laminis 19–30 × 5–7 mm (non 25–50 × 10–25 mm), capitulis in syncephalis aggregatis (non glomerulis), cypsela prismatica ab obconica (non cylindrica) differt.

Treelet up to 1.3 m tall, erect, twisted, densely branched towards the apex. Stems cylindrical, pilose, stramineous, old stems becoming glabrescent, rugose, pubescent, dark grey, leaf scars circular. Leaves alternate, simple, densely spiraled, deciduous, sessile, pad-like leaf sheath ligulate, 2–3 mm long; blade narrowly elliptic, 19–30 × 5–7 mm, concolorous, grayish-green, densely sericeous, chartaceous, venation eucamptodromous, midrib prominent abaxially, margins entire, flat, apex acute, with a tuft of trichomes resembling an apiculus in young leaves, base attenuate, with an exceeding tuft of trichomes. Capitula organized in a dichasium of 1-8 syncephalia (secondary order inflorescence). Syncephalium 1–1.3 cm tall, 1.5–2.1 cm in diam, hemispherical, with capitula slightly adpressed at base, on retained peduncle following flowering, peduncle 8–65 cm long; secondary bracts 10–18 × 3–5 mm, leaf-like, narrowly elliptic to elliptic, base attenuate to truncate. Capitula 6–9, homogamous, discoid, sessile; involucre 7–8 mm tall × 4–5 mm diam, 7–8 seriate, cylindrical or slightly obovoid; phyllaries imbricate, scarious, margins entire, outer phyllaries ovate to deltate, 3–5 × 0.4–0.5 mm, apex long attenuate, stramineous, densely velutinous, inner phyllaries narrowly trullate, 6.5–7 × 0.8–1 mm, apex attenuate, stramineous with green middle line and brown apex, velutinous only in the apex, glandular-punctate; receptacle flat, fimbriate. Florets 3–5, bisexual, fertile; corolla actinomorphic, deeply 5-lobed, purple to violet, glabrous, glandular-punctate, 7.5–8 mm long, throat ca. 1 mm long, corolla tube 3–3.2 × 1.2–1.5 mm., corolla lobes 3.5–3.8 × 0.8–1 mm, apex acute; anthers purple, apical appendages acute, anther base sagittate; style shaft 7–8.2 mm long, violet, glabrous throughout except for pubescent upper 1–1.2 mm beneath style arms, style base glabrous, lacking basal node, style arms 1.1–1.6 mm long, apex acute, pubescent outside throughout. Cypsela prismatic to obconic, 2.5–3 × 1.0–1.2 mm, 10-ribbed, puberulous, glandular-punctate inside the furrows, yellowish-brown, carpopodium annular, minute; pappus 3-seriate, deciduous, paleaceous, serrulate throughout except for barbellate upper part, narrowed, outer series setae 1.2–2.5 mm, reddish, inner series setae 5–6 mm, reddish to light stramineous in the apex. Fig. 2 D–F, 4).

Distribution and habitat:— *Lychnophorella saxicola* occurs in campos rupestres vegetation (highland rocky grasslands – 1,918 m) in the basal plateau of Chapada Diamantina, in the summit of Pico do Itobira, in the state of Bahia. According to the Reflora - Herbário Virtual (2019) and SpeciesLink (2019) databases, only one additional Asteraceae collection is registered for this location, gathered by R.M. Harley in November 15, 1996, which is the type material of *Lychnophorella sericea* Loeuille, Semir & Pirani (2019: 78), a microendemic species from this locality, which therefore occurs in sympatry with the new species (Fig. 3).

Conservation status:— The species is known from a single locality and population, which is located outside protection areas, being approximately 63 km distant from Chapada Diamantina National Park. Therefore, this single collection of the species does not provide a reliable evaluation of its conservation status through GeoCAT analysis (Bachmann *et al.* 2011). Thus, we suggest this species should be classified as Data Deficient (DD), according to the IUCN Red List Categories and Criteria (IUCN 2017). We believe this species to be microendemic, however more collection efforts are necessary to better understand its distribution.

Etymology:— The epithet *saxicola* refers to the species habitat, which growing among rocks.

Phenology:— Flowering and fruiting specimens were found in October however most of the heads were in fruit.

Notes:— *Lychnophorella saxicola* resembles *L. leucodendron* Loeuille, Semir & Pirani (2019: 76) due to its grayish-green, concolored leaves with eucamptodromous venation and heads organized in a congested dichasium, however it differs from it in the canescent stems (vs. lanate); densely sericeous leaves (vs. tomentose); and leaf blades measuring 19–30 × 5–7 mm (vs. 25–50 × 10–25 mm); dichasium of 1-8 syncephalia (vs. dichasium of glomerules), florets 3–5 per capitulum (vs. florets 5 or 10–15 in putative polyploids), cypsela prismatic to obconic (vs. cylindrical), pappus with a reddish outer series and reddish to white inner series (vs. stramineous).

The new species occurs in the same locality of *L. sericea*, but differs from it due to the narrowly elliptic leaf blade (vs. linear to aciculate), 19–30 × 5–7 mm (vs. 12–16 × 1.5–2.3 mm), with flat margins (vs. revolute), acute apex (vs. apiculate), syncephalia with 6–9 capitula (vs. 20), involucre 7–8 seriate (vs. 3–4-seriate), 3–5 florets per capitulum (vs. 2–4 florets), 10-ribbed cypselae (vs. shallowly ribbed), pappus 3-seriate (vs. uniseriate) and deciduous (vs. caducous).

The presence of a 3-seriate pappus in *Lychnophorella saxicola* slightly amplifies the concept of the genus since Loeuille *et al.* 2019 described it with pappus biseriate or rarely uniseriate. However, the number of series of the pappus is a variable character among Lychnophorineae genera and cannot be used as a diagnostic character at the generic level. For example, *Eremanthus* was traditionally described with 3- to 5-seriate pappus (MacLeish 1987) but species with a biseriate pappus have been added to the genus in the last decades (Robinson 1995, Loeuille *et al.* 2012). Similarly, genera such as *Lychnophora* Martius (1822: 148) or *Piptolepis* Schultz-Bipontinus (1863: 380) were understood as having exclusively biseriate pappus (Semir *et al.* 2011, Schultz-Bipontinus 1863) and exceptions to this pattern have been observed: uniseriate pappus for some *Lychnophora* species (Loeuille *et al.* 2019) and 3-seriate pappus in at least two species of *Piptolepis* (Bringel *et al.* 2019, unpubl. data).

Diagnostic key for species of Lychnophorella (modified from Loeuille *et al.* 2019)

1. Leaves not ericoid, margins flat, venation camptodromous …………………….……………. 2

–. Leaves ericoid, margins revolute, venation hyphodromous …………………….….………… 5

2. Leaves concolorous, abaxial surface pubescent or densely sericeous; heads organized in a dichasium of glomerules or of syncephalia ……………………………………….……….………3
–. Leaves discolorous, abaxial surface lanulose; heads fused in solitary syncephalium……………………………….….……………..…...….…..……………4
3. Synflorescence dichasium of glomerules, cypsela cylindrical, pappus biseriate, stramineous …………………………………………………...……… *Lychnophorella leucodendron*
–. Inflorescence dichasium of syncephalia, cypsela prismatic to obconic, pappus 3-seriate, reddish to light stramineous ………………………………..…....… *Lychnophorella saxicola*

4. Shrubs; leaf blade spathulate or obovate, venation brochidodromous, base acute; pappus reddish …………………………………………..……..………… *Lychnophorella santosii*

–. Treelets; leaves elliptic or ovate, venation eucamptodromous, base rounded; pappus stramineous ……………………………………………………...…...… *Lychnophorella hindii*

5. Adaxial surface of the leaves densely sericeous …………………... *Lychnophorella sericea*

–. Adaxial surface of the leaves glabrous to glabrescent ……………………….…….………… 6

6. Leaf base attenuate to decurrent; cypsela strigose …………….…… *Lychnophorella bishopii*

–. Leaf base subcordate to rounded; cypsela glabrous ……………………………………… 7

7. Syncephalium not surrounded by foliage leaves ……….……………… *Lychnophorella regis*

–. Syncephalium surrounded by foliage leaves ……………….……………………………… 8

8. Cypsela prismatic, pappus uniseriate ……………………..………..……………….…... 9

–. Cypsela cylindrical, pappus biseriate ………………………..….………..………… 10

9. Leaves ovate, patent; 1–3 florets per head ………………..……..……..… *Lychnophorella morii*

–. Leaves narrowly lanceolate, ascending; 3–4 florets per head ……..…. *Lychnophorella triflora*

10. Leaves narrowly elliptic to lanceolate, frequently conduplicate; capitula 5–6.1 mm diam, phyllaries tomentose to tomentulose (at least in the upper portion) …………………………………………………….….……….. *Lychnophorella jacobinensis*

–. Leaves linear to linear-lanceolate, always flat; capitula 7–11 mm diam, phyllaries glabrous ………………..…………………………………..…………… *Lychnophorella blanchetii*

Acknowledgments

The authors thank Regina Maria Alcântara de Carvalho for the line drawings, Francione Gomes Silva for his assistance during fieldwork and Fábio Alves for helping produce the maps. J. B. Cândido thanks Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (Finance Code 001) for the fellowship granted (CAPES/PROEX).

Author contributions

J. B. Cândido designed and wrote the paper, B. Loeuille provided Latin descriptions, comments, suggestions and reviewed the manuscript.

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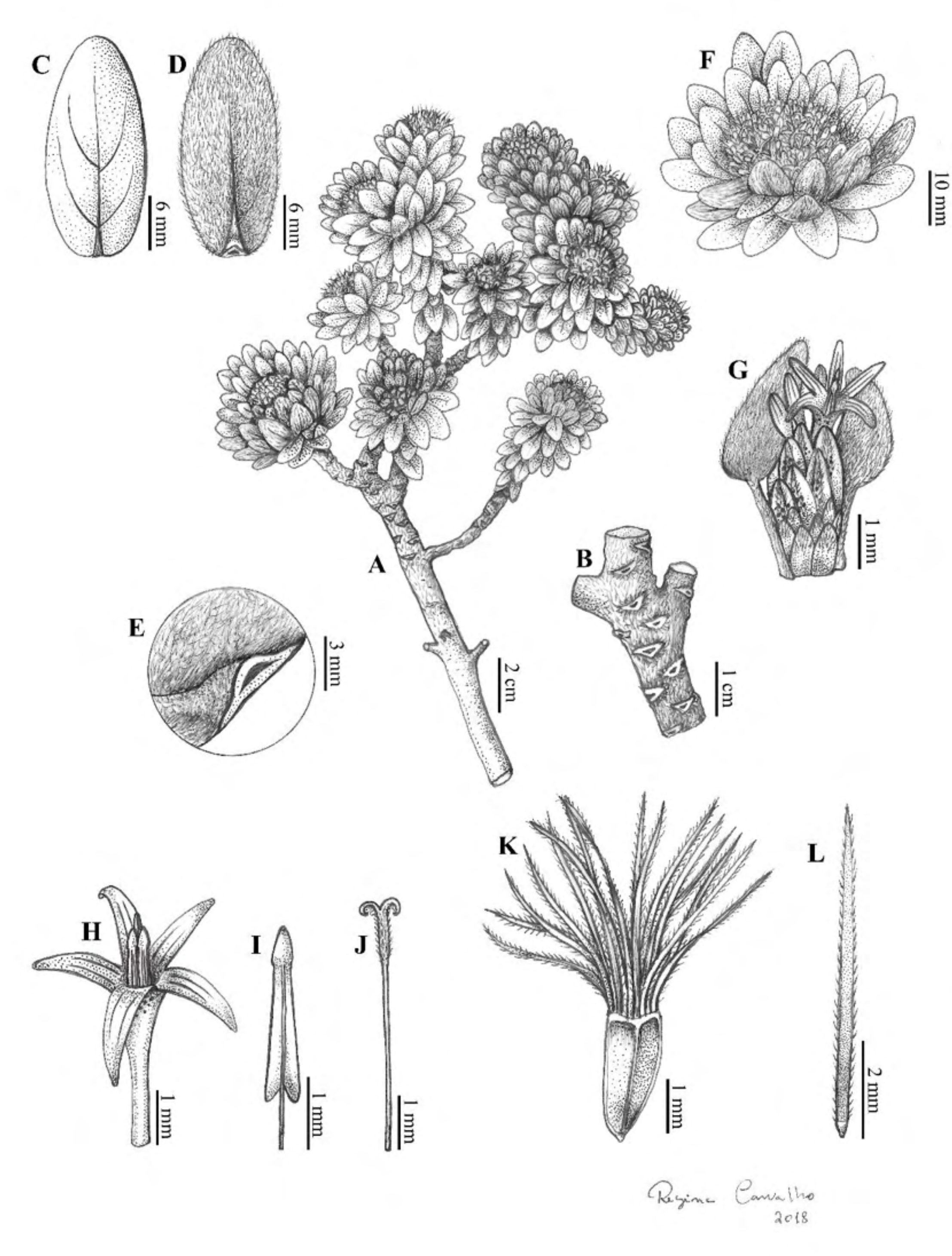


FIGURE 1. *Lychnophorella hindii* sp. nov. **A.** Flowering branch. **B.** Stems with leaf scars. **C.** Leaf, adaxial surface. **D.** Leaf, abaxial surface. **E.** Pad-like leaf sheath. **F.** Syncephalium. **G.** Capitulum. **H.** Corolla, androecium and style. **I.** Anther. **J.** Style. **K.** Cypsela. **L.** Pappus element. Drawing by the late Regina Maria Alcântara de Carvalho.

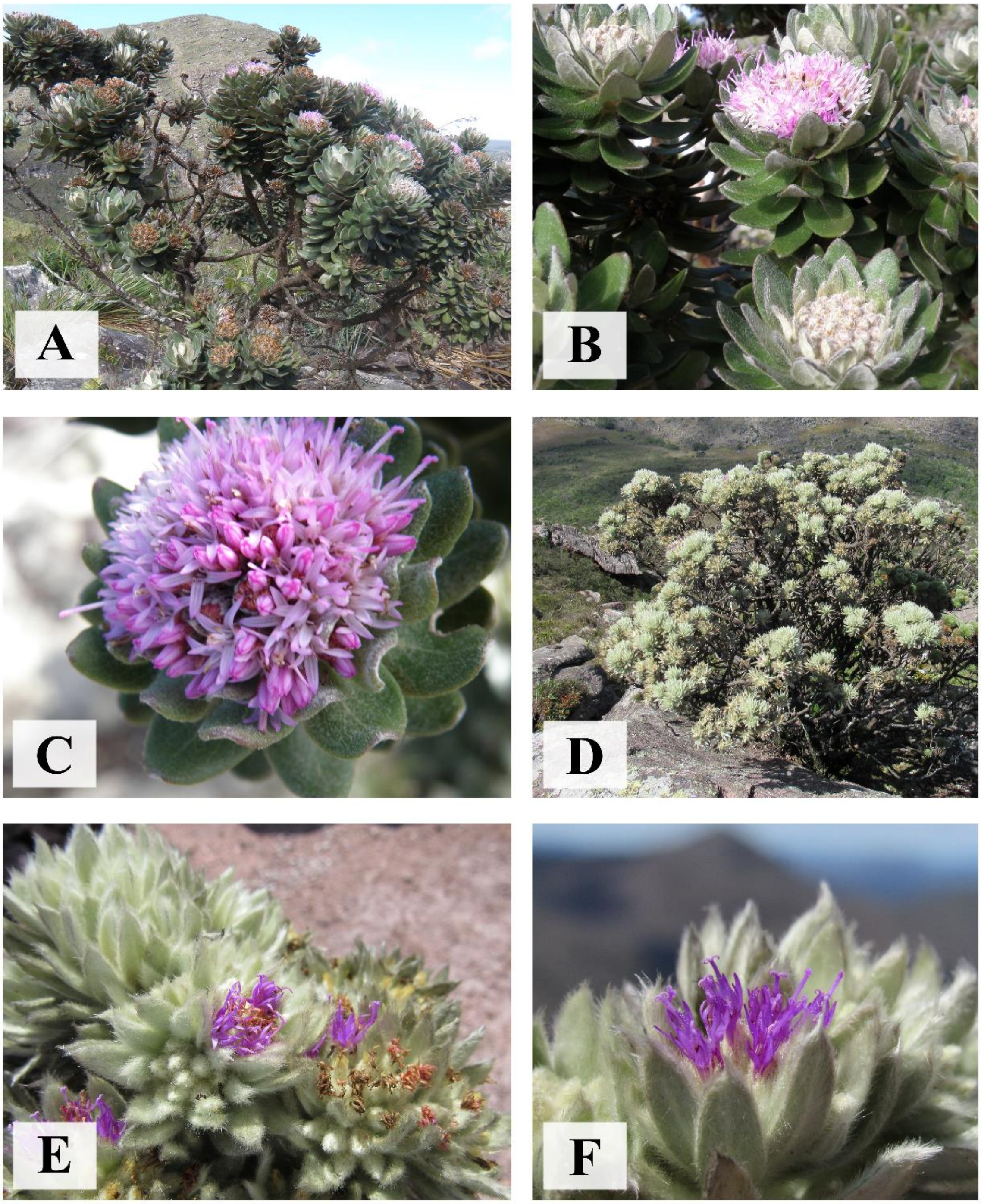


FIGURE 2. **A–C:** *Lychnophorella hindii* sp. nov **A.** Habitat. **B.** Syncephalia. **C.** Floret. **D–F:** *Lychnophorella saxicola* sp. nov. **D.** Habitat. **E.** Syncephalia. **F.** Syncephalium. **A–C.** by H. A. Ogasawara; **D–F.** By J. B. Cândido.

