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## A tiny rediscovery in the Land of Giants: a new combination in *Giuliettia* (*Eriocaulaceae*, *Poales*) and other implications of finding *Paepalanthus minimus* again

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**Abstract:** Serra do Padre Ângelo, a quartzitic massif in eastern Minas Gerais, Brazil, was nicknamed “Land of Giants” due to the gigantism observed in some plant species found in its campos rupestres. During fieldwork for the floristic inventory of this Serra, a small *Eriocaulaceae* species was collected. Initially it was believed to be a new species, but a thorough revision of names and type specimens revealed that it was conspecific with *Paepalanthus minimus*. This taxon was known only from the type specimen collected over 100 years ago and more than 200 km distant from the new collections. It had been overlooked in previous studies dealing with the family in Brazil, which could be explained by its diminutive size and the poor conditions of the type specimen. Here we present the implications of this rediscovery, including the combination of *P. minimus* in *Giuliettia*, a genus recently proposed based on general habit, inflorescence and seed morphology. We also present information on distribution and ecology and briefly discuss the biogeographical pattern that could explain this rediscovery far away from the previous record. Considering its likely local extinction at the type locality and threats to the quality of its remaining habitat, the species is preliminarily assessed as Critically Endangered. This highlights the urgent need for conservation actions to protect Serra do Padre Ângelo and its unique biodiversity.

**Keywords:** campos rupestres, conservation, *Eriocaulaceae*, *Giuliettia*, monocots, *Paepalanthus*, *Poales*, Serra do Padre Ângelo, threatened species

**Resumo:** A Serra do Padre Ângelo, um maciço quartzítico no leste de Minas Gerais, Brasil, foi apelidada de “Terra de Gigantes” devido ao gigantismo observado em algumas espécies de plantas encontradas em seus campos rupestres. Durante o trabalho de campo para o inventário florístico desta Serra, uma pequena espécie de *Eriocaulaceae* foi coletada. Inicialmente, acreditava-se ser uma nova espécie, mas uma revisão minuciosa dos nomes e espécimes tipo revelou que ela era na verdade conspecífica com *Paepalanthus minimus*. Esse táxon era conhecido apenas pelo espécime tipo, coletado há mais de 100 anos e a mais de 200 km das novas coletas, tendo passado despercebido em estudos anteriores sobre a família no Brasil, o que pode ser explicado pelo seu tamanho diminuto e pelas condições precárias do espécime tipo. Aqui, apresentamos as implicações dessa redescoberta, incluindo a combinação de *P. minimus* em *Giuliettia*, um gênero recentemente proposto, com base em seu hábito geral, morfologia da inflorescência e da semente. Também fornecemos informações sobre a distribuição e ecologia, e discutimos brevemente o padrão biogeográfico que poderia explicar essa redescoberta tão distante do registro anterior. Considerando sua provável extinção local na localidade tipo e as ameaças à qualidade de seu habitat remanescente, a espécie é preliminarmente avaliada como Criticamente em Perigo. Isso destaca a necessidade urgente de ações de conservação para proteger a Serra do Padre Ângelo e sua biodiversidade única.

**Palavras-chave:** campos rupestres, conservação, *Eriocaulaceae*, espécie ameaçada, *Giuliettia*, monocotiledôneas, *Paepalanthus*, *Poales*, Serra do Padre Ângelo

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### Introduction

*Eriocaulaceae* is the iconic component of the flora of the campos rupestres (Giulietti & al. 1997), a megadiverse ecosystem found in ancient mountain ranges across South America, but especially in central and eastern Brazil (Silveira & al. 2016). While this ecosystem has been

the focus of an increasing number of studies in the past decades (Miola & al. 2021), new areas harbouring campos rupestres are still being discovered in the 21<sup>st</sup> century. Such is the case of Serra do Padre Ângelo, Pico da Aliança and other neighbouring quartzitic sierras of the João Pinto formation in the Doce river valley in eastern Minas Gerais, southeastern Brazil (Gonella & al. 2015;