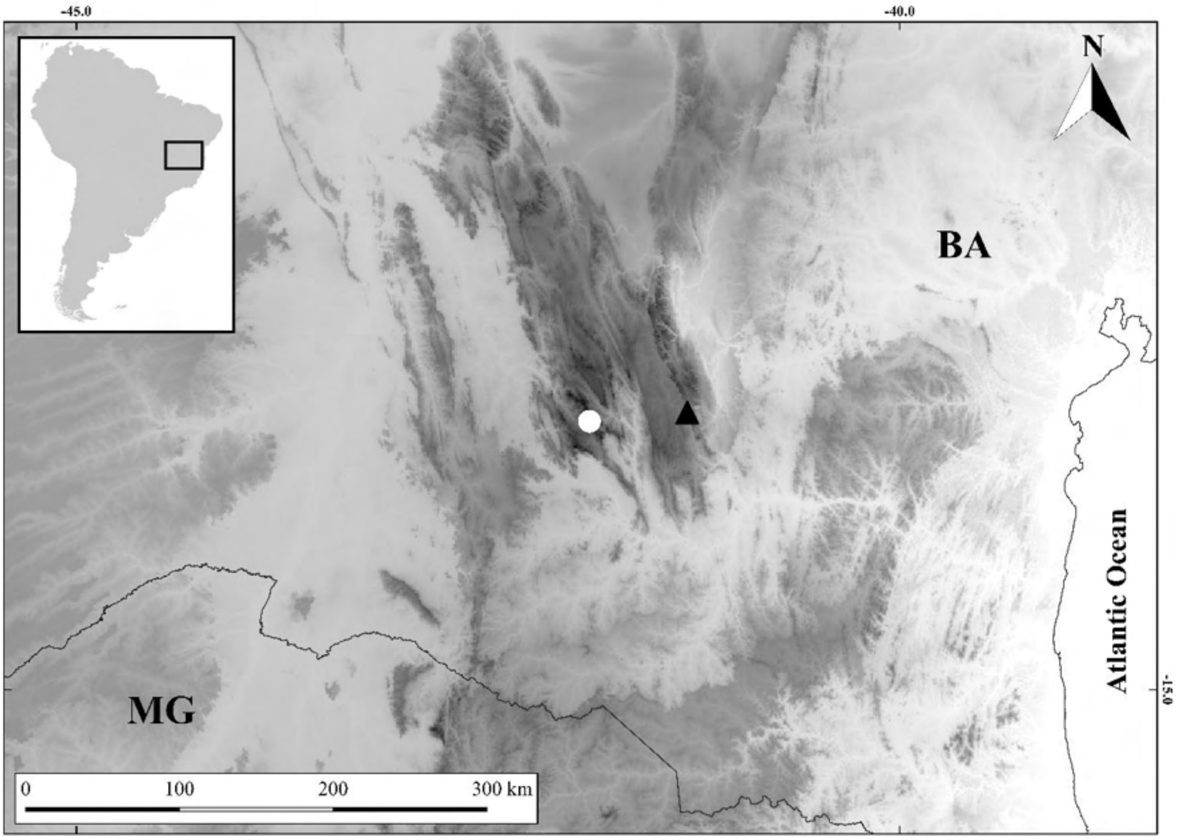
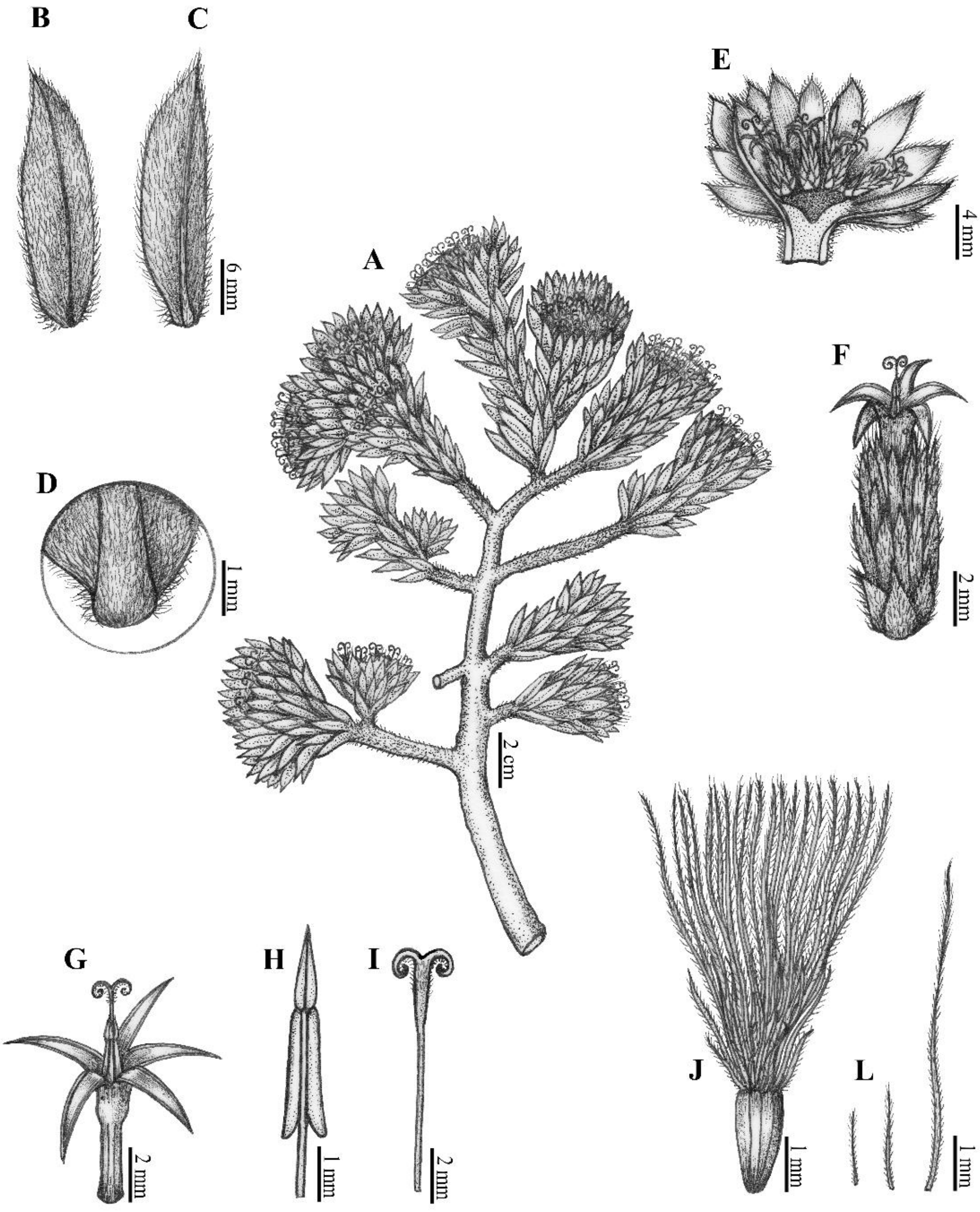


FIGURE 3. Distribution of *Lychnophorella hindii* (black triangle) and *L. saxicola* (white circle).



Regina Carvalho

FIGURE 4. *Lychnophorella saxicola* sp. nov. **A.** Flowering branch. **B.** Leaf, adaxial surface. **C.** Leaf, abaxial surface. **D.** Pad-like leaf sheath. **E.** Cross-section section of syncephalium. **F.** Capitulum. **G.** Corolla, androecium and style. **H.** Anther**. I**. Style. **J.** Cypsela. **L.** Outer, middle and inner pappus. Drawing by the late Regina Maria Alcântara de Carvalho.

TABLE 1. Comparison of morphological characters among *Lychnophorella hindii*, *L. saxicola* and related species.

Species characters	*L. hindii*	*L. santosii*	*L. saxicola*	*L. leucodendron*	*L. sericea*
Leaf shape	Elliptic or ovate	Spathulate or obovate	Narrowly elliptic	Elliptic or obovate to oblong	Linear to aciculate
Leaf apex	Rounded	Rounded	Acute	Acute or Rounded	Apiculate
Leaf base	Rounded	Acute	Attenuate	Cuneate	Truncate
Leaf size (mm)	15–28 × 6.5–12	12–15 ×5–7	19–30 × 5–7	25–50×10–25	12–16 × 1.5–2.3
Adaxial surface indumentum	Glabrous to pubescent	Glabrous	Densely sericeous	Pubescent	Sericeous
Abaxial surface indumentum	Lanulose	Lanulose	Densely sericeous	Pubescent	Sericeous
Venation	Eucamptodromous	Brochidodromous	Eucamptodromous	Eucamptodromous	Hyphodromous
Synflorescence type	Solitary syncephalium	Solitary syncephalium	Dichasium of syncephalia	Dichasium of glomerules	Solitary syncephalium
Number of florets	5	1–5	3–5	5 or 10–15 (putative polyploids)	2 - 4
Cypsela shape	Prismatic	Prismatic	Prismatic to obconic	Cylindrical	Prismatic
Number of pappus series	Biseriate	Biseriate	3-seriate	Biseriate	Uniseriate

APÊNDICE C – THREE NEW SPECIES OF *PIPTOLEPIS* (VERNONIEAE, ASTERACEAE) FROM THE DIAMANTINA PLATEAU, MINAS GERAIS, BRAZIL

ARTIGO PUBLICADO NO PERIÓDICO SYSTEMATIC BOTANY 46 (2): 493−503, 2019.

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Abstract— *Piptolepis* is an endemic genus of the Brazilian Central Plateau. It comprises 13 species, almost all of them microendemic and poorly collected. They are shrubs, subshrubs or treelets, with leaves displayed in a typical pad-like sheath, the heads are solitary or organized in a pseudoglomerule, or rarely a syncephalium (second-order inflorescence), with weakly imbricate phyllaries. As a preliminary result of an ongoing taxonomic revision of *Piptolepis*, we hereby report three new species. ***P. corymbosa*** J.B.Cândido & Loeuille is similar to *P. leptospermoides* (Mart. ex DC.) Sch.Bip., while ***P. pilosa*** J.B.Cândido & Loeuille resembles *P. ericoides* Sch.Bip. and ***Piptolepis procumbens*** J.B.Cândido & Loeuille is similar to *P. campestris* Semir & Loeuille. These new species are described and illustrated, their taxonomic affinities are discussed, and their conservation status are assessed.

Keywords— Campo rupestre, Compositae, endemism, Espinhaço Range, Lychnophorinae.

The Espinhaço Range of mountains is located in southeastern Brazil. In the state of Minas Gerais, it extends from Ouro Branco in the south to Grão Mogol in its northern portion, reaching ca. 550 km North-South and being 50–100 km East-West. It is located in the Cerrado, Caatinga and Atlantic Forest phytogeographic domains and presents a mosaic of phytophysiognomies. The campo rupestre (tropical high altitude grasslands on quartzite rock outcrops) is a vegetation type that occurs mostly in the Espinhaço Range, where it is associated with elevations higher than 900 m a.s.l., rock outcrops, sandy, dry and wet fields, and a herbaceous to open shrubby vegetation on oligotrophic soils over quartzite or iron, often displaying high levels of aluminum (Giulietti et al. 1987; Rapini et al. 2008; Echternacht et al. 2011; Morellato and Silveira 2018; Chaves et al. 2019a).

Campos rupestres present a high diversity and high level of endemism, comprising 5,215 species of vascular plants, nearly 15% of the Brazilian plant diversity (Morellato and Silveira 2018; Mucina 2018; Flora do Brasil 2020 under construction 2020). It is also the vegetation type with the highest percentage of endemism in Brazil (ca. 40%) (BFG 2015). Approximately 118 genera and 634 species of Asteraceae have been documented in campos rupestres (Flora do Brasil 2020 under construction 2020).

The flora of the Espinhaço Range in the state of Minas Gerais has been intensively studied in specific areas, such as Serra do Cipó (Pirani et al. 2020 and references therein; Zappi et al. 2014), Grão Mogol (Pirani et al. 2003; Vasquez and Harley 2004; Skorupa 2006; Vitta and Prata 2009; Yamamoto 2009), Diamantina Plateau (Franco et al. 2014; Andrino et al. 2015; Araújo and Romero 2016; Gonçalves et al. 2017; Chaves et al. 2019b) and Ouro Preto (Messias et al. 2017). This effort has provided numerous insights about the evolutionary history, biogeographical relationships, distribution pattern, phylogenetic structure, ecology and conservation of the flora of campos rupestres (Hopper 2009; Echternacht et al. 2011; Fernandes et al. 2014; Silveira et al. 2016; Fernandes et al. 2018; Monteiro et al. 2018; Morellato and Silveira 2018; Mucina 2018; Zappi et al. 2017), highlighting its extreme endemism richness. However, some regions inside the Diamantina Plateau are surprisingly poorly collected and increased collection effort in these regions has provided new discoveries of endemic taxa (Echternacht et al. 2010).

The Diamantina Plateau is part of the meridional Espinhaço Range in Minas Gerais, north from Serra do Cipó and south from Grão Mogol (Echternacht et al. 2011). The Diamantina Plateau has a high floristic and structural heterogeneity of herbaceous and woody Asteraceae species. Endangered species of the family are irregularly distributed in the Plateau, presenting few individuals per population (Conceição and Pirani 2005; Chaves et al. 2019a, Chaves et al. 2019b).

Additionally, a higher number of endemic species is found in the Diamantina Plateau than in other regions of the Espinhaço Range in the state of Minas Gerais (Echternacht et al. 2011). This was corroborated by Chaves et al. (2019b), who found a significant number of Asteraceae (7.5% of sampled species) endemic to the Diamantina Plateau, further suggesting that the true number of endemic species of the family in the region may be even higher, as new species are continuously being discovered.

Vernonieae is considered the fifth largest tribe of Asteraceae, with 21 subtribes, 129 genera and ca. 1500 species (Robinson 2007; Panero and Crozier 2016). The tribe has a pantropical distribution with two main biodiversity centers (Brazil and Africa) and show high diversity of habits (from small annual herbs to large trees), generally bearing alternate leaves and discoid heads with white, blue or purple corollas (rarely red or yellow) (Keeley and Robinson 2009).

Among the subtribes currently recognized in Vernonieae, Lychnophorinae comprises 19 genera and 117 species, consisting mostly of shrubs and treelets growing in the cerrados and campos rupestres of the Brazilian Central Plateau, where some species are often dominant in the vegetation (Loeuille et al. 2019).

Piptolepis Sch.Bip. is a monophyletic genus, endemic to the Brazilian Central Plateau, presenting its center of diversity in the Diamantina Plateau (Loeuille et al. 2012, Loeuille et al. 2015). It comprises 13 species with a disjunct distribution: 11 species occur in the campos rupestres in the Espinhaço Range in the state of Minas Gerais, and two species occur in the state of Goiás (*P. pabstii* (G.M. Barroso) Loeuille, Semir & Pirani and *P. rosmarinifolia* Bringel, J.B.Cândido & Loeuille). They are shrubs, subshrubs or treelets with profusely branched stems, covered by a tomentose to velutinous indumentum composed of 3- to 5-armed trichomes. The leaves are alternate, sessile to petiolate, with a typical pad-like or rarely semi-amplexicaul leaf sheath. The heads are solitary or organized in a terminal pseudoglomerule, rarely a syncephalium (second-order inflorescence), with weakly imbricate phyllaries (Loeuille et al. 2019).

Piptolepis presents a high level of microendemism. Almost all species are usually represented in herbaria by a few collections, with the exception of *Piptolepis ericoides* Sch.Bip., which is widespread along several mountains in the Espinhaço Range in Minas Gerais. Consequently, the genus is still poorly known in several aspects (e.g. taxonomic, evolutionary, systematic, ecological and conservation). The present study brings preliminary results of an ongoing taxonomic revision of *Piptolepis*, and we hereby report three new species, which are described, illustrated and have their affinities discussed.

MATERIALS AND METHODS

This study was based on intensive fieldwork in the campos rupestres of Minas Gerais and analyses of herbarium specimens. Morphological features of the specimens were analyzed with a 10–16 × magnification stereomicroscope. Measurements were taken using a digital caliper rule and optical graticule attached to the microscope. The measurements of the heads, corollas, anthers and styles were made from dried specimens rehydrated for microscopic examination of floral parts, whereas leaves were measured using only dried material. Maps were prepared with Quantum GIS version 3.0 (QGIS Development Team 2018). Morphological terminology follows Small (1919) for pappus and receptacle forms; Hickey (1973) for leaf shape; Harris and Harris (2001) and Beentje (2010) for general morphology and color terminology.

TAXONOMIC TREATMENT

Piptolepis corymbosa J.B.Cândido & Loeuille, sp. nov. TYPE: BRAZIL. Minas Gerais, Buenópolis, Parque Nacional das Sempre Vivas, área de afloramento rochoso, logo atrás do alojamento, [-17.916472°, -43.784861°], elev. 1,267 m, fl. fr., 10 May 2019, *J. B. Cândido et al. 332* (holotype: UFP!, isotypes: BHCB!, K!, RB!).

Species Piptolepi leptospermoide maxime simile, sed foliis anguste ellipticis ad ovata (non ellipticis), supra pilosis (non pubescentibus), apice subacuto (non obtuso), inflorescentia corymbosa (non racemosa) et seriebus pappi subaequilongis vel aequilongis (non inaequilongis) differt.

Shrubs 0.4–0.7 m tall, densely branched, spreading, straggling, arching branches. **Stems** terete, dark brown puberulent to pilose, old stems rugose, leaf scars deltate. **Leaves** alternate, simple, spiraled, patent to ascending, sessile to subsessile, petiole (0–)0.1–0.5 mm, pad-like leaf sheath ligulate, 0.5–1 mm long; blade narrow elliptic to ovate, 2.2–5 × 1.2–1.8 mm, discolorous, coriaceous, venation hyphodromous, midrib adaxially impressed, mostly concealed by indumentum, abaxially prominent, adaxial surface olive green, pilose, abaxially citrine, lanate, margins entire, revolute, apex subacute, with a tuft of trichomes in the younger leaves, base cuneate to obtuse. **Inflorescence** in terminal corymbs, with leaf-like bracts at base of capitula, 4–6 × 1–1.5 mm, apex obtuse, base attenuate. **Capitula** 4–16, homogamous, discoid, sessile; involucre campanulate, 6–7 mm tall × 6–7 mm diam., 6–7 seriate; phyllaries weakly imbricate, scarious, margins entire, glandular-punctate, light-green, apex vinaceous, lanulose, outer phyllaries triangular to lanceolate, 1.8–3 × 0.5–1 mm, apex acute, inner phyllaries lanceolate, 5–5.5 × 1–1.2 mm, apex subacute; receptacle flat, fimbrillate. **Florets** 12–17, bisexual, fertile; corolla actinomorphic, deeply 5-lobed, purple, glabrous, glandular-punctate, 7.5–8 mm long., corolla tube 4–5 × 1–1.8 mm., corolla lobes 3 × 0.7–0.9 mm, apex acute; anthers calcarate, purple, apical appendages acute, anther base sagittate; style shaft 8–8.5 mm long, purple, glabrous throughout except for pubescent upper 0.5 mm beneath style arms, style base glabrous, lacking basal node, style arms 1.6–2 mm long, apex acute, short-pubescent outside throughout. **Cypselae** prismatic, 1.6–2 × 0.6–1 mm, 9–10 ribbed, glabrous, ochraceous, glandular-punctate, light brown; carpopodium annular, minute; pappus setae biseriate, 4–4.5 mm long., subequal or equal, stramineous, vinaceous at apex of younger pappus setae, deciduous, paleaceous, serrulate. Figures 1 (A–C), 2.

Distribution and habitat— Endemic to the Diamantina Plateau of the Espinhaço Range of mountains in Minas Gerais, at Sempre Vivas National Park, a protected area of ca. 124,154 hectares within the boundaries of the municipalities of Olhos d'Água, Bocaiúva, Buenópolis and Diamantina (Fig. 3). *P. corymbosa* occurs in campos rupestres vegetation, over rock outcrops and, on the banks of small streams, at elevations between 1,267 and 1,280 m.

Informal Conservation Status— This species is known only from a single population and three collections [see additional specimens studied]. Studies have been published on the Asteraceae of Sempre Vivas National Park (Franco et al. 2014; Chaves et al. 2019b) but no additional populations were sampled. Microendemism is very frequent in *Piptolepis* (Bringel et al. 2019; Loeuille et al. 2019), thus it is likely there are very few populations, or even just this single recorded population. Although it was collected in a conservation unit, the area of occurrence of the species has been affected by frequent anthropogenic fires that easily pervade the park limits. The Sempre Vivas National Park managers have been working to control and manage fire through actions such as formation of fire brigades, daily rounds, educational campaigns, and integrated fire management (Fontana et al. 2016). These are extremely important conservation actions to prevent frequent fires in this key area for conservation of threatened plants (Monteiro et al. 2018). If a formal assessment was performed according to the IUCN guidelines (2019) using the GeoCAT tool analysis (Bachmann et al. 2011), this species would probably be classified as Critically Endangered CR B1a+B2a, according to IUCN guidelines (2019), as it has an area of occupancy (AOO) of 8 km^2, and extent of occurrence (EOO) of 0.139 km^2, being known from a single locality.

In addition to the fires that affect Sempre Vivas National Park, the population of *P. corymbosa* is near to the park staff lodging, in an area that has undergone anthropic disturbance.

Etymology— The epithet *corymbosa* refers to the capitulescence type.

Phenology— Flowering and fruiting specimens were found in May, September and November.

Notes— *Piptolepis corymbosa* is very similar to *P. leptospermoides* (Mart. ex DC.) Sch.Bip. due to its deltate leaf scars, small, discolorous, coriaceous leaves with hyphodromous venation, cuneate to obtuse base and revolute margins. Both species also have a campanulate involucre. However, the new species differs by its leaf shape (narrow elliptic to ovate vs.

elliptic), adaxial leaf surface indumentum (pilose vs. pubescent), leaf apex (subacute vs. obtuse), inflorescence type (corymbose vs. racemose), smaller involucre (6–7 mm vs. 8–10 mm diam.) and relative size of pappus setae series (subequal or equal vs. unequal) (Table 1).

Although *Piptolepis leptospermoides* is also endemic to the Diamantina Plateau, the two species are not sympatry, as no populations of this species have been recorded in Sempre Vivas National Park.

***Additional Specimens Examined*—Brazil.**—MINAS GERAIS: Mun. Buenópolis, Parque Nacional das Sempre Vivas, área de afloramento rochoso atrás do alojamento dos guarda-parques, as margens de pequeno córrego, [-17.917°, -43.785666°], elev. 1267 m, fl. fr., 10 May 2019, *J.B. Cândido et al. 331* (UFP!); ibid, [-17.916666°, -43.785555°], elev. 1280 m, fl. fr., 03 September 2014, *C.M Siniscalchi et al. 549* (DIAM!, SPF!, UFP!); ibid, [-17.916666°, -43.785°], elev.1277 m, fl. fr., 19 November 2013, *D.A. Chaves 117* (HDJF!, UB!).

Piptolepis pilosa J.B.Cândido & Loeuille, sp. nov. TYPE: BRAZIL. Minas Gerais, Buenópolis, Parque Nacional das Sempre Vivas, próximo ao rio Jequitaí, estrada à direita do alojamento ca. de 4 km de distância, [-17.891833º, -43.806166º], 1,236 m, fl. fr., 23 May 2019, *J.B. Cândido 376* (holotype: UFP!, isotypes: BHCB!, K!, RB!).

Species Piptolepi ericoide simile, sed caulibus patentibus (non virgatis), foliis brevioribus (3.2–9 × 0.8–1.6 mm, non 4–41× 0.8–3.5 mm), supra villosis (non tomentulosis), infra pilosis (non canescentibus), caespite trichomatum apiculiformi apicem versus (non sine caespite trichomatum), coriaceis (non chartaceis) et marginibus revolutis (non planis) differt.