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Lopes & al. 2016; Mello-Silva 2018; Andrino & Gonella 2021). The João Pinto formation is a geologically ancient region with a quartzitic rock substrate distinct from its surroundings (Oliveira 2000), characterized by granitic rock outcrops and vast lowlands that were once covered by seasonal forests of the Atlantic forest domain, a biodiversity hotspot (Myers & al. 2000), but now majorly deforested and converted into grazing land (MapBiomass Project 2023). These rocky areas form “islands” of isolated mountaintops among a forest matrix and harbour several newly described and endemic species of plants (Gonella & al. 2015; Andrino & Gonella 2021; Antar & al. 2021a, 2021b; Mezzonato-Pires & al. 2021; Cavalcanti & al. 2022; Goldenberg & al. 2022; Oliveira & al. 2022; Couto & al. 2023; Leme & al. 2023) and animals (Reategui & al. 2022; Cordeiro & Camico 2023; Zacca & al. 2023). Because of this, the region can be seen as a significant location of biodiversity and endemism for the neotropical flora, previously referred to as the “João Pinto centre of biodiversity” (Leme & al. 2023). Only in the last decade, over 30 new species have been described from this small region, and many others are still to be named as explorations in the region progress. Two of the recent discoveries from Serra do Padre Ângelo are remarkable in their gigantism within their respective families: they are *Drosera magnifica* Rivadavia & Gonella (*Droseraceae*; Gonella & al. 2015) and *Vellozia gigantea* N. L. Menezes & Mello-Silva (*Velloziaceae*), rendering the nickname “Land of Giants” to these mountains (Mello-Silva 2018).

The João Pinto formation is located around 200 km to the east of the Espinhaço range, a cordillera of over 1000 km extending from Minas Gerais to Bahia in eastern Brazil that is the core area of the Brazilian campos rupestres and a centre of diversity for *Eriocaulaceae* (Costa & al. 2023). The family has the largest number of endemic species in the Espinhaço range (Colli-Silva & al. 2019), and *Paepalanthus* Mart. is the most endemic-rich genus, with a high rate of micro-endemism, i.e. species known only from a single locality or even only from the type specimen (Costa & al. 2008, 2023). Many of these species were described by the Brazilian naturalist Álvaro Astolpho da Silveira (1867–1945), who travelled along the Espinhaço range collecting plants and describing new taxa. Silveira published over 250 new plant names, at least 181 of which were new *Paepalanthus* species (Heringer 2012). While most of the species published by Silveira are still accepted, many were later considered synonyms (Andrino & al. 2022). This can be explained by the limited number of herbarium specimens in Brazil at that time, hindering the study of morphological variation, the difficult access to type specimens mainly deposited in European herbaria and the adoption of very restrictive species delimitation concepts (Heringer 2012). The delimitation of some species described by Silveira remains challenging due to several factors. Many of these species are still known only from the type specimens, which often have

very nonspecific location data and are represented by a single or a few collected plants (Andrino & al. 2022).

Recently, a new classification for *Eriocaulaceae* was carried out, focusing on the subfamily *Paepalanthoidae* (Andrino & al. 2023a). The limits of the megadiverse genus *Paepalanthus* have been revised based on molecular and morphological evidence, with distinctive clades recognized as segregated genera. One of these genera is *Giuliettia* Andrino & Sano, consisting so far of 30 species and one variety, which are characterized by plants that hardly exceed 20 cm tall, with mostly unbranched stems with fasciculate scapes at the apex, trimerous flowers, pistillate flowers with free petals, and seed coat surface with irregular isodiametric cells without any kind of appendages (Andrino & al. 2023a).