Shrub 0.4–0.6 m tall, densely branched, spreading, straggling, arching branches. **Stems** terete, ochraceous puberulent to pilose, old stems dark brown, glabrescent, rugose, leaf scars semi-circular. **Leaves** alternate, simple, spiraled, patent to ascending, sessile to subsessile, petiole (0–)0.2–0.5 mm, pad-like leaf sheath ligulate, 0.4–0.7 mm long; blade narrow elliptic to very narrow elliptic, 3.2–9 × 0.8–1.6 mm, discolorous, coriaceous, venation hyphodromous, midrib adaxially impressed, slightly concealed by indumentum, abaxially slightly prominent, adaxial surface olive green, villous, abaxially sage-green, pilose, margins entire, revolute, apex acute, with a tuft of trichomes resembling an apiculus, base attenuate. Inflorescence in racemes or solitary capitulum, terminal at apex of branches, with leaf-like bracts, 6.5–7.5 × 0.4–1 mm, apex obtuse, base attenuate. **Capitula** 1–16, homogamous, discoid, sessile; involucre campanulate, 6.5–7 mm tall × 5–6 mm diam, 7–8 seriate; phyllaries weakly imbricate, scarious, margins entire, glandular-punctate, stramineous with brownish apex, lanulose, outer phyllaries triangular 2–3.6 × 0.8–1.1 mm, apex acuminate, inner phyllaries lanceolate,4.5–6 × 1–1.2 mm, apex acute; receptacle flat, fimbrillate. **Florets** 10–13, bisexual, fertile; corolla actinomorphic, deeply 5-lobed, purple, glabrous, glandular-punctate, 6–7.2 mm long., corolla tube 3.3–4.2 × 0.6–1.2 mm., corolla lobes 2.5–3 × 0.5–0.6 mm, apex acute; anthers calcarate, pale lilac, apical appendages acute, anther base sagittate; style shaft 4.5–6.5 mm long, purple, glabrous throughout except for pubescent upper 1–1.5 mm beneath style arms, style base glabrous, lacking basal node, style arms 1.5–2 mm long, apex acute, short-pubescent outside throughout. **Cypselae** prismatic, 2–2.4 × 0.8–1 mm, 10-ribbed, glabrous, densely glandular-punctate, ochraceous; carpopodium annular, minute; pappus setae biseriate, 4–5 mm long., subequal or equal, stramineous, purplish at apex of younger pappus setae, rarely purplish when older, deciduous, paleaceous, barbellate. Figures 4, 1(D–F).

Distribution and habitat— Endemic to the Diamantina Plateau of the Espinhaço Range in the state of Minas Gerais, in Sempre Vivas National Park, a protected area of ca. 124,154 hectares within the boundaries of the municipalities of Olhos d'Água, Bocaiúva, Buenópolis and Diamantina (Fig. 3). *P. pilosa* occurs in campos rupestres vegetation, in areas of quartzite rock outcrops in sandy and rocky soils, close to waterlogged grasslands, 1,236 m alt.

Informal Conservation Status— Considering the same aspects discussed previously [see conservation assessment for *Piptolepis corymbosa*], we suggest that if a formal assessment was performed this species would probably be classified Critically Endangered CR B1a+2a, as it has an area of occupancy (AOO) of 4 km^2, and null extent of occurrence (EOO), given it is known from a single locality.

Etymology—The epithet *pilosa* refers to the abaxial indumentum of the leaves, which is a distinguishing feature of the new species.

Phenology—Flowering and fruiting specimens were found in May and in November, only fruiting specimens.

Notes—*Piptolepis pilosa* resembles *P. ericoides* Sch.Bip. due to its semicircular leaf scars, narrow elliptic to very narrow elliptic leaves with acute apex, attenuate base and hyphodromous venation. Both species also display heads in racemes and subequal or equal biseriate pappus. However, *P. pilosa* differs from that species by its procumbent stems (vs. virgate) and several characteristics of the leaves: size (3.2–9 × 0.8–1.6 vs. 4–41× 0.8–3.5 mm), apex with a tuft of trichomes resembling an apiculus (vs. without a tuft of trichomes), adaxial surface villous, olive green (vs. tomentulose, dark green), abaxially pilose (vs. canescent), coriaceous (vs. chartaceous) and margins revolute (vs. flat) (Table 1).

Piptolepis pilosa does not occur in sympatry with *P. ericoides*, which is distributed almost continuously along the Espinhaço Range in Minas Gerais, being the most common species within *Piptolepis*. However, its major area of occurrence is in northern Minas Gerais, in the Grão Mogol area, being less frequent in Serra do Cipó and in the Southern Mountains complex (Serra de Ouro Branco, Serra do Caraça and Serra do Itacolomi). Although the Diamantina Plateau is the center of endemism of the genus, there are not many collection records for *P. ericoides* in this area, with no known records in Sempre Vivas National Park.

Piptolepis gardneri Baker is the only other species of *Piptolepis* known from Sempre Vivas National Park. However, *P. pilosa* is easily distinguished by its habit (shrub 0.4– 0.6 m vs. treelet 1–2.4 m), leaf shape (narrow elliptic to very narrow elliptic vs. oblanceolate to narrow oblanceolate) and size (3.2–9 × 0.8–1.6 mm vs. 8–68 × 3–9 mm), indumentum of adaxial (villous vs. pannose) and abaxial (pilose vs. hirsutulous) leaf surfaces, and number of florets per head (10–13 vs. 22–23 florets).

Additional Specimens Examined**—Brazil.**—MINAS GERAIS: Mun. Buenópolis, Parque Nacional das Sempre Vivas, próximo ao rio Jequitaí, estrada à direita do alojamento ca. de 4 km de distância, [-17.891166º, -43.806888°], elev. 1232 m, fl. fr., 23 May 2019, *J.B. Cândido 377* (UFP!); ibid, [-17.891666°, -43.806388°], elev.1238 m, fr., 1 November 2016, G. *Martinelli et al. 19506* (ALCB!, DIAM!, RB!, SPF!, UFP!); ibid, [-17.891111°, -43.806944°], elev. 1231 m, fl. fr., 28 November 2014, *L. Echternacht et al. 2572* (DIAM!, HUFU!).

Piptolepis procumbens J.B.Cândido & Loeuille, sp. nov. TYPE: BRAZIL. Minas Gerais, Diamantina, Reserva Ambiental Pau de Fruta, [-18.2785°, -43.674388º], elev. 1,399 m, fl. fr., *07 May 2019, J.B. Cândido 324 (holotype: UFP!, isotypes: BHCB!, K!, RB!).*

Species Piptolepi campestri simile, sed altitudine (0.5 m, non 1.2–2 m), caulibus procumbentibus (non virgatis), foliis brevioribus (3.5–9 mm, non 8–21 mm) et seriebus pappi inaequilongis (non subaequilongis vel aequilongis) differt.

Shrub 0.5 m tall, crown 1.5 m diam., procumbent, densely branched. **Stems** terete, brownish manicate, old stems rugose, becoming glabrescent, dark grey, leaf scars deltate. **Leaves** alternate, simple, spiraled, patent to ascending, subsessile, petiole 0.2–0.5 mm long, pad-like leaf sheath ligulate, 0.5–1 mm long; blade ovate to elliptic, 3.5–9 × 4–9 mm, discolorous, chartaceous, venation brochidodromous, midrib adaxially impressed, not concealed by indumentum, abaxially prominent, adaxial surface dark olive green, tomentose, abaxially light green, lanate, margins entire, flat, apex subacute, base rounded. **Inflorescence** in pseudoglomerules, terminal at apex of branches, interspersed by leaf-like bracts at base of pseudoglomerule, leaf-like bracts, 5–9 × 1–3.5 mm, apex subacute, base rounded to attenuate. **Capitula** 2–7, homogamous, discoid, sessile or shortly pedunculate, peduncle (0–)4–6 mm long; involucre cylindrical, 8–9 mm tall × 5–8 mm diam., 7–8 seriate; phyllaries weakly imbricate, scarious, margins entire, apex acute, glandular-punctate, outer phyllaries narrowly triangular, 2–3.5 × 0.2–1 mm, stramineous, lanate, inner phyllaries lanceolate, 6.5–8 × 1–1.2 mm, stramineous with reddish apex, lanate only at apex; receptacle flat, fimbrillate. **Florets** 14–22, bisexual, fertile; corolla actinomorphic, deeply 5-lobed, lilac, glabrous, glandular-punctate, 8–9 mm long., corolla tube 4–5 × 1–1.3 mm., corolla lobes 3–6 × 0.5–0.6 mm, apex acute; anthers calcarate, lilac, apical appendages acute, anther base sagittate; style shaft 7–8 mm long, pale lilac, glabrous throughout except for pubescent upper 0.5–1 mm beneath style arms, style base glabrous, lacking basal node, style arms 2–2.5 mm long, apex acute, short-pubescent outside throughout. **Cypselae** prismatic, 2–2.2 × 0.8–1 mm, 10-ribbed, glabrous, furrows glandular-punctate, light brown; carpopodium annular, minute; pappus setae biseriate, unequal, stramineous, paleaceous, outer series 0.6–1.5 mm long, serrulate, persistent, inner series 4–7 mm long, barbellate, deciduous, tapering towards the apex. Figures 5–6.

Distribution and Habitat— Endemic to the Diamantina plateau of the Espinhaço Range of mountains in the state of Minas Gerais (Fig. 3). *Piptolepis procumbens* occurs in campos rupestres vegetation, in areas with quartzite rock outcrops in sandy and rocky soils, with nearby peatland areas (1,399 m alt.).

Informal Conservation Status— The species occurs at the Special Protection Area (APE) Manacial Pau de Fruta, which has ca. 1,700 hectares, and is under responsibility of the Minas Gerais Sanitation Company (COPASA) (Fig. 3). The area is approximately 7 km away from the town of Diamantina in the state of Minas Gerais. The species is known from a single collection, locality and population. According to Silveira et al. (2016), a considerable portion of campo rupestre species occurs on single mountains, or part of a mountain, sometimes being known from just one population, therefore being considered narrow endemics (microendemics). Many campos rupestres taxa are known only from the type collection or type locality.

Due to the fact that only a single collection of the species is currently known, the GeoCAT analysis (Bachmann et al. 2011) does not provide a confident evaluation of conservation status. Thus, we suggest species should be classified as Data Deficient (DD), according to the IUCN Red List Categories and Criteria (IUCN 2019).

Etymology—The epithet *procumbens* refers to the species habit: leaning over or reclining on the ground.

Phenology— Flowering and fruiting specimens were found in May.

Notes— *Piptolepis procumbens* resembles *P. campestris* Semir & Loeuille by its terete stems with deltate leaf scars, its patent to slightly ascending, chartaceous leaves, with rounded base, and heads with 19–21 florets organized in pseudoglomerules. However, the new species differs from the latter by its height (0.5 m tall vs. 1.2–2 m tall), procumbent stems (vs. virgate), smaller leaves (3.5–9 mm vs. 8–21 mm long), which are subsessile (0.2–0.5 mm vs. shortly petiolate 1-3 mm), smaller leaf sheath (0.5–1 mm vs. 1–1.5 mm long), the number of phyllary series in the heads (7–8 vs. 5–6) and unequal pappus series (vs. subequal or equal) (Table 1).

Piptolepis procumbens occurs in the same locality of *Piptolepis glaziouana* Beauverd, but it differs from that species by the leaf scar shape (deltate vs. semicircular), subsessile leaves (vs. sessile), larger leaf sheath (0.5–1 mm vs. 0.3–0.5 mm long.), larger leaves (3.5–9 × 4–9 mm vs. 2–5 × 1–1.6 mm) with brochidodromous venation (vs. hyphodromous), heads organized in pseudoglomerules (vs. in racemes or solitary) with cylindrical involucre (vs. campanulate) and higher number of phyllary series (7–8 vs. 5–7).

ACKNOWLEDGMENTS

J.B. Cândido thanks Fabiane Nepomuceno da Costa of Universidade Federal do Vale do Jequitinhonha e Mucuri (UFVJM), for kindly hosting the author and providing logistic support during fieldwork in the state of Minas Gerais; Instituto Estadual de Florestas - Minas Gerais and ICMBio for issuing collection permits; Regina Maria Alcântara de Carvalho for line drawings; Fábio Alves for helping producing the maps and Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (Finance Code 001) for the granted fellowship (CAPES/PROEX).

AUTHOR CONTRIBUTIONS

J.B. Cândido designed and wrote the paper, B. Loeuille provided Latin descriptions, suggestions and reviewed the manuscript.

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TABLE 1. Comparison of morphological characters and distribution among *P. procumbens*, *P. pilosa*, *P. corymbosa*, and related species. Source material: *P. campestris* — *J.B. Cândido et al.* 299 (UFP); A.M. Giulietti et al. CFCR 2302 (HUFU, SPF, UFP); *P. ericoides* — *J.B. Cândido et al.* 311, 355, 357, 369, 370, 383, 387, 401, 408 (UFP); *P. leptospermoides* — *J.B. Cândido et al.* 304, 305, 306, 312 (UFP).

	P. procumbens	*P. campestris*	*P. pilosa*	*P. ericoides*	*P. corymbosa*	*P. leptospermoides*
Stems	procumbent	virgate	spreading	virgate	spreading	spreading
Leaf scars	deltate	deltate	semi-circular	deltate	deltate	deltate
Leaf shape	ovate to elliptic	elliptic	very narrow elliptic to narrow elliptic	very narrow elliptic	narrow elliptic to ovate	elliptic
Leaf size (mm)	3.5–9 × 4–9	8–21 × 4–10	3.2–9 × 0.8–1.6	4–41× 0.8–3.5	2.2–5 × 1.2–1.8	2.8–5.3 × 1.5–2
Leaf texture	chartaceous	chartaceous	coriaceous	chartaceous	coriaceous	coriaceous
Leaf apex	subacute	acute to obtuse	acute	acute	subacute	obtuse
Leaf base	rounded	rounded	attenuate	attenuate	cuneate to obtuse	cuneate to obtuse
Adaxial surface indumentum	tomentose	woolly	villous	tomentulose	pilose	pubescent
Abaxial surface indumentum	lanate	tomentose	pilose	canescent	lanate	lanate
Leaf margin	flat	flat	revolute	flat	revolute	revolute
Inflorescence type	pseudoglomerules	pseudoglomerules	raceme or solitary capitulum	raceme	corymb	raceme
Phyllaries (number of series)	7–8	5–6	7–8	6–7	6–7	5–7
Relative size of pappus series	unequal	subequal or equal	subequal or equal	subequal or equal	subequal or equal	unequal
Distribution in the Espinhaço Range	eastern Diamantina Plateau (Environmental Protection Area Pau de Fruta)	south-central Diamantina Plateau	northwestern Diamantina Plateau (Sempre Vivas National Park)	widespread in the Espinhaço Range in Minas Gerais	northwestern Diamantina Plateau (Sempre Vivas National Park)	southeastern Diamantina Plateau (Diamantina and Serro)

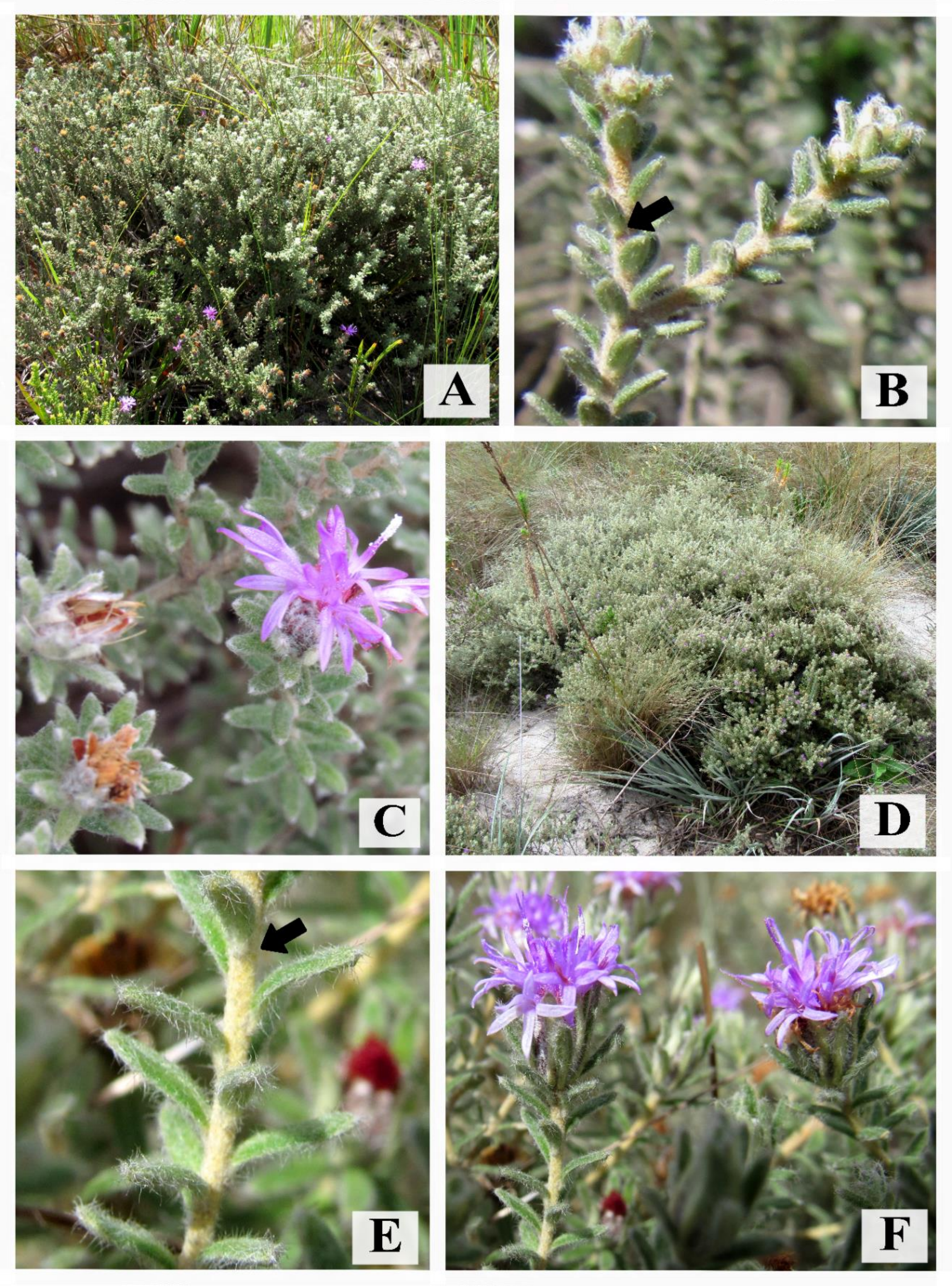

FIG. 1. A–C. *Piptolepis corymbosa* sp. nov. A. Habit. B. Leaf arrangement and pad-like leaf sheath (black arrow). C. Head. D–F. *Piptolepis pilosa* sp. nov. D. Habit. E. Leaf arrangement and pad-like leaf sheath (black arrow). F. Heads. A–F. Photograph by J.B. Cândido.

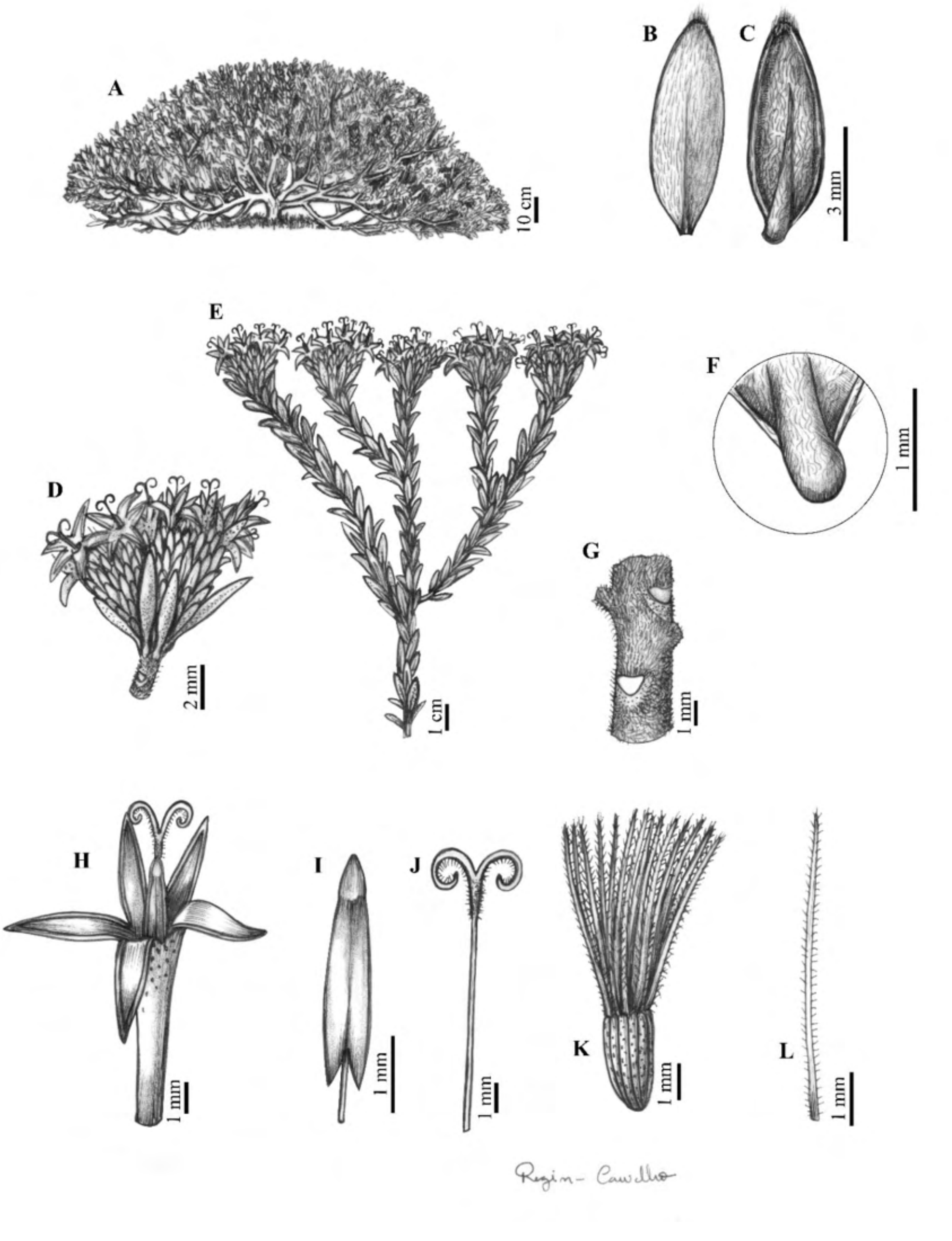

FIG. 2. *Piptolepis corymbosa* sp. nov. A. Spreading habit. B. Leaf, adaxial surface. C. Leaf, abaxial surface. D. Capitulum. E. Flowering branch with inflorescence in corymb. F. Pad-like leaf sheath. G. Stems with leaf scars. H. Corolla, androecium and style. I. Anther. J. Style. K. Cypsela. L. Pappus element.

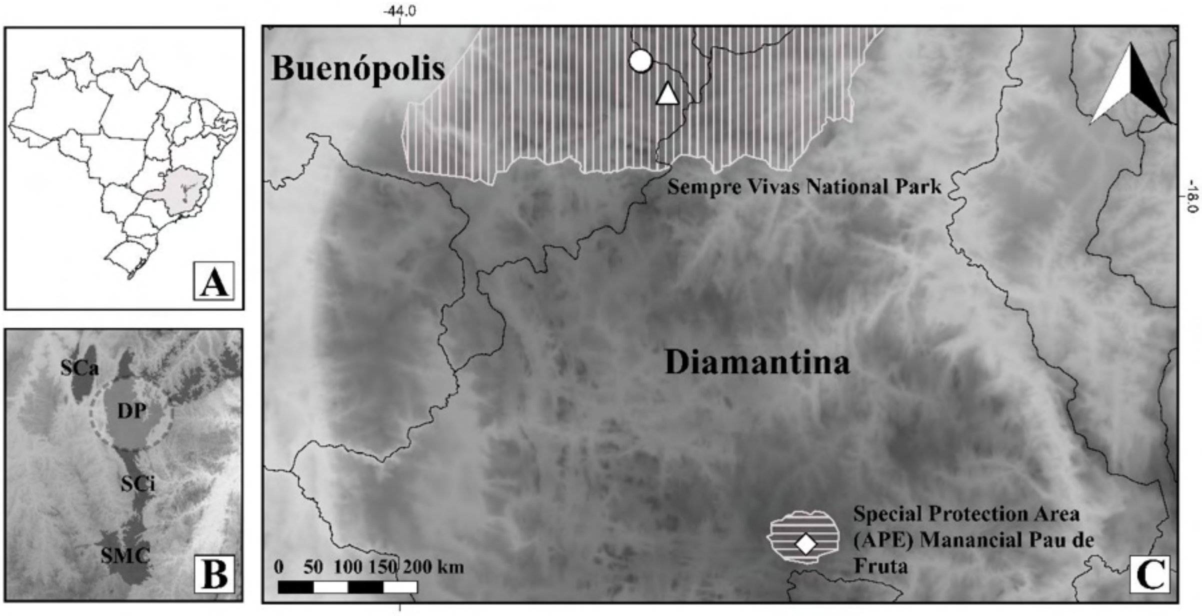

FIG. 3. A. Brazil with state of Minas Gerais highlighted. B. Espinhaço Range in Minas Gerais: SCa = Serra do Cabral, DP = Diamantina Plateau; SCi = Serra do Cipó, SMC = Southern Mountains Complex (Serras de Ouro Branco, Caraça and Itacolomi). C. Distribution of *Piptolepis procumbens* (diamond), *P. pilosa* (circle) and *P. corymbosa* (triangle) in the Diamantina Plateau.

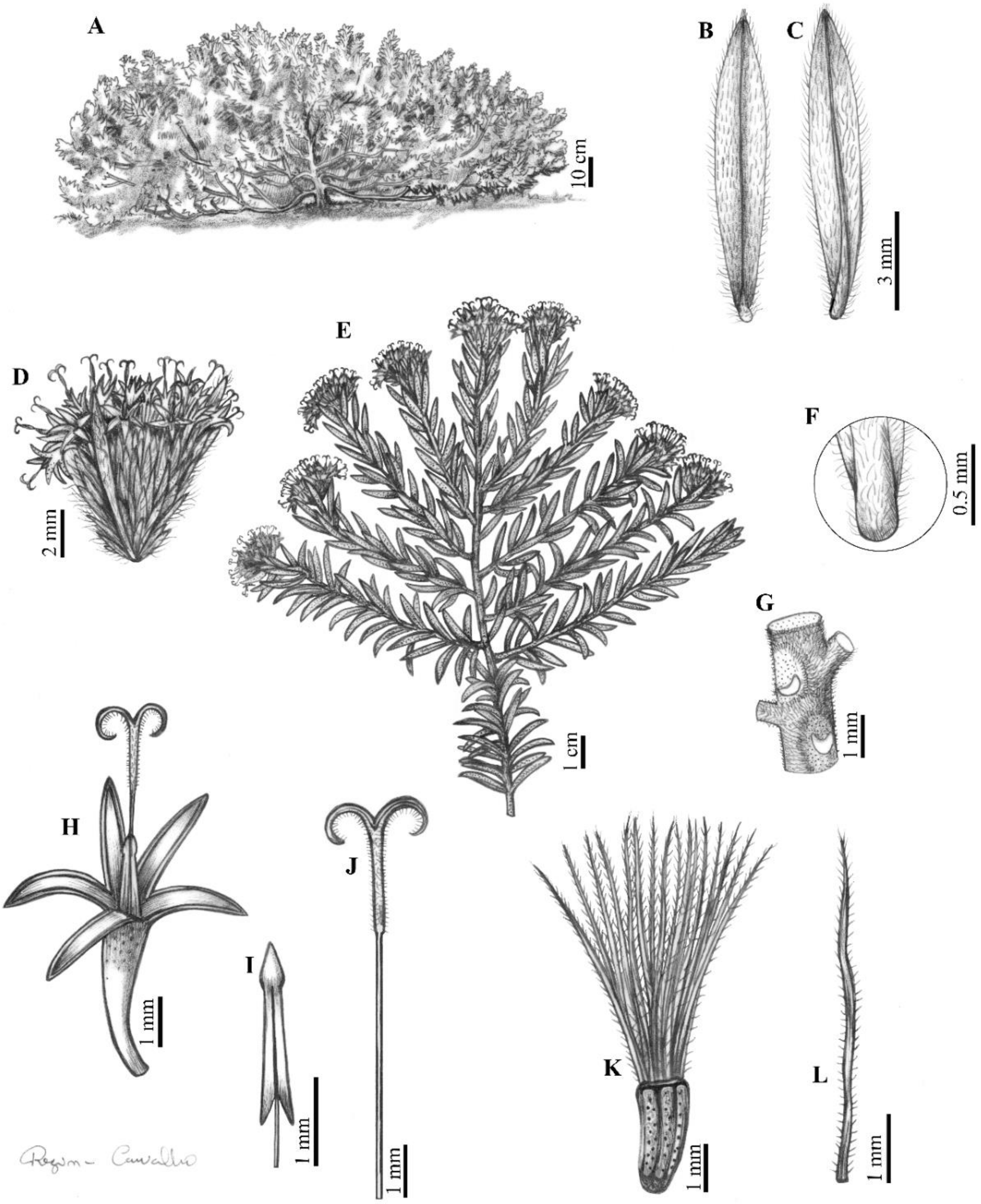

FIG. 4. *Piptolepis pilosa* sp. nov. A. Spreading habit. B. Leaf, adaxial surface. C. Leaf, abaxial surface. D. Capitulum. E. Flowering branch with inflorescence in raceme. F. Pad-like leaf sheath. G. Stems with leaf scars. H. Corolla, androecium and style. I. Anther. J. Style. K. Cypsela. L. Pappus element.

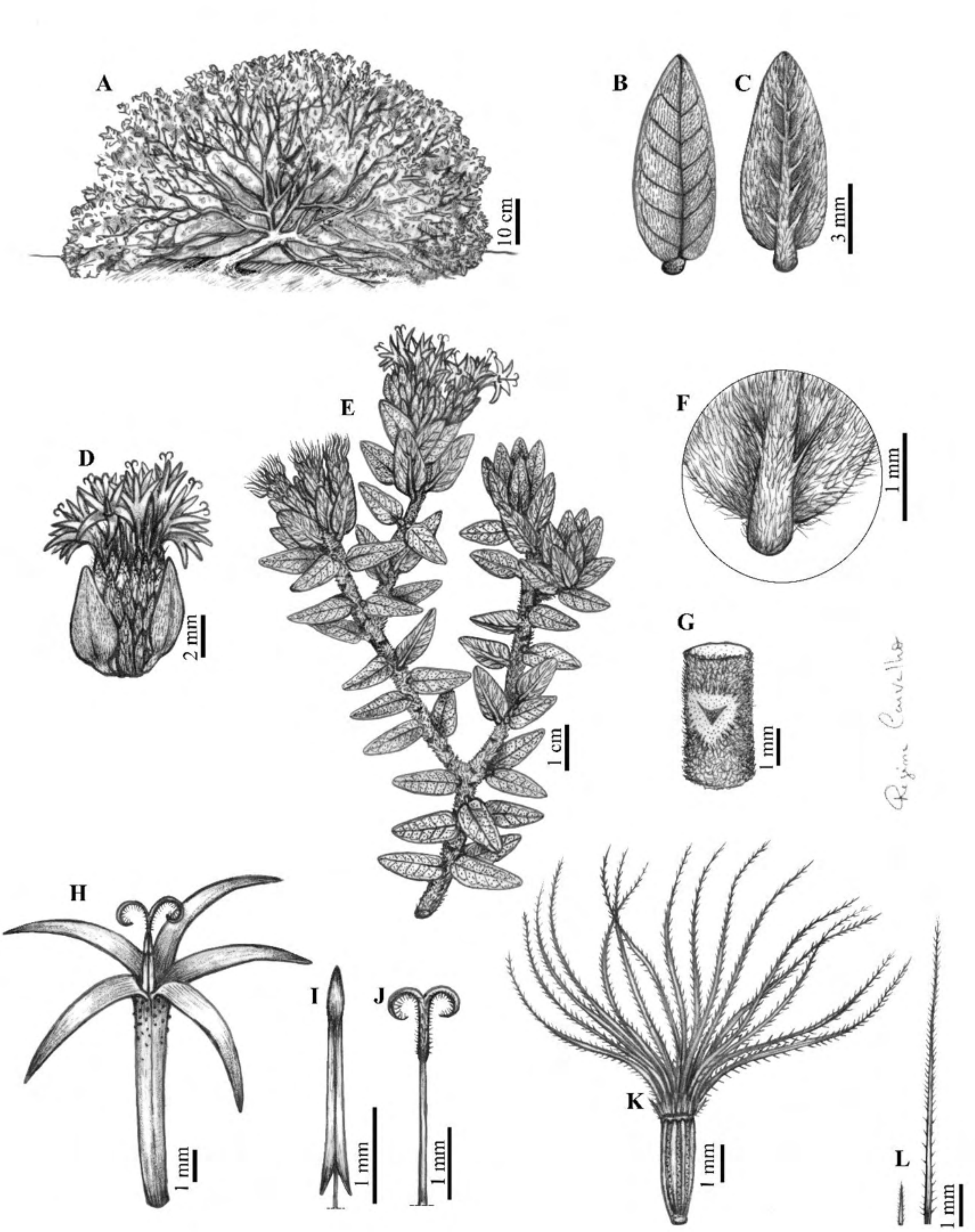

FIG. 5. *Piptolepis procumbens* sp. nov. A. Procumbent habit. B. Leaf, adaxial surface. C. Leaf, abaxial surface. D. Capitulum. E. Flowering branch with inflorescence in pseudoglomerules. F. Pad-like leaf sheath. G. Stems with leaf scars. H. Corolla, androecium and style. I. Anther. J. Style. K. Cypsela. L. Outer and inner pappus elements.

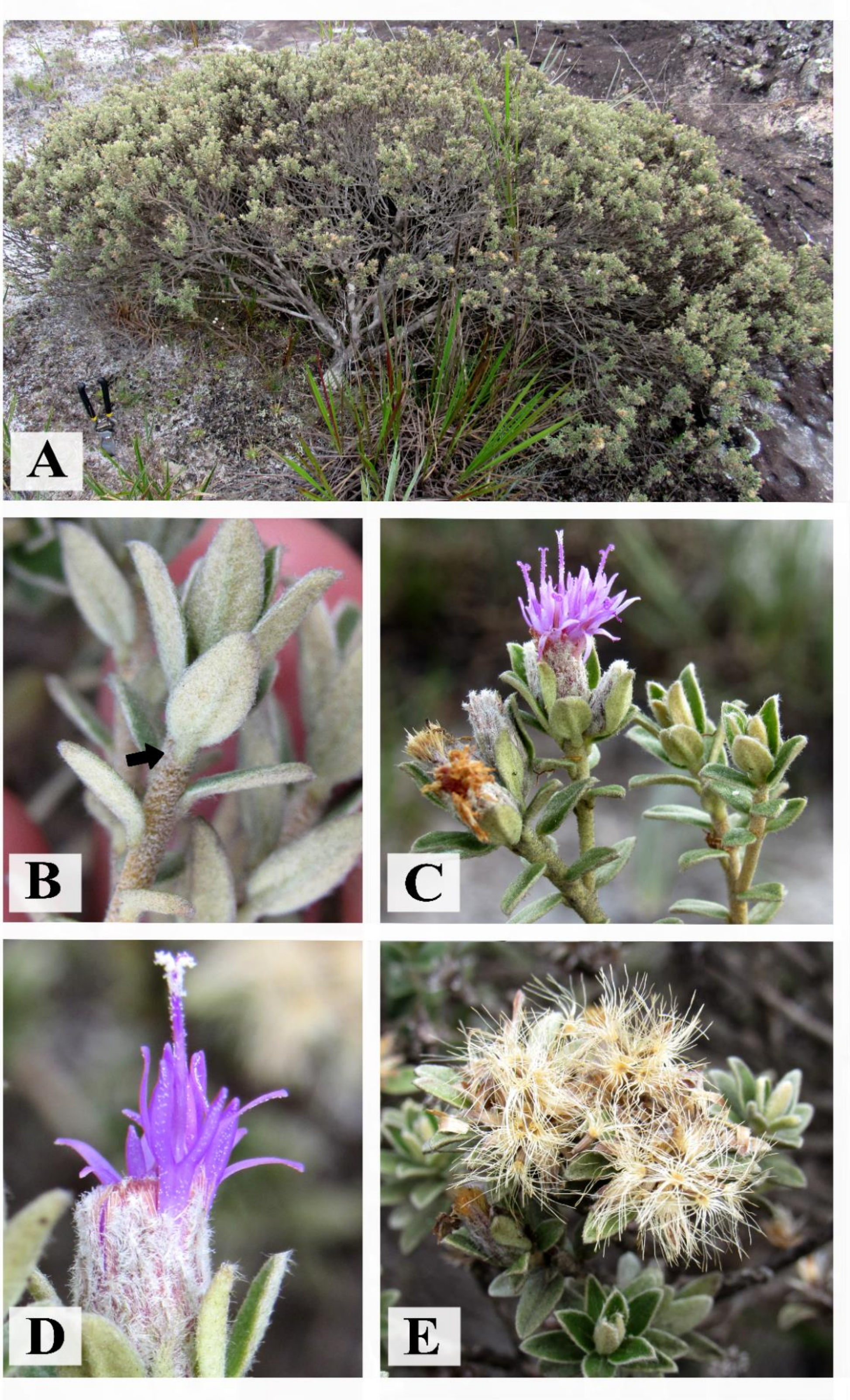

FIG. 6. *Piptolepis procumbens* sp. nov A. Habit. B. Leaf arrangement and pad-like leaf sheath (black arrow). C. Pseudoglomerule. D. Head. E. Fruiting heads. A–E. Photographs by J.B. Cândido.

APÊNDICE D – COMPARATIVE MORPHOLOGY AND ANATOMY OF CYPSELAE IN *PIPTOLEPIS* (VERNONIEAE, ASTERACEAE) 2 WITH EMPHASIS ON THE PAPPUS SYSTEMATIC SIGNIFICANCE

ARTIGO PUBLICADO NO PERIÓDICO FLORA 287: 151988, 2022.

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Abstract

Comparative studies of cypselae from Asteraceae have revealed traits of high taxonomic value. The pappus structure, cypsela shape, indument, pericarp structure and its variations between groups are robust features that help assessing the family's evolutionary history. Systematic knowledge has advanced in the subtribe Lychnophorinae (tribe Vernonieae), and the evolution of specific structures has been debated. Thus, we carried out the first morphoanatomical study of the cypselae in *Piptolepis* (Lychnophorinae), searching for morphological variations to help classify the group and understand its evolutionary history. Cypselae were studied using scanning electron microscopy and historesin inclusion techniques. Our results showed that collenchymatic tissue in the outer mesocarp in *Piptolepis* distinguishes it from other Vernonieae studied so far. Furthermore, some pappus characteristics such as type, number of series, duration, and lateral projections, and cypsela features such as shape, presence of crystals in the outer mesocarp and occurrence of carpellary bundles may help identify some closely related species. A vestigial pappus series in *Piptolepis* shed light on the evolutionary history of genus and Lychnophorinae as a whole.

Keywords achene · Compositae · fruit · Lychnophorinae · pericarp

1. Introduction

Piptolepis is a monophyletic genus of the subtribe Lychnophorinae (Vernonieae) (Loeuille et al., 2015). The genus comprises 13 species, most of them endemic to the *campos rupestres* (rupestrian grasslands ecosystem) of the Espinhaço Range in Minas Gerais state and the ranges in eastern Goiás state, Brazil (Bringel Jr. et al., 2019; Loeuille et al. 2019). Its species are characterized by a shrubby habit, petiole bearing pad-like leaf sheaths (rarely semiamplexicaul), capitula with weakly imbricate caducous phyllaries and capitulescence with one to few capitula, rarely organized in a syncephalium (second-order inflorescence) (Hind, 2003; Robinson, 2007; Loeuille et al. 2012a, 2019). In general, the capitula have 9 to 29 florets and, rarely, one floret per capitulum; the cypselae are cylindrical, rarely prismatic or turbinate, glabrous or rarely pubescent; the carpopodium is inconspicuous; the pappus is 2–3-seriate, containing bristles setose to paleaceous, sometimes with outer series shorter than the inner ones, and deciduous to caducous (Hind, 2003; Robinson, 2007; Loeuille et al., 2012a, 2019).

Several studies have demonstrated the importance of the morphology and anatomy of cypselae and their structures for the taxonomic delimitation of genera and species (Roth, 1977; Pandey and Singh, 1982; Haque and Godward, 1984; Källersjö, 1985; Bruhl and Quinn, 1990; Bremer, 1994; Tadesse et al., 1995; Bean, 2001; Hood and Semple, 2003; Marzinek and Oliveira, 2010; Marzinek et al., 2010; Franca et al., 2015; Marques et al., 2018; Silva et al., 2018; Marques et al., 2020). In Vernonieae, studies with relevant taxonomic sampling (Martins and Oliveira, 2007; Galastri and Oliveira, 2010; Angulo et al., 2015; Freitas et al., 2015; Via do Pico et al., 2016, Redonda-Martínez et al., 2017; Marques et al., 2018, 2020) reinforce the importance of the morphological and anatomical traits of the cypselae at the generic or, more frequently, species level. A noteworthy example is the presence of phytomelanin in the cypsela walls as a synapomorphy of *Heterocoma* (Loeuille et al., 2015). However, the synapomorphy status was recently questioned by the occurrence of this substance in cypselas walls of *Lychnophora salicifolia*, nested in the same subtribe of *Heterocoma* (Marques et al. 2021).