As the biological prospecting studies of Serra do Padre Ângelo advance, new records and taxa are being identified, including in *Eriocaulaceae* a new species described for the region, *Paepalanthus oreodoxus* Andrino & Gonella (Andrino & Gonella 2021). This species presents a remarkable disjunction pattern between Serra do Padre Ângelo and the core area of campos rupestres, the Espinhaço range. Other unidentified plants of *Eriocaulaceae* were collected subsequently, including a small species with very distinctive morphology that was, at first, thought to belong to a new, undescribed species of *Giuliettia*. In thoroughly reviewing the names and types in *Giuliettia*, and because the genus was segregated from species previously contained in *Paepalanthus* (Andrino & al. 2023a), we decided to thoroughly examine the species in *Paepalanthus* as well. However, despite this recent taxonomic change, the newly examined specimens of *Giuliettia* showed morphological similarities to the enigmatic *P. minimus* Silveira, a small species that was known only from the type specimen and collected more than one hundred years ago and more than 200 km from the new collections. Here, we present a report on the rediscovery of *P. minimus* and its subsequent transfer to the genus *Giuliettia*, which is supported by observations of its growth habit, reproductive characteristics and seed morphology, as well as the updated classification system. Furthermore, we discuss the implications of this rediscovery for the taxonomy, biogeography and conservation of this diminutive species. The rediscovery of this taxon enriches the flora of this small but peculiar Serra, which still lacks any kind of protected area status.

## Material and methods

Fieldwork to Serra do Padre Ângelo has been carried out since 2013. Specimens were collected, herborized and deposited in the herbaria MBML and UB (acronyms according to Thiers 2023+). The morphological data were obtained from the study of herbarium specimens and in situ observations. The description and illustrations of the taxon followed the usual botanical terminology (Stearn

1973; Radford 1986) and Rosa & Scatena (2007) for flower morphology.

The maps were prepared using the QGIS software (QGIS Software Team 2023) using layers obtained from IBGE (2023), ICMBio (2023) and Sisema (2023) plus data on land use and fire history from the MapBiomas Project (2023). The preliminary conservation status was assessed following the IUCN Red List categories and criteria (IUCN 2012), and the calculations of area of occupancy (AOO) and extent of occurrence (EOO) were obtained with the GeoCAT tool (Bachman & al. 2011) using the standard parameters.

For the scanning electron microscopy (SEM) analysis, seeds were taken from herbarium specimens (*A. Silveira* 697 and *P. M. Gonella* & al. 3588), embedded in water to remove parts of the fruit, dried and mounted on stubs and gold-coated in a Leica SCD 500 sputter coater. Specimens were viewed and photographed with a scanning electron microscope JEOL-JSM-7001F.

## Results

### Taxonomic treatment

*Giuliettia minima* (Silveira) Andrino, L. H. Rocha & Gonella, **comb. nov.**  $\equiv$  *Paepalanthus minimus* Silveira, Floral. Mont. 1: 107, t. 66. 1928. – Holotype: Brazil, Minas Gerais, in campis et sub rupibus prope Barauna [in fields and under rocks near Barauna – former name of the current Barão de Guaicuí, district of the municipality of Gouveia], Apr 1918, *A. Silveira* 697 (R [barcode R000181868]!; isotype: UB!). – Fig. 1–6.