The pericarp has anatomical structures such as crystals, trichomes and idioblasts that have a high taxonomic value in the segregation of genera and species of Vernonieae (Wagner et al., 2014; Angulo et al., 2015; Via do Pico et al., 2016; Redonda-Martínez et al., 2017, 2020; Marques et al., 2018, 2020). Furthermore, the pappus, a modified calyx, can determine species and genera since it presents significant morphological variations (e.g., types of setae, duration, number of series, and color) (Loeuille et al., 2015; Esteves et al., 2017). Lastly, the carpopodium, a structure located at the base of the cypsela, also has a morphological and anatomical variation (symmetric or asymmetric, distinct or indistinct, thin or thick cell walls, presence of crystals) that can be used in the delimitation of taxa (Haque and Godward, 1984; Robinson, 1999; Freitas et al., 2015; Siniscalchi et al., 2016; Marques et al., 2018, 2020).

In the case of the subtribe Lychnophorinae, the pappus morphological variation (e.g., number of series, persistence, and relative size) has traditionally been used to define genera or species (e.g., Schultz-Bipontinus, 1861, 1863; Baker, 1873). More recently, a taxonomic revision of *Eremanthus* (MacLeish, 1987) has proved the utility of more subtle and less explored characteristics (such pappus caducous vs deciduous or subpaleaceous vs paleaceous) to set apart species of that genus. Semir et al. (2014) also emphasized the morphological diversity in the large genus *Lychnophora*, which usually displays a biseriate paleaceous pappus with twisted bristles. However, other morphological types of *Lychnophora* pappus are noteworthy, such as the extreme reduction of the outer series in some species (previously placed in *Haplostephium*) or their total absence (Loeuille et al., 2019).

The cypselae structure in *Piptolepis* has been extensively used in the taxonomy of the genus since its establishment by Schultz-Bipontinus (1863) and later for the floristic treatment in *Flora Brasiliensis* (Baker, 1873). The relative size (equal or subequal) of the pappus setae series, and the indument (pilose or glabrous, glandular-punctate or not) of the cypselae interribs are essential features for the species identification. Nonetheless, few morphological observations have been made due to the restricted number of specimens since they belong to microendemic species. Recently a species has been described with a 3-seriate pappus (*Piptolepis rosmarinifolia*) (Bringel Jr. et al., 2019; Loeuille et al., 2019), but the definition of the number of series when they are equally sized is often uncertain. Therefore, a detailed anatomical study is necessary to clarify the pappus features.

In our study, we describe the morphology and anatomy of the cypselae in *Piptolepis*. In addition, we compare the cypselae of the genus with previously studied Vernonieae by searching for morphological variations with potential taxonomic value. As a whole, these results might help to assess the evolutionary history of *Piptolepis* and its phylogenetic relationships within the Lychnophorinae.

2. Materials and methods

We analyzed all *Piptolepis* species obtained from exsiccate envelopes or carefully removed from the capitulum (Table 1).

For the morphological study, the samples were mounted on aluminum stubs and coated with gold using a sputter coating device (Leica EM SCD050). The samples were analyzed under a Zeiss EVO MA 100, and the images were acquired through scanning electron microscopy (SEM).

For the anatomical study, cypselae were rehydrated with a 5 M NaOH solution for four hours (Anderson, 1963 modified) and later dehydrated in an ethanol series and embedded in methacrylate resin, following the manufacturer's protocol. The cypselae were serially transected using a rotary microtome (Leica RM 2235) at 10 µm thickness. The sections were stained with 0.05% toluidine blue in acetate buffer, pH 4.7 (O'Brien et al., 1964 modified), and mounted in synthetic resin. To verify the presence of lignin, an alcohol solution of phloroglucinol plus hydrochloric acid for lignified walls (Sass, 1951) was used. All sections were observed under a light microscope (Olympus BX41), from which the images were acquired. Terminology follows Small (1919) for pappus morphology, Beentje (2016) for cypsela shape, and Roth (1977) for pericarp anatomy.

2. Results

3.1. Morphology

Piptolepis buxoides (Fig. 1a), *P. ericoides* (Fig. 1c), *P. leptospermoides* (Fig. 1g), and *P. schultziana* (Fig. 2f) have cylindrical cypselae with a tapering base. *Piptolepis campestris* (Fig. 1b), *P. monticola* (Fig. 2a), *P. pabstii* (Fig. 2c), and *P. riparia* (Fig. 2d) possess ovoid cypselae. *Piptolepis gardneri* (Fig. 1d) and *P. glaziouana* (Fig. 1e) have narrow obconical cypselae. *Piptolepis imbricata* (Fig. 1f) and *P. rosmarinifolia* (Fig. 2e) have obconical cypselae. *Piptolepis oleaster* (Fig. 2b) possesses tubular cypselae. Most of the cypselae are glabrous (Table 2), except in *P. leptospermoides* (Fig. 1i), *P. pabstii* (Fig. 2c), and *P. rosmarinifolia* (Fig. 2e), which have tector twin hairs; and *P. glaziouana* (Fig. 6e), *P. imbricata* (Fig. 6f), *P. leptospermoides* (Fig. 1g, h), and *P. rosmarinifolia* (Fig. 2e), which possess glandular trichomes. The ribs are conspicuous (Table 2) in *P. buxoides* (Fig. 1a), *P. ericoides* (Fig. 1c), *P. glaziouana* (Fig. 1e), *P. imbricata* (Fig. 1f), *P. leptospermoides* (Fig. 1g), *P. monticola* (Fig.

2a), *P. oleaster* (Fig. 2b), *P. riparia* (Fig. 2d), and *P. schultziana* (Fig. 2f). They are inconspicuous in *P. campestris* (Fig. 1b), *P. gardneri* (Fig. 1d), *P. pabstii* (Fig. 2c), and *P. rosmarinifolia* (Fig. 2e).

In some species, the bristle projections can only be located at the bristle margin, such as in *P. buxoides* (Fig. 3a), *P. campestris* (Fig. 3b), *P. ericoides* (Fig. 3c), *P. gardneri* (Fig. 3d), *P. leptospermoides* (Fig. 3g), *P. monticola* (Fig. 3h), *P. oleaster* (Fig. 3i), *P. riparia* (Fig. 3k) and *P. schultziana* (Fig. 3m). On the other hand, in *P. glaziouana* (Fig. 3e), *P. imbricata* (Fig. 3f), *P. pabstii* (Fig. 3j), and *P. rosmarinifolia* (Fig. 3l), the projections can be distributed throughout the bristle.

The pappus (Table 3) is biseriate with vestigial outer series and well-developed inner series in *Piptolepis buxoides* (Fig. 4a), *P. campestris* (Fig. 4b), *P. gardneri* (Fig. 4d), *P. monticola* (Fig. 4h), *P. oleaster* (Fig. 4i), and *P. riparia* (Fig. 4k); biseriate with outer series smaller than the inner one(s), and vestigial series absent in *P. glaziouana* (Fig. 4e), *P. imbricata* (Fig. 4f), *P. leptospermoides* (Fig. 4g), *P. pabstii* (Fig. 4j), and *P. rosmarinifolia* (Fig. 4l); biseriate with well-developed outer and inner series of equal or subequal size in *P. ericoides* (Fig. 4c); or 3seriate with vestigial outer series and two well-developed series in *P. schultziana* (Fig. 4m).

The pappus is deciduous in most species, two of them (*Piptolepis buxoides* and *P. schultziana*) with both series caducous, and four others (*P. imbricata, P. leptospermoides, P. pabstii* and *P. rosmarinifolia*) with the two series persistent. In *P. ericoides* the bristles from the outer series are fused at the base, whereas in *P. imbricata* they are free or sometimes fused at the base. In *P. buxoides, P. campestris, P. gardneri, P. glaziouana, P. leptospermoides, P. monticola, P. oleaster, P. pabstii, P. riparia, P. rosmarinifolia* and *P. schultziana*, the bristles of the outer series are free. In all species, the inner series is always free (Table 3).

The pappus is paleaceous in *P. buxoides, P. campestris, P. ericoides, P. gardneri, P. glaziouana, P. imbricata, P. leptospermoides, P. monticola, P. oleaster*, and *P. schultziana*. Those of the outer series are setose, whereas the inner ones are paleaceous in *Piptolepis pabstii, P. riparia*, and *P. rosmarinifolia*. The lateral projection is serrulate in most species and barbellate in *P. campestris, P. glaziouana, P. pabstii* (only outer series), *P. riparia, P. rosmarinifolia,* and *P. schultziana* (Table 3).

The surface of the carpopodium is indistinct from the rest of the cypsela (Table 2).

3.2. Anatomy

The pericarp transverse section is rounded in all species (Fig. 5a–m) with visible indentations in *P. buxoides* (Fig. 5a), *P. ericoides* (Fig. 5c), *P. glaziouana* (Fig. 5e), *P.*

imbricata (Fig. 5f), *P. leptospermoides* (Fig. 5g), *P. monticola* (Fig. 5h), *P. oleaster* (Fig. 5i), *P. riparia* (Fig 5k), and *P. schultziana* (Fig. 5m). The apex of the fruit is formed by cells of varying sizes and shapes (Fig. 5n), and the carpopodium is composed of a lignified uniseriate exocarp with slightly elongated cells in the periclinal sense. The center of the carpopodium is divided into two regions: the outer region with 3–5 layers of lignified cells containing crystals, and the inner region filled with parenchyma tissue (Fig. 5o).

The exocarp is uniseriate with isodiametric cells (Fig. 6a–h, Fig. 7a–f) and some secretory idioblasts (Fig. 6g).

The mesocarp is divided into two regions (Fig. 6a). The outer mesocarp is fully lignified in *P. buxoides* (Fig. 6a), *P. riparia* (Fig. 7d), and *P. rosmarinifolia* (Fig. 7e). In the remaining species, it is partially lignified, mainly between the ribs, and partially collenchymatous, mainly around the vascular bundles (Figs. 6b–h, 7a–c, f). Calcium oxalate crystals are observed in the outer mesocarp, mainly in the interrib region in most species (Fig. 6a–h, Fig. 7a, b, d), except in *P. pabstii* (Fig. 7c) and *P. rosmarinifolia* (Fig. 7e). The inner mesocarp is parenchymatic (Figs.
6a–h, 7a–f).

Most of the species have ten collateral vascular bundles located in the outer mesocarp, reaching 15 in *P. ericoides*, nine in *P. glaziouana*, eight *P. imbricata*, 11 in *P. monticola*, and eight *P. oleaster* (Table 2). In *P. rosmarinifolia*, in addition to the ten bundles in the outer mesocarp, two vascular bundles are found in the inner mesocarp (Fig. 7e).

The endocarp consists of a layer of isodiametric cells (Fig. 6h), crushed by seed growth through the development (Fig. 7f).

4. Discussion

4.1. Morphology

The cypselae in Lychnophorinae are frequently glabrous (e.g., *Blanchetia*, *Chronopappus*, *Eremanthus*, *Gorceixia*, *Heterocoma*, *Lychnophora*, and *Paralychnophora*), and when pubescent, they present twin trichomes, as is typical in Asteraceae (except in Barnadesioideae) (Freitas et al., 2015; Loeuille et al., 2019). In *Piptolepis*, most species have glabrous cypselae, but twin hairs and/or glandular trichomes were found in five species. The presence of twin hairs bifurcated at the apex, and the abundance of these trichomes in *P. pabstii* and *P. rosmarinifolia* distinguishes them from the congeneric species.

Piptolepis campestris and *P. gardneri* present some inconspicuous ribs, and according to Marzinek et al. (2010), the presence or absence of conspicuous ribs could be caused by the position occupied by the flower in the receptacle. Inconspicuous ribs are also found in *Heterocoma* (Freitas et al., 2015), *Chrysolaena* (Marques et al., 2020), *Lepidaploa* (Marques et al., 2018, 2020) and *Lessingianthus* (Marques et al., 2020).

Pappus features, such as the number of series and type of bristles, are essential for the delimitation of genera and species in Vernonieae (Redonda-Martínez et al., 2017), but always in combination with other traits (Robinson, 1999). In Lychnophorinae, the pappus is frequently biseriate (*Albertinia*, *Anteremanthus*, *Chronopappus*, *Heterocoma*, *Hololepis*, *Maschalostachys*, *Minasia*, and *Vinicia*), and sometimes uniseriate (*Centratherum* and *Gorceixia*) or 3–5-seriate (*Prestelia*) (Loeuille et al., 2019), but variation can be found in several genera (uniseriate or biseriate in *Blanchetia*, *Lychnocephalus*, *Lychnophora*, *Lychnophorella* and *Proteopsis*; biseriate or 3–5-seriate in *Eremanthus* and *Paralychnophora*). In *Piptolepis*, traits of the pappus do not help to delimit the genus in conjunction with other traits but are important in species identification (Table 3). Concerning the number of series, the pappus of *Piptolepis* had been traditionally described as biseriate with equal or unequal sized series (Schultz-Bipontinus, 1863; Baker, 1873; Loeuille et al., 2012a, 2019). However, our results challenge this interpretation, as we believe the insertion pattern of setae and the presence of a vestigial outer series in several species have probably misled taxonomists. This new understanding follows the current phylogenetic knowledge regarding Lychnophorinae.

In *Piptolepis buxoides*, *P. campestris*, *P. gardneri*, *P. monticola*, and *P. oleaster* (Table 3), there is a basal overlap of setae from the same series to a contorted aestivation. When observed with a stereomicroscope, the pappus superficially appear as biseriate with setae of both series having equal size. However, in *P. ericoides* and *P. schultziana*, there are no such setae overlap, with the insertion being similar to valvate aestivation, and the two series show an equal or subequal size.

Series of vestigial pappus have been rarely documented, mainly in the tribe Astereae (*Symphyotrichum* Semple and Hood, 2005 and *Osbertia* Semple, 2006). A vestigial scale-like series is here reported for *Piptolepis buxoides*, *P. campestris*, *P. gardneri*, *P. monticola*, and *P. oleaster*. *P. schultziana* also has a vestigial pappus series and should be considered as 3-seriate. It remains uncertain whether the vestigial series of pappus indicate an increase or decrease in the number of series during the evolution of *Piptolepis*, as in the recent phylogenetic analyses of Lychnophorinae, *Piptolepis* has been meagerly sampled (six out of 13 species) (Loeuille et al., 2015). The most recently diversified clade comprises *P. ericoides*, *P. riparia*, and *P. schultziana*, of which *P. ericoides* and *P. riparia* have two well-developed series without a vestigial outer series, while *P. schultziana* has 3-seriate pappus with a vestigial outer series.

This suggests an evolutionary increase in the number of series that conform the pappus. The pappus in the closely related genera *Eremanthus* and *Lychnophora* is 3–5-seriate in the former (rarely biseriate) and biseriate in the latter (rarely uniseriate). Several species of *Lychnophora* (e.g., *L. passerina* Gardner, *L. phylicifolia*, and *L. ramosissima*) also have a highly reduced outer pappus series (Loeuille et al., 2019). Ongoing phylogenetic studies will likely allow us to unravel the evolution of pappus in *Piptolepis*.

The outer pappus series is smaller than the inner one in *Piptolepis imbricata*, *P. glaziouana*, *P. leptospermoides*, *P. pabstii*, and *P. rosmarinifolia*. This is a common pattern in Lychnophorinae, and bristles of this outer series are sometimes fused at the base in *P. imbricata* as well as in several species of *Lychnophora* (e.g., the *L. rupestris* species complex), or bristles are even fused into a collar, as in *Gorceixia* (Semir et al., 2014; Loeuille et al., 2019).

Based on the number of pappus series and their relative size, four groups of species can be defined: (1) biseriate pappus with a vestigial outer series (*Piptolepis buxoides*, *P. campestris*, *P. gardneri*, *P. monticola*, and *P. oleaster*); (2) biseriate pappus with an outer series smaller than the inner series (*P. imbricata*, *P. glaziouana*, *P. leptospermoides*, *P. pabstii*, *P. riparia*, and *P. rosmarinifolia*); (3) biseriate pappus with outer and inner series of equal or subequal size (*P. ericoides*) and (4) 3-seriate pappus with a vestigial outer series (*P. schultziana*).

Other pappus features such as type, persistence, and lateral projection are helpful for species identification. For example, *Piptolepis leptospermoides* is frequently mistaken with *P. imbricata* and *P. glaziouana*, but the pappus in the latter is deciduous and barbellate with a twisted inner series (vs persistent and serrulate with a straight inner series in *P. imbricata* and *P. leptospermoides*). In addition, the base of the outer series bristles is dilated only in *P. leptospermoides*. Two similar species, *P. pabstii* and *P. rosmarinifolia* can be recognized by the morphology of the pappus bristles: as they have a dilated base and narrowed apex in *P. rosmarinifolia*, whereas in *P. pabstii* the base and apex of the bristles are not tapered.

The carpopodium is generally well-developed in the subtribes Lepidaploinae (Martins and Oliveira, 2007; Galastri and Oliveira, 2010; Marques et al., 2018, 2020) and Leiboldiinae (Redonda-Martínez et al., 2017). In Lychnophorinae, *Albertinia*, *Anteremanthus*, *Heterocoma*, *Hololepis*, *Minasia*, *Paralychnophora*, *Piptolepis*, and *Proteopsis* have a prominent carpopodium; however, in the remaining genera it is often poorly developed and inconspicuous (Freitas et al., 2015; Loeuille et al., 2019). In addition to, the variation in carpopodium size among congeneric species has been reported for *Heterocoma* (Freitas et al., 2015) and *Paralychnophora* (Loeuille et al., 2012b).

4.2. Anatomy

The sulcate edges of cypselae in the transverse section is uncommon in Asteraceae but prevail in most *Piptolepis* species. In other genera of Asteraceae, the cypselae commonly present round, polygonal, amorphous, or prismatic contour (Freitas et al., 2015; Marques et al., 2018; Silva et al., 2018; Bonifácio et al., 2019; Marques et al., 2020). However, rounded cypselae were found in *P. pabstii* and *P. rosmarinifolia*, thus distinguishing them from those in the remaining *Piptolepis species*, which have sulcate edges.

The anatomy of the fruit apex and carpopodium was homogeneous among species and did not present features that could be used as diagnostic traits. The fruit apex of *Piptolepis* is similar that in some *Vernonia* (Pandey and Singh, 1980) and *Chrysolaena* (Galastri and Oliveira, 2010; Marques et al., 2020), *Echinocoryne* (Marques et al., 2020), *Lepidaploa* (Marques et al., 2018, 2020), and *Lessingianthus* (Marques et al., 2020). The carpopodium of *Piptolepis* is similar to that in *Chrysolaena* (Galastri and Oliveira, 2010; Marques et al., 2020) and some species of *Echinocoryne* (Marques et al., 2020), *Lepidaploa* (Marques et al., 2018, 2020), and *Lessingianthus* (Martins and Oliveira, 2007; Marques et al., 2020). No difference in the lignification of the carpopodium exocarp was detected in this study, which contrasts with the findings of Marques et al. (2018, 2020) in *Chrysolaena*, *Echinocoryne, Lepidaploa*, and *Lessingianthus*.

The collenchymatic mesocarp was a novelty for the tribe and distinguished *Piptolepis* from other Vernonieae. However, the number of layers in the outer mesocarp does not vary consistently among species, which prevent the use of this trait as diagnostic at a specific level. In addition, the presence of crystals in this region of the cypsela, a feature reported for Vernonieae (Isawumi, 1995a, 1995b, 1999; Isawumi et al., 1996; Martins and Oliveira, 2007; Galastri and Oliveira, 2010; Freitas et al., 2015; Redonda-Martinez et al., 2017; Marques et al., 2018, 2020), and its absence in *P. pabstii* and *P. rosmarinifolia* needs to be further investigated.

In general, the cypselae of *Piptolepis* present ten vascular bundles, but this number differs in four species. Similar variation has also been reported for other Asteraceae (Marzinek and Oliveira, 2010; Marques et al., 2018, 2020). Two vascular bundles in an innermost position were found in *P. rosmarinifolia*. These vascular bundles likely correspond to the carpellary bundles described by Bonifácio et al. (2019) in *Stifftia* and *Wunderlichia*. All species with conspicuous ribs have the same number of vascular bundles and ribs. Nevertheless, vascular bundles may or may not be equal to the number of ribs in species with inconspicuous ribs. According to Marzinek et al. (2010), the presence of conspicuous or inconspicuous ribs may be related to the position occupied by the floret in the receptacle. The number of florets per head could also affect the shape of the cypselae since capitula with many cypselae tend to have a polygonal or sulcate shape as these fruits suffer compression in their pericarps (Marzinek et al., 2010). This fact would explain why *Piptolepis* species with only one floret per head (*P. pabstii* and *P. rosmarinifolia*) (Bringel Jr. et al., 2019) present cypselae with round contours, while species with more than floret per head have cypselae with polygonal or sulcate contours (Schultz-Bipontinus, 1863; Baker, 1873; Beauverd, 1913; Loeuille et al., 2012a, 2019).

5. Conclusions

The collenchymatic outer mesocarp differentiates *Piptolepis* from all other Vernonieae cypselae. In addition, some pappus features such as type, series, persistence, and lateral projections, together with cypsela features such as shape, calcium oxalate crystals, and carpellary bundles, provide reliable traits to distinguish some closely related species.

6. Acknowledgements

J.B. Cândido thanks the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (Finance Code 001) for the granted fellowship (CAPES/PROEX). D. Marques thanks the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (PDCTR proc. 301734/2020-8) and Fundação de Amparo a Pesquisa do Estado do Ceará (PDCTR proc. DC8-014500117.01.00/18 and 9973919/2018). All authors thank the Laboratório Multiusuário de Microscopia Eletrônica of the Faculdade de Engenharia Química (UFU) for support with SEM.

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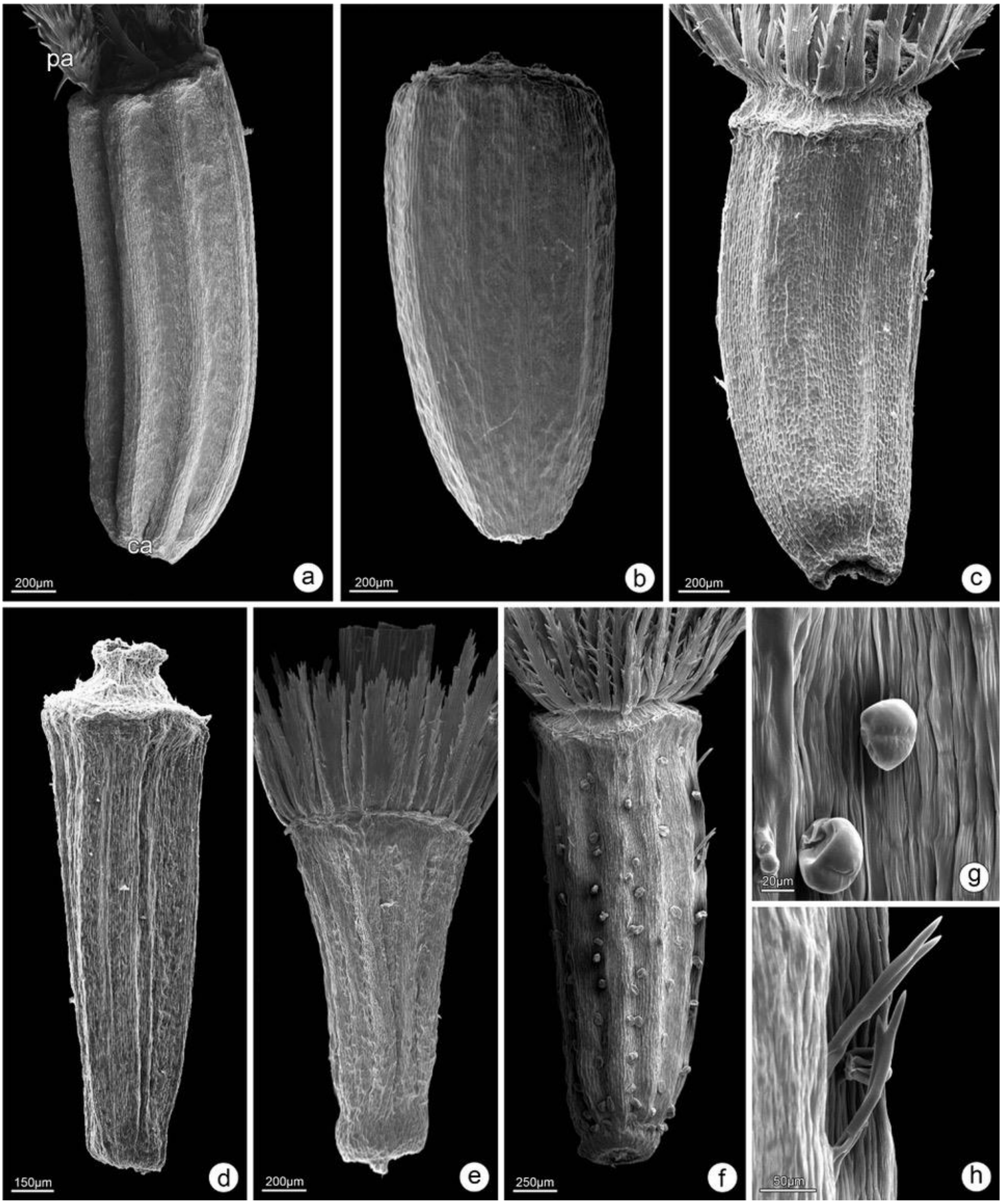

Figure 1. Fruit morphology of *Piptolepis*. **a–g**, General views. **a**, *P. buxoides* (cylindrical cypsela with tapering base); arrow points to the carpopodium. **b**, *P. campestris* (ovoid cypsela). **c**, *P. ericoides* (cylindrical cypsela with tapering base). **d**, *P. gardneri* (narrow obconical cypsela). **e**, *P. glaziouana* (narrow obconical cypsela). **f**, *P. imbricata* (obconical cypsela). **g**, *P. leptospermoides* (cylindrical cypsela with tapering base). **h–i**, Detail of trichomes of *P. leptospermoides*. **h**, glandular. **i**, biseriate tector. Abbreviations: **pa:** pappus.

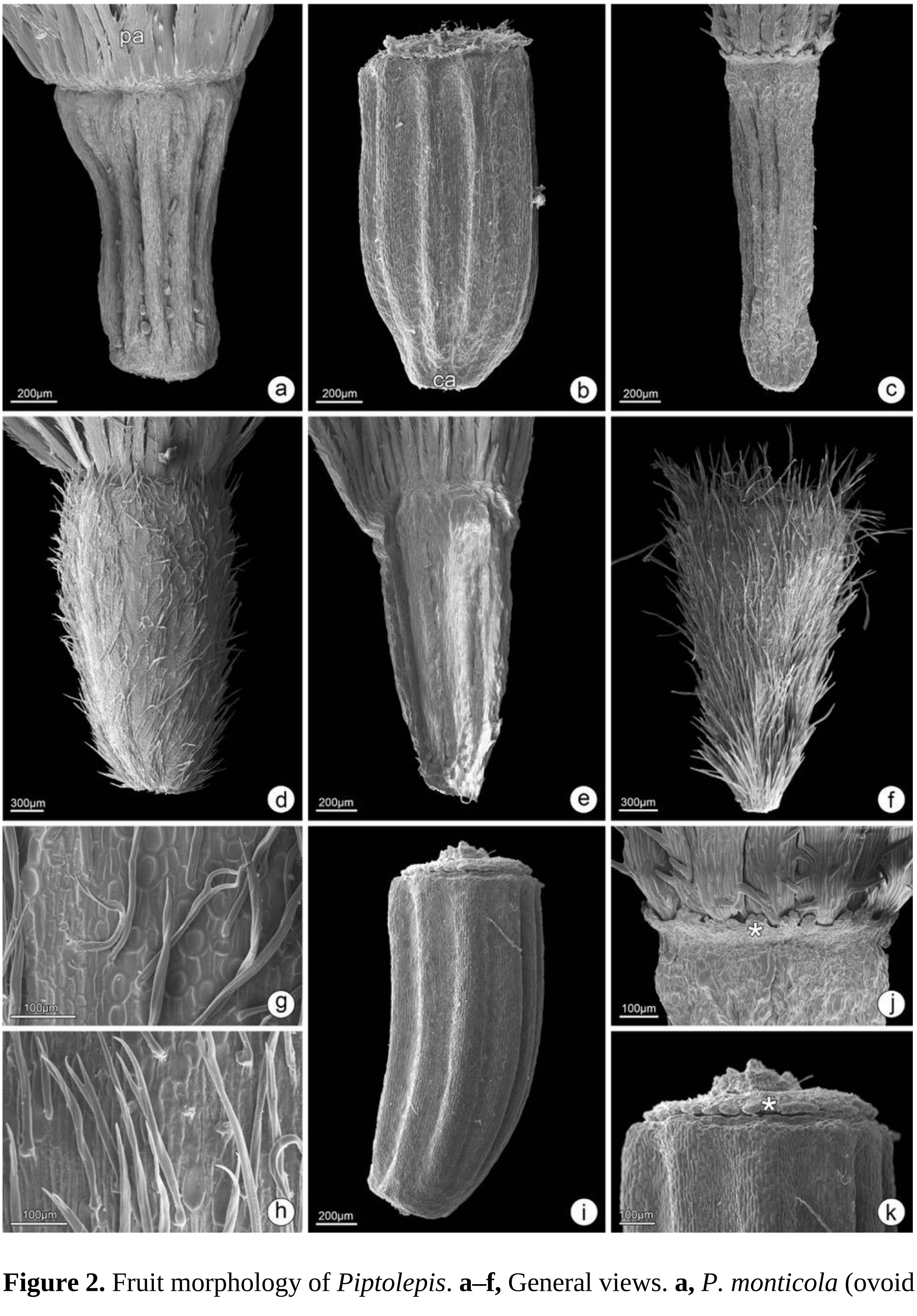

Figure 2. Fruit morphology of *Piptolepis*. **a–f,** General views. **a,** *P*. *monticola* (ovoid cypsela); arrow points to carpopodium. **b,** *P*. *oleaster* (tubular cypsela). **c,** *P*. *pabstii* (ovoid cypsela). **d,** *P*. *riparia* (ovoid cypsela). **e,** *P*. *rosmarinifolia* (obconical cypsela). **f,** *P*. *schultziana* (cylindrical cypsela with tapering base).

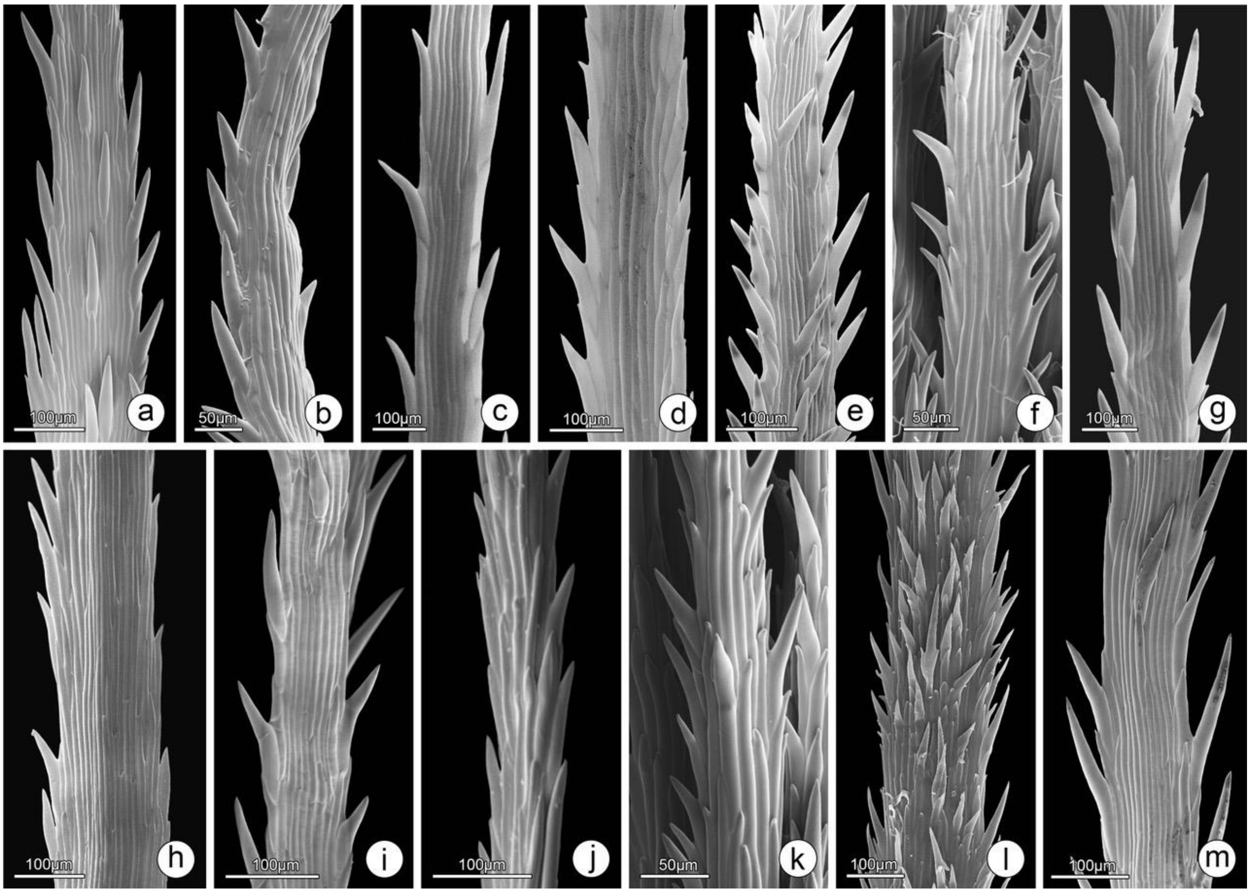

Figure 3. Pappus morphology of *Piptolepis*. **a–m**, Median region. **a**, *P. buxoides*. **b**, *P. campestris*. **c**, *P. ericoides*. **d**, *P. gardneri*. **e**, *P. glaziouana*. **f**, *P. imbricata*. **g**, *P. leptospermoides*. **h**, *P. monticola*. **i**, *P. oleaster*. **j**, *P. pabstii*. **k**, *P. riparia*. **l,** *P. rosmarinifolia*, **m**, *P. schultziana*.

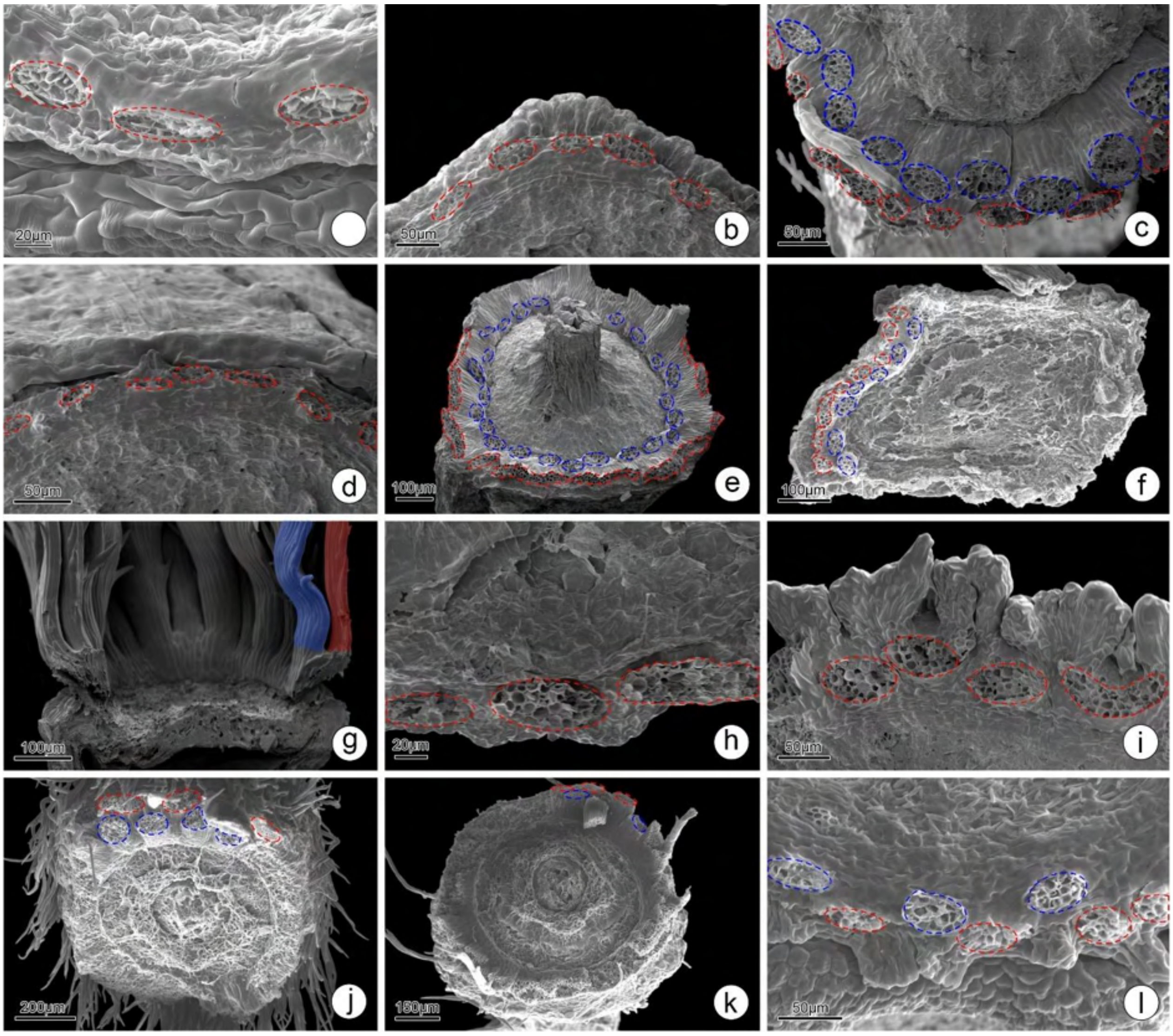

Figure 4. Pappus series arrangement in *Piptolepis*. **a**–**f**, **h**–**m**. Apical view. **g.** Lateral view. **a**, *P. buxoides*. **b**, *P. campestris*. **c**, *P. ericoides*. **d**, *P. gardneri*. **e**, *P. glaziouana*. **f**, *P. imbricata*. **g**, *P. leptospermoides*. **h**, *P. monticola*. **i**, *P. oleaster*. **j**, *P. pabstii*. **k**, *P. riparia*, **l,** *P. rosmarinifolia*, **m**, *P. schultziana*. Asterisks point to vestigial series; blue-coloured areas mark inner series; redcoloured areas mark outer series.

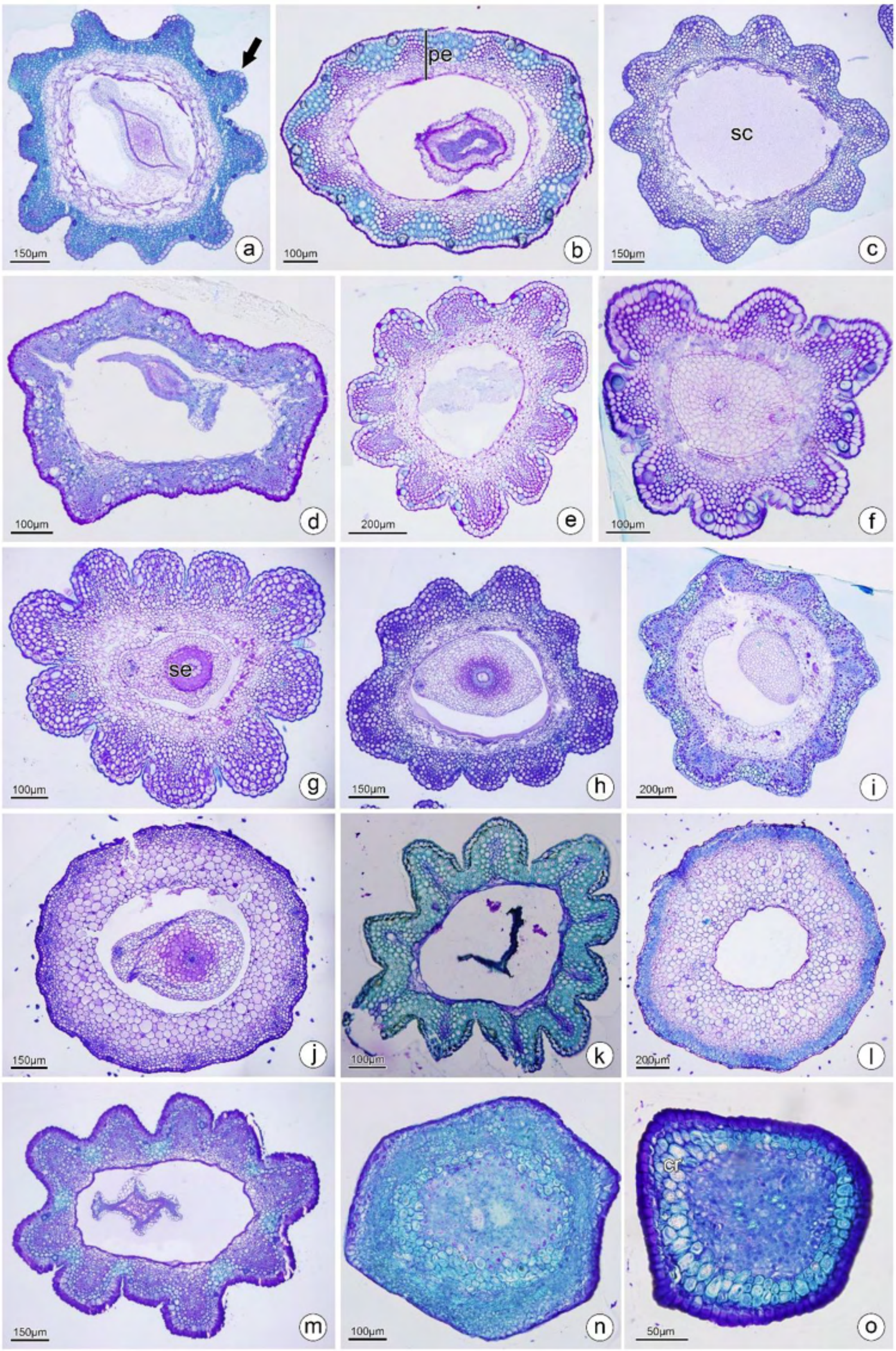

Figure 5. Transverse sections of *Piptolepis* fruits. **a–m** Median region. **a**, *P. buxoides*; arrow points to a rib. **b**, *P. campestris*. **c**, *P. ericoides*. **d**, *P. gardneri*. **e**, *P. glaziouana*. **f**, *P. imbricata*. **g**, *P. leptospermoides*. **h**, *P. monticola*. **i**, *P. oleaster*. **j**, *P. pabstii*. **k**, *P. riparia* **l**, *P. rosmarinifolia*. **m**, *P. schultziana*. **n**, Apical region of *P. gardneri*. **o**, Carpopodium of *P. gardneri*. Abbreviations: **cr**, crystal. **pe**, pericarp. **sc**, seminal chamber. **se**, seed.

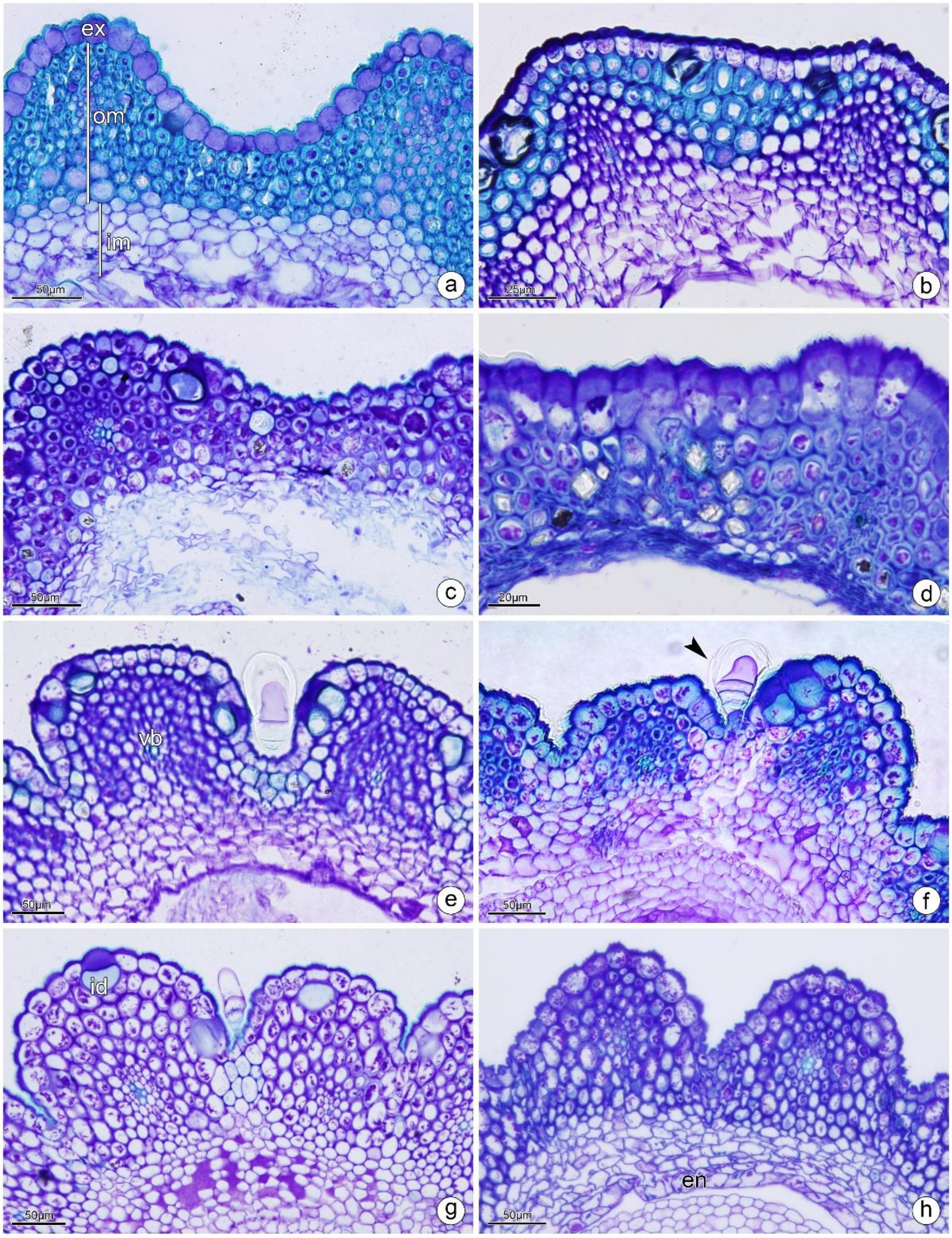

Figure 6. Transverse sections of *Piptolepis* pericarp. **a**, *P. buxoides*. **b**, *P. campestris*. **c**, *P. ericoides*. **d**, *P. gardneri*. **e**, *P. glaziouana*. **f**, *P. imbricata*. **g**, *P. leptospermoides*. Note that the sclerenchyma reacts in red with acidified phloroglucin. **h**, *P. monticola*. Arrowheads point to glandular trichomes. Abbreviations: **co**, collenchyma. **cr**, crystal. **en**, endocarp. **ex**, exocarp. **im**, inner mesocarp. **om**, outer mesocarp. **se**, seed. **sl,** sclerenchyma. **vb**, vascular bundle.

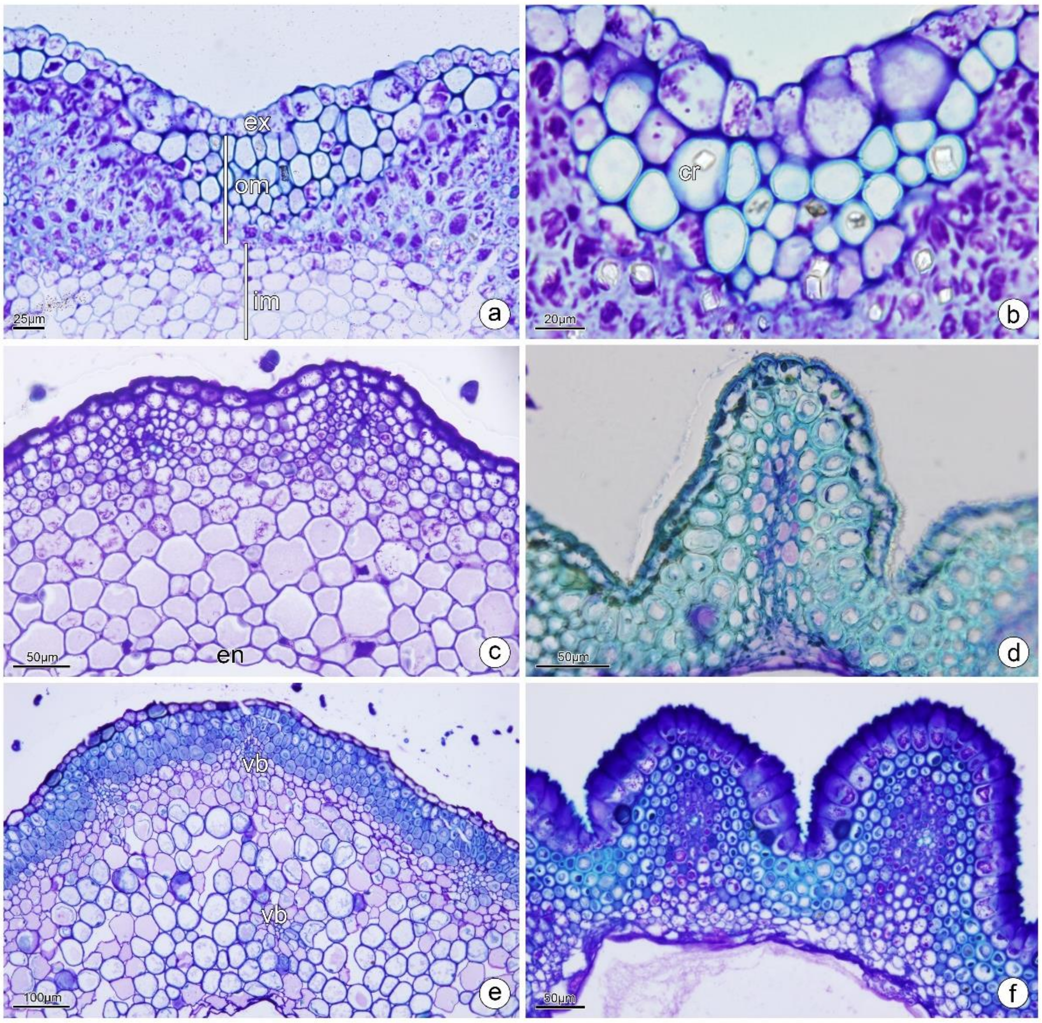

Figure 7. Transverse sections of *Piptolepis* pericarp. **a–b**, *P. oleaster*. **c**, *P. pabstii*. **d**, *P. riparia*. **e**, *P. rosmarinifolia*; **f**, *P. schultziana*. Abbreviations: **co**, collenchyma. **cr**, crystal. **en**, endocarp. **ex**, exocarp. **im**, inner mesocarp. **om**, outer mesocarp. **vb**, vascular bundle.

Table 1. Vouchers of the species of *Piptolepis* examined here

Species	Voucher
P. buxoides	M.M. Saavedra *et al.* 529
	B. Loeuille *et al.* 599
P. campestris	R.C. Forzaa & Mello-Silva 3759
	R. Mello-Silva *et al.* 9966
	A.M. Giulietti *et al.* 2302
P. ericoides	B. Loeuille *et al.* 534
	J.H.L. El-Ottra *et al.* 33
	R. Mello-Silva *et al.* 1377
P. gardneri	M. Saavedra *et al.* 877
P. glaziouana	M.M. Arbo *et al.* 5224
P. imbricata	B. Loeuille *et al.* 581
P. leptospermoides	R. Romero *et al.* 8506
	I.M. Franco *et al*. 609
	A.P. Duarte 10518
P. monticola	B. Loeuille *et al.* 590
	J.R. Pirani *et al.* 5954
P. oleaster	B. Loeuille *et al.* 517
	B. Loeuille *et al.* 518
P. pabstii	B. Loeuille *et al.* 833
	B. Loeuille *et al.* 835
P. riparia	G. Martinelli *et al.* 19248
P. rosmarinifolia	G. Hatschbach *et al.* 70631
P. schultziana	J.R. Pirani *et al.* 4179
	V.C. Souza *et al.* 32693

Table 2: Anatomical features of the cypsela of the studied species of *Piptolepis*

Species	Ribs	Carpopodium	Exocarp			Mesocarp	
			twin hair	glandular trichome	idioblast	crystals	number of vascular bundles
P. buxoides	conspicuous	indistinct	absent	absent	present	present	10
P. campestris	inconspicuous	indistinct	absent	absent	present	present	10
P. ericoides	conspicuous	indistinct	absent	absent	present	present	10–15
P. gardneri	inconspicuous	indistinct	absent	absent	present	present	10
P. glaziouana	conspicuous	indistinct	absent	present	present	present	9–10
P. imbricata	conspicuous	indistinct	absent	present	present	present	8–10
P. leptospermoides	conspicuous	indistinct	present	present	present	present	10
P. monticola	conspicuous	indistinct	absent	absent	present	present	10–11
P. oleaster	conspicuous	indistinct	absent	absent	present	present	8–10
P. pabstii	inconspicuous	indistinct	present	absent	present	absent	10
P. riparia	conspicuous	indistinct	absent	absent	present	present	10
P. rosmarinifolia	inconspicuous	indistinct	present	present	present	absent	10+2
P. schultziana	conspicuous	indistinct	absent	absent	present	present	10

Table 3: *Piptolepis* pappus morphology

Species	**Number of pappus series**	**Outer Pappus duration**	**Vestigial series**	**Outer Pappus fusion**	**Outer papus relative size to inner series**	**Outer pappus type**	**Outer pappus lateral projection**	**Outer pappus setae base**	**Outer pappus setae apex**	**Inner Pappus duration**	**Inner Pappus fusion**	**Inner pappus twisted**	**Inner pappus type**	**Inner pappus lateral projection**	**Inner pappus setae base**	**Inner pappus setae apex**
P. buxoides	two	caducous	yes	free	Subequal or equal	paleaceous	serrulate	dilated	narrowed	caducous	free	yes	paleaceous	serrulate	dilated	narrowed
P. campestris	two	deciduous	yes	free	Subequal or equal	paleaceous	barbellate	dilated	narrowed	deciduous	free	no	paleaceous	barbellate	dilated	narrowed
P. ericoides	two	deciduous	no	fused at base	Subequal or equal	paleaceous	none	not dilated	not tapering	caducous	free	no	paleaceous	serrulate	not dilated	not tapering
P. gardneri	two	deciduous	yes	free	Subequal or equal	paleaceous	serrulate	not dilated	not tapering	deciduous	free	no	paleaceous	serrulate	not dilated	not tapering
P. glaziouana	two	deciduous	no	free	smaller	paleaceous	barbellate	dilated	not tapering	deciduous	free	no	paleaceous	barbellate	dilated	not tapering
P. imbricata	two	persistent	no	fused at base or free	smaller	paleaceous	serrulate	dilated	narrowed	persistent	free	yes	paleaceous	serrulate	dilated	not tapering
P. leptospermoides	two	persistent	no	free	smaller	paleaceous	serrulate	not dilated	not tapering	persistent	free	yes	paleaceous	serrulate	dilated	not tapering
P. monticola	two	deciduous	yes	free	subequal or equal	paleaceous	serrulate	dilated	not tapering	deciduous	free	no	paleaceous	serrulate	not dilated	not tapering
P. oleaster	two	caducous	yes	free	subequal or equal	paleaceous	serrulate	dilated	not tapering	deciduous	free	yes	paleaceous	serrulate	dilated	not tapering
P. pabstii	two	persistent	no	free	smaller	setose	barbellate	not dilated	not tapering	persistent	free	no	paleaceous	serrulate	not dilated	not tapering
P. riparia	two	deciduous	no	free	smaller	setose	barbellate	dilated	not tapering	deciduous	free	no	paleaceous	barbellate	not dilated	not tapering
P. rosmarinifolia	two	persistent	no	free	smaller	setose	barbellate	dilated	narrowed	persistent	free	no	paleaceous	serrulate to barbellate	dilated	narrowed
P. schultziana	three	caducous	yes	free	subequal or equal	paleaceous	barbellate	dilated	not tapering	caducous	free	no	paleaceous	barbellate	dilated	not tapering

APÊNDICE E – REESTABLISHMENT OF THE NAME *PIPTOLEPIS PSEUDOMYRTUS* (VERNONIEAE, ASTERACEAE)

ARTIGO PUBLICADO NO PERIÓDICO PHYTOTAXA 531 (2): 136–142, 2022.

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Abstract

In the course of a taxonomic revision of the genus *Piptolepis* (Vernonieae, Asteraceae), it became clear that *P. pseudomyrtus*, until now considered a synonym of *P. buxoides*, should be reestablished. It differs from *P. buxoides* by its habit, leaf shape, number of florets per head, cypsela shape, and length of pappus series. An updated morphological description, geographic distribution, illustration and conservation status of *P. pseudomyrtus* are provided, as well as a comparative discussion with *P. buxoides*.

Keywords: Compositae, Nomenclature, Taxonomy

Introduction

Asteraceae comprises about 25,000–30,000 species belonging to 1,600–1,700 genera, distributed in 16 subfamilies and 50 tribes (Funk *et al.* 2009, Susanna *et al.* 2020, Keeley *et al.* 2021). In Brazil the family is represented by 2,205 species in 326 genera, with ca. 62% of species and ca. 22% of genera considered endemic to the country (Roque *et al.* 2020).

Vernonieae is the sixth largest tribe in Asteraceae, with 21 subtribes, 129 genera and ca. 1,500 species (Robinson 2007, Panero & Crozier 2016, Keeley *et al.* 2021). One of its largest subtribes, Lychnophorinae, contains 19 genera and 128 species, many of them restricted to the campos rupestres of the Espinhaço Range in the Brazilian southeastern and northeastern

(Marques *et al.* 2018, 2021, Bringel *et al.* 2019, Loeuille *et al.* 2019, Cândido & Loeuille 2020, 2021, Gomes & Loeuille 2021).

Piptolepis Schultz Bipontinus (1863: 60), which belongs to Lychnophorinae, is endemic to the Brazilian Central Plateau, presenting its center of diversity in the Diamantina Plateau in the Espinhaço Range in Minas Gerais (Loeuille *et al.* 2012). The genus comprises 16 species (Bringel *et al.* 2019, Loeuille *et al.* 2019, Cândido & Loeuille 2021) of shrubs, subshrubs or treelets with profusely branched stems, covered by a dense indumentum mainly composed of 3–5-armed trichomes. The leaves are alternate with a typical pad-like leaf sheath. The heads are solitary or organized in a terminal raceme, pseudoglomerule, or rarely in a syncephalium (second-order inflorescence) (Loeuille *et al.* 2019).

In the course of a taxonomic revision of *Piptolepis*, a thorough examination of the type material of *Piptolepis buxoides* (Lessing 1829: 247) Schultz Bipontinus (1863: 63) and its heterotypic synonym *P. pseudomyrtus* (Saint-Hilaire 1833: 367) Schultz Bipontinus (1863: 64) lead us to the conclusion that these taxa are not conspecific.

Historical background

In 1829, Lessing described *Vernonia buxoides* Lessing (1829: 247) based on a Brazilian collection by Sellow. A few years later, in 1833, on his book *Voyage dans le district des diamans et sur le littoral du Brésil*, Saint-Hilaire described *Vernonia pseudomyrtus* Saint-Hilaire (1833: 94, 367), based on his own collection from the Itapanhoacanga region in the state of Minas Gerais. Saint-Hilaire (1833) included a taxonomic commenting explaining that the shortly petiolate and lanceolate leaves of *V. pseudomyrtus* distinguished the species from *V. buxoides* (sessile, obovate) and *Vernonia ericoides* Lessing (1831: 629) (sessile, linear). Three decades later, Schultz Bipontinus (1863: 60) established the genus *Piptolepis* and proposed six new combinations for species previously placed in *Vernonia*, among them, *P. buxoides* and *P. pseudomyrtus*. However, in the last available taxonomic treatment of the genus *Piptolepis* in Martius' *Flora brasiliensis* (1873), Baker noticed that the material used by Schultz Bipontinus to describe *P. pseudomyrtus* was in fact a different species from the one described by Saint-Hilaire. Thus, he separated both species, but created an illegitimate name, *P. pseudomyrtus* Baker (1873: 145), for the diverging species (= *Piptolepis monticola* Loeuille in Loeuille *et al.* (2012: 14)) and placed *V. pseudomyrtus* Saint-Hilaire as a synonym of *P. buxoides*.

In the light of the morphological differences between *P. buxoides* and *Vernonia pseudomyrtus* and our investigation of their history, it is clear that *P. pseudomyrtus* must be re-established (ICBN, Art. 41.1 and 7.3 in Turland *et al.* 2018). Therefore, an updated morphological description, geographic distribution, illustrations and conservation status are provided, as well as a comparative discussion with *P. buxoides*.

Materials and Methods

This study was based on literature review, observation of specimens in the field, in online databases [Reflora–Herbário Virtual 2021; SpeciesLink 2021] and analyses of specimens, including the types and historical collections belonging to the following herbaria: HDJF, HUFU, K, MA, MBM, NY, P, R, RB, SPF, UB, UFP and US. Morphological features of the specimens were analyzed with a 10–16 × magnification stereomicroscope. Measurements were taken using a digital caliper rule and optical graticule attached to the microscope. The heads, corollas, anthers and styles were rehydrated from dried specimens for measurements. Morphological terminology follows Small (1919) for pappus and receptacle forms, Hickey (1973) for leaf shape, Harris & Harris (2001) and Beentje (2010) for general morphology and color terminology, respectively. Maps were prepared with Quantum GIS version 3.0 (QGIS Development Team 2018).

Results

Vernonia pseudomyrtus A. St.-Hil. is excluded from the *P. buxoides* synonymy. Based on the historical background and morphological differences summarized in Table 1.

Piptolepis pseudomyrtus (A. St.-Hil.) Schultz-Bipontinus (1863: 64), non *P. pseudomyrtus* Baker (1873: 145), *nom. illeg. Vernonia pseudomyrtus* Saint-Hilaire (1833: 367). Type:—BRAZIL. Minas Gerais: près Tapinhoancanga [Itapanhoacanga], *A. de Saint-Hilaire catologue B' 910, n° 574* (lectotype: P [P00683104], designated by Loeuille *et al.* (2019: 90); isolectotypes: B†, K *e*! [K000497136], MPU *e*! [MPU023508], P [P00683105, P00683106]).

Treelet 0.70–1.4 m tall, virgate, densely branched towards apex. Stems corrugated, manicate, ochraceous, old stems terete, puberulent, light brown, leaf scars deltate. Leaves alternate, simple, spiraled, ascending, subsessile to shortly petiolate, 0.3–1 mm, pad-like leaf sheath semi-conical, 0.5–1 mm long; blade very narrow elliptic to elliptic or oblanceolate, 6–19 × 1.8–6 mm, discolorous, chartaceous, venation eucamptodromous, midrib prominent abaxially and sunken adaxially, adaxial surface dark olive green, tomentulose, with black glandular dots, abaxially light green, velutinous, margins entire, flat, apex subacute to obtuse, base attenuate. Inflorescence in terminal raceme, with leaf-like bracts at base of capitula, 8–12 × 1.5–3.5 mm, apex acute, base attenuate. Capitula 3–6, homogamous, discoid, sessile; involucre campanulate, 9–12 mm tall × 7–15 mm diam, 6–7 seriate; phyllaries weakly imbricate, scarious, margins entire, glandular-punctate, outer phyllaries triangular to narrowly triangular or lanceolate, 2.5–4.2 × 0.9–1.2 mm, apex acute, stramineous, lanulose, inner phyllaries narrowly oblong, 9–10 × 0.9–1.6 mm, apex acuminate, stramineous sometimes with reddish apex, pubescent, glandular-punctate; receptacle flat, fimbrillate. Florets 17–31, bisexual, fertile; corolla actinomorphic, deeply 5-lobed, pale lilac, glabrous, glandular-punctate, 9–11 mm long., corolla tube 5–8 × 0.5–1.4 mm., corolla lobes 3.6–4 × 0.6–0.7 mm, apex acute; anthers calcarate, white, apical appendages acute, anther base sagittate; style shaft 6–11 mm long, pale lilac, glabrous throughout except for pubescent upper 1 mm beneath style-arms, style base glabrous, lacking basal node, style arms 1.5–3 mm long, apex acute, short-pubescent outside throughout. Cypselae prismatic, 2–2.2 × 0.6–1 mm, 10-ribbed, glabrous, glandular-punctate, dark brown; carpopodium annular, minute; pappus setae biseriate, 4–6.5 mm long., subequal or equal, deciduous, stramineous, paleaceous, barbellate, tapering towards the apex (Fig. 1, 2).

Distribution and habitat:—Endemic to the Espinhaço Range in the state of Minas Gerais, the species currently occurs within the boundaries of the municipalities of Serro and Alvorada de Minas (in the Itapanhoacanga area) (Fig. 3) but some historical collections from Diamantina and Ouro Preto indicate that the species may have had a larger geographical distribution. *P. pseudomyrtus* occurs in campos rupestres, in areas of quartzite rock outcrops in sandy and rocky soils, close to small streams, at elevations between 672 and 1,132 m a.s.l..

Phenology:—Flowering and fruiting specimens were found in April and May, and with flowers only in November.

Additional specimens examined:—BRAZIL. Minas Gerais: *s.l.*, fr., *s.d.*, *G. Gardner 4752* (NY *e*!; R!, S); Serra da Lapa, *s.d.*, *Riedel 911* (K; NY *e*!); Diamantina, ao tombador, fl., fr., 7 April 1892, *A.F.M. Glaziou 19552* (R!); Diamantina, fl., 9 May 1905, *L. Damazio s.n* (RB 57108!); Ouro Preto, fl. fr., *s.d.*, *L. Damazio s.n* (RB 57107!); Serro, Distrito de Mato Grosso, Pedra do Cruzeiro, elev. 1,132 m, [-18.693611°, -43.458333°], fl. fr., 28 May 2001, *J.N. Nakajima 3066 & R. Romero* (HUFU!). Alvorada de Minas, Itapanhoacanga, trilha para a cachoeira Campina, elev. 846 m, [-18.7975°, -43.443055°], fl., 14 November 2007, *M.M. Saavedra et al. 529* (RB!, SPF!, UFP!); ibid, elev. 672 m, [-18.805277°, -43.436388°], fl., 19 November 2011, *B. Loeuille et al. 599* (K!, MA!, MBM!, RB!, SPF!, UFP!, US!); ibid, elev. 696 m, [-18.804722°, -43.436666°], fl. fr., 14 May 2019, *J.B. Cândido 345 & Almir* (UFP!).

Conservation status:—*Piptolepis pseudomyrtus* is known from less than ten collections [According to the Reflora – Herbário Virtual (2021) and SpeciesLink (2021) databases]. An analysis with the GeoCAT tool (Bachmann *et al.* 2011) provides an area of occupancy (AOO) of 24,000 km^2 and extent of occurrence (EOO) of 334,189 km^2, indicating that if a formal assessment were to be carried out according to the IUCN guidelines (2021) this species would probably be classified as Endangered EN B1a+B2a.

The closest protected area from recent collections is Serra do Cipó National Park, but all specimens were sampled outside the park area. *P. pseudomyrtus* occurs in relatively preserved vegetation, however its distribution area comprises areas of touristic interest such as waterfalls. Additionally, some of the collection localities are surrounded by roads and inhabited areas, which could lead to future decline in habitat quality. More attention should be given to this restablished species, including the possibility of proposing new protected areas.

Notes:—*Piptolepis pseudomyrtus* differs from *P. buxoides* by the habit (treelet vs. shrub), leaf shape (narrowly elliptic to elliptic or oblanceolate vs. obovate), subsessile to shortly petiolate leaves (vs. sessile), larger leaves (6–19 × 1.8–6 mm vs. 6–8 × 4 mm), number of florets per head (17–31 vs. 7), prismatic cypselae (vs. cylindrical) and equal to subequal series of pappus setae (vs. unequal).

There are no register of other *Piptolepis* species co-occurring with *P. pseudomyrtus*, however it is morphologically similar to *P. schultziana* Loeuille & D.J.N.Hind in Loeuille *et al.* (2012: 12). *P. pseudomyrtus* can be distinguished from *P. schultziana* by the leaves with eucamptodromous venation (vs. hyphodromous), fewer capitula per inflorescence (3–6 vs. 7–18), campanulate involucre (vs. cylindrical), prismatic cypselae (vs. cylindric) and shorter pappus (4–6.5 vs. 6–7 mm long). It also resembles *P. ericoides* (Lessing 1831: 629) Schultz Bipontinus (1863: 63), however *P. pseudomyrtus* differs by its leaves with eucamptodromous venation (vs. hyphodromous), higher number of florets per head (17–31 vs. 10–16) and barbellate pappus setae (vs. serrulate).

Schultz Bipontinus (1863) based his description of *P. pseudomyrtus* on Martius 545, a material belonging to a different species (*P. monticola*). According to Loeuille *et al.* (2012), Schultz Bipontinus probably did not study the type of *Vernonia pseudomyrtus* (Saint-Hilaire B' 910-574) and only knew that species through Saint-Hilaire's (1833: 94, 367) and Candolle's (1836: 17) descriptions. However, *P. pseudomyrtus* was a validly published new combination, as Schultz Bipontinus correctly referenced the basionym (ICBN, Art. 41.1 in Turland *et al.* 2018) and the misidentification of the species does not invalidate it (ICBN, Art. 7.3, Ex.3 in Turland *et al.* 2018). Additionally, in his combination of *P. buxoides,* Schultz Bipontinus presents an additional material (Riedel 911/1824) that belongs to *V. pseudomyrtus* A. St.-Hill. This probably explains why Baker (1873) considered the two species synonymous in *Flora brasiliensis*.

Acknowledgments

J.B. Cândido thanks Instituto Estadual de Florestas - Minas Gerais and ICMBio for issuing collection permits; Fabiane Nepomuceno da Costa from Universidade Federal do Vale do Jequitinhonha e Mucuri (UFVJM), for kindly hosting the author and providing logistic support during fieldwork in the state of Minas Gerais; Regina Maria Alcântara de Carvalho for line drawings and Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (Finance Code 001) for the granted fellowship (CAPES/PROEX).

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TABLE 1. Comparison of morphological characters between *P. buxoides* and *P. pseudomyrtus*. Source material: *P. buxoides*— *F. Sello(w) s.n.* (P [P02511977]) and based on the protologue description; *P. pseudomyrtus*— *B. Loeuille et al.* 599 (RB, SPF, UFP); *J.B. Cândido* 345 (UFP); *M.M. Saavedra et al.* 529 (RB, UFP, USP).

	Habit	**Leaf shape**	**Leaf size (mm)**	**Petiole**	**Florets per head**	**Cypsela shape**	**Relative size of pappus series**
P. buxoides	shrub	obovate	6–8 × 4 mm	sessile	7	cylindrical	unequal
P. pseudomyrtus	treelet	elliptic, narrow elliptic to very narrow elliptic or oblanceolate	6–19 × 1.8–6 mm	subsessile to shortly petiolate (0.3–1 mm)	17–31	prismatic	subequal or equal

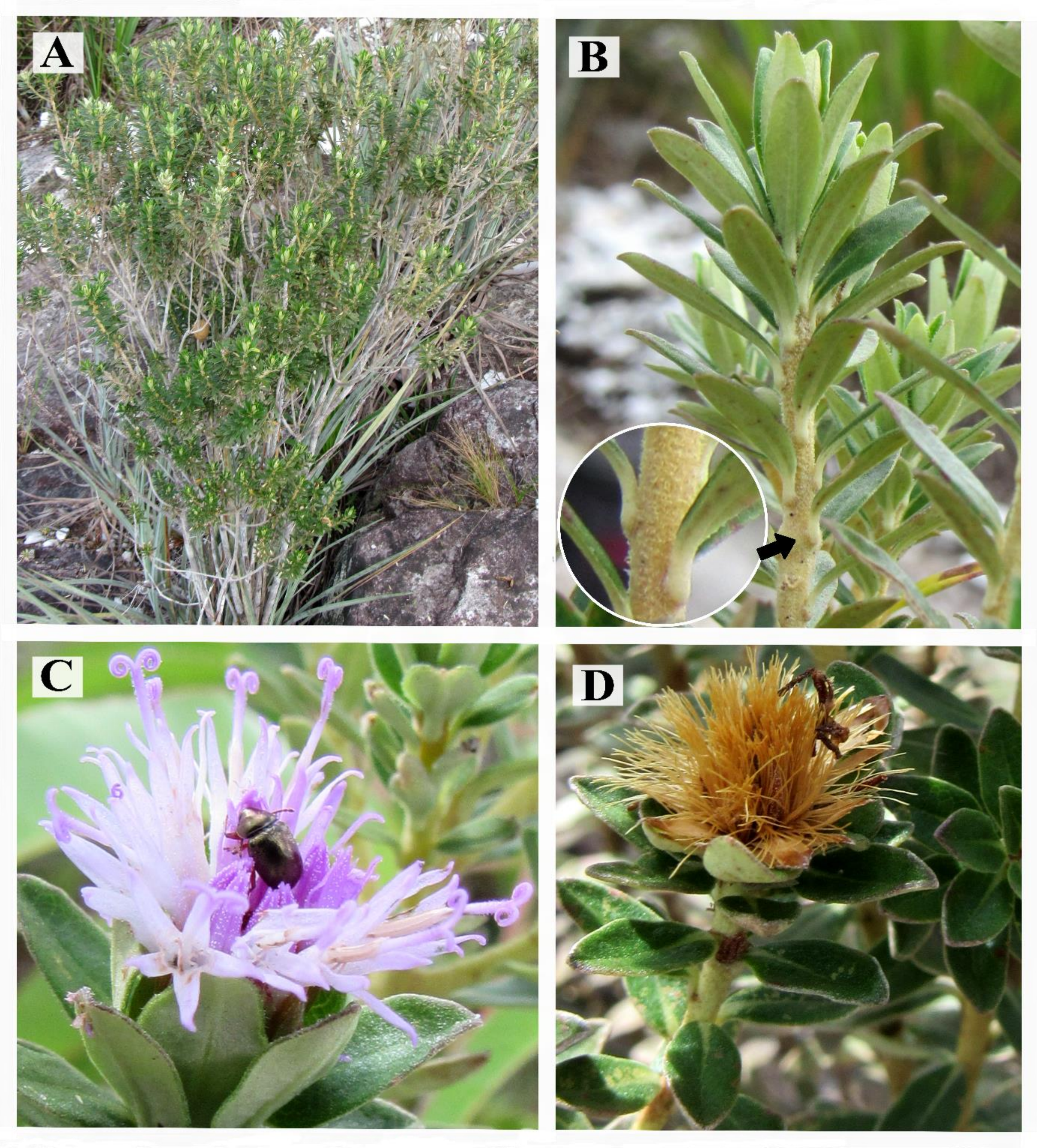

FIGURE 1. *Piptolepis pseudomyrtus*. **A.** Habit. **B.** Leaf arrangement and pad-like leaf sheath (highlighted). **C.** Head. **D.–E.** Fruiting heads. **A.–E.** by J.B. Cândido.

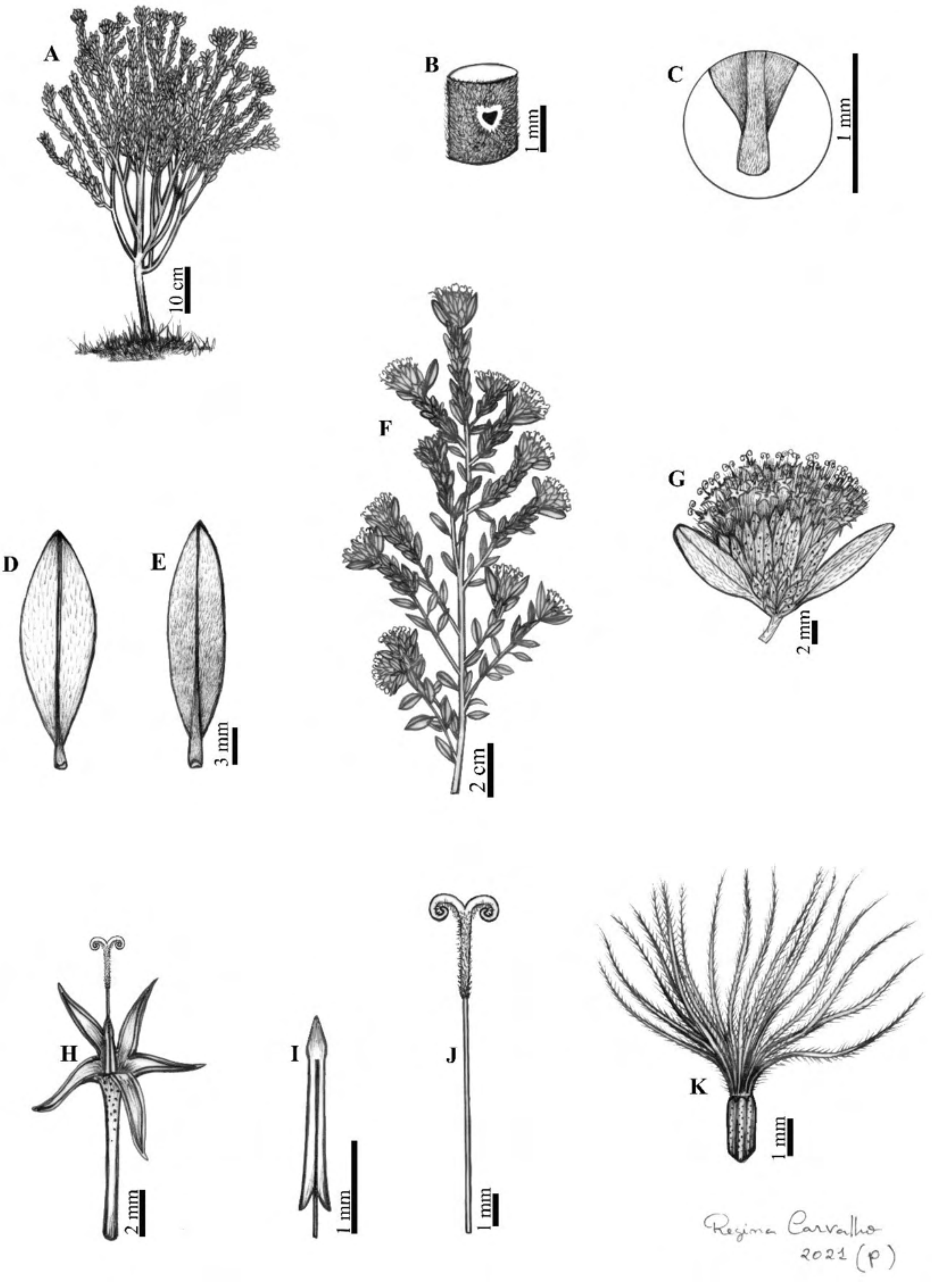

FIGURE 2. *Piptolepis pseudomyrtus*. **A.** Virgate habit. **B.** Leaf, adaxial surface. **C.** Leaf, abaxial surface. **D.** Head. **E.** Flowering branch with raceme. **F.** Pad-like leaf sheath. **G.** Stems with leaf scars. **H.** Corolla, androecium and style. **I.** Anther. **J.** Style. **K.** Cypsela. **A.–K.** illustration by Regina Carvalho.

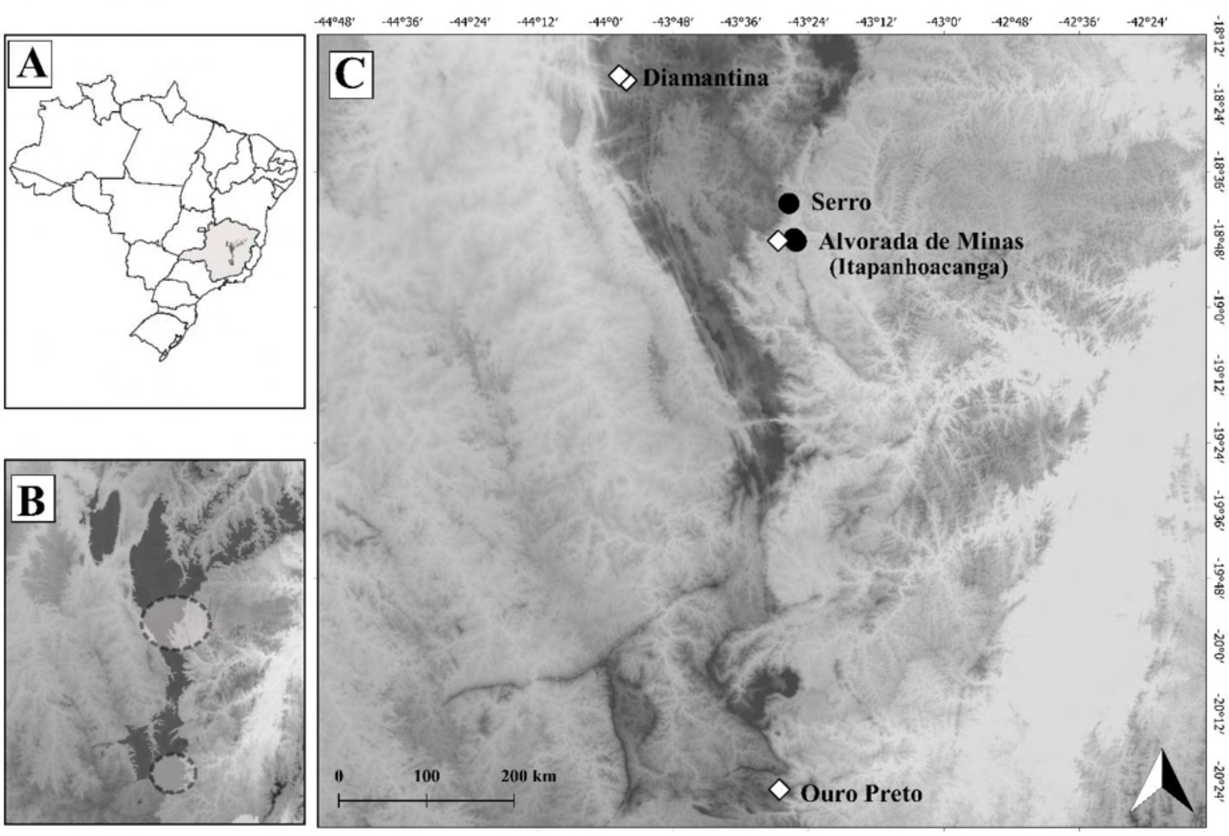

FIGURE 3. A. Brazil with the state of Minas Gerais highlighted. **B.** Espinhaço Range in Minas Gerais with area of occurrence highlighted. **C.** Distribution of *Piptolepis pseudomyrtus*: recent collections (black circle), 19th century collections (white diamond).

ANEXO – LINKS PARA AS NORMAS DE SUBMISSÃO DAS REVISTAS CIENTÍFICAS

PARTE 1: Normas para publicação no periódico Phytotaxa

Disponível em: https://www.mapress.com/j/pt/pages/view/forauthors

PARTE 2: Normas para publicação no periódico Flora

Disponível em: https://www.elsevier.com/journals/flora/0367-2530/guide-for-authors