**Description** — *Herbs* annual, rupicolous, 1–12.5 cm tall. *Roots* capillary. *Stem* unbranched, restricted to rosette or etiolated, elongated, decumbent, thin, 0.1–8.8 mm long. *Leaves* rosulate or spiralled, green, linear-lanceolate, flat, 0.5–3  $\times$  0.1–0.3 cm, membranous, pilose with short trichomes on both surfaces c. 1 mm long, central nerve visible up to  $\frac{2}{3}$  of length, margin ciliate, apex acute. *Spathes* 0.1–0.6 mm long, abaxial surface pilose, base with a tuft of long trichomes, margin ciliate, aperture oblique, apex acuminate. *Scapes* free, fasciculate, 1–35 per plant, green, 0.6–4.5 cm long, pilose with trichomes 0.2–0.5 mm long. *Capitula* cream-coloured, 2–6 mm in diam.; *involucral bracts* in 2 series; bracts of external series green, linear-lanceolate to narrowly ovate, 1.2–3  $\times$  0.2–0.8 mm, surpassing length of flowers by 0.7–2 mm, pilose along central nerve abaxially, margin ciliate, apex acute to obtuse; bracts of internal series ovate, 1–1.2  $\times$  0.7–1.4 mm, hyaline, surfaces glabrous, margin ciliate, apex obtuse to rounded. *Floral bracts* narrowly ovate, c. 1 mm long, hyaline, surfaces glabrous, margin ciliate, apex obtuse. *Flowers* 3-merous, diclinous, with pistillate flowers in periphery of capitula and staminate flowers in centre. *Staminate flowers* c. 1.5 mm long; pedicel

c. 0.5 mm long, with trichomes c. 2 mm long; sepals 3, free, narrowly oblong, c. 0.5 mm long, hyaline, surfaces glabrous, margin ciliate, apex obtuse; androphore plus petals c. 1 mm long; petals 3, fused except free at apex, c. 0.3 mm long, hyaline, glabrous, margin entire; anthers dorsifixed; pistillodes filiform. *Pistillate flowers* 1.5–2 mm long; pedicel c. 0.5 mm long, pilose, trichomes equalling those of staminate flowers; sepals 3, oblong-ob lanceolate, c. 1 mm long, hyaline, enlarging and becoming hygroscopic in fruit, margin ciliate; petals 3, free, narrowly obovate, c. 0.5 mm long, hyaline, glabrous, apex fimbriate; staminodes absent; gynoecium with nectariferous and stigmatic branches inserted in column at same height; stigmatic branches 3, bifid, c. 0.8 mm long; nectariferous branches 3, c.  $\frac{1}{2}$  as long as stigmatic branches, papillose; ovary c. 0.5 mm long. *Fruit* a loculicidal capsule, dispersed as an entire unit by calyx (autochorous). *Seeds* reddish brown, ovoid, 390–500  $\times$  230–290  $\mu$ m; seed coat formed by irregular isodiametric cells, without appendages.

**Phenology** — Collected with flowers and fruits in February, March, April, May and June; not observed during the dry season, when only dried and dead plants of the previous rainy season could be found (usually from July to October).

**Distribution, habitat and ecology** — The exact location where Álvaro da Silveira collected the specimens he used to describe *Paepalanthus minimus* is unknown, because the specimen label states it was collected around Barauna, a district now named Barão de Guaicuí, in the municipality of Gouveia (located at around 1200 m a.s.l.), but the protologue (Silveira 1928) indicates it was collected in the Pico do Itambé, at around 2000 m a.s.l. (Fig. 1). Both the specimen label and the protologue indicate that the species was found under rocks in a shaded place. Both areas are located in quartzitic campo rupestre, in the Diamantina plateau, part of the Espinhaço range in central Minas Gerais (Fig. 1).

The new specimens were collected over 200 km to the southeast of the possible type locality (Fig. 1), in quartzitic campo rupestre areas of Serra do Padre Ângelo, municipality of Conselheiro Pena, Minas Gerais. In this Serra, the species was found in two localities c. 3 km distant from each other, in the Pico da Bela Adormecida (also known as Pico do Padre Ângelo; Fig. 4A) and in the contiguous Serra da Palha Branca (locally known as Mirante da Bela; Fig. 4B) to the southeast (Fig. 1C, 5). At both places, *Giuliettia minima* grows on north-facing, vertical rock walls with seasonal seepages. The species is found mainly in rock crevices protected from direct sunlight (Fig. 3A–C), agreeing with the type specimen label, which indicates that the species was found under rocks. Only a few individuals were also observed on more exposed seepages, also facing north (Fig. 3D). The species is found at elevations from 1080 to 1400 m.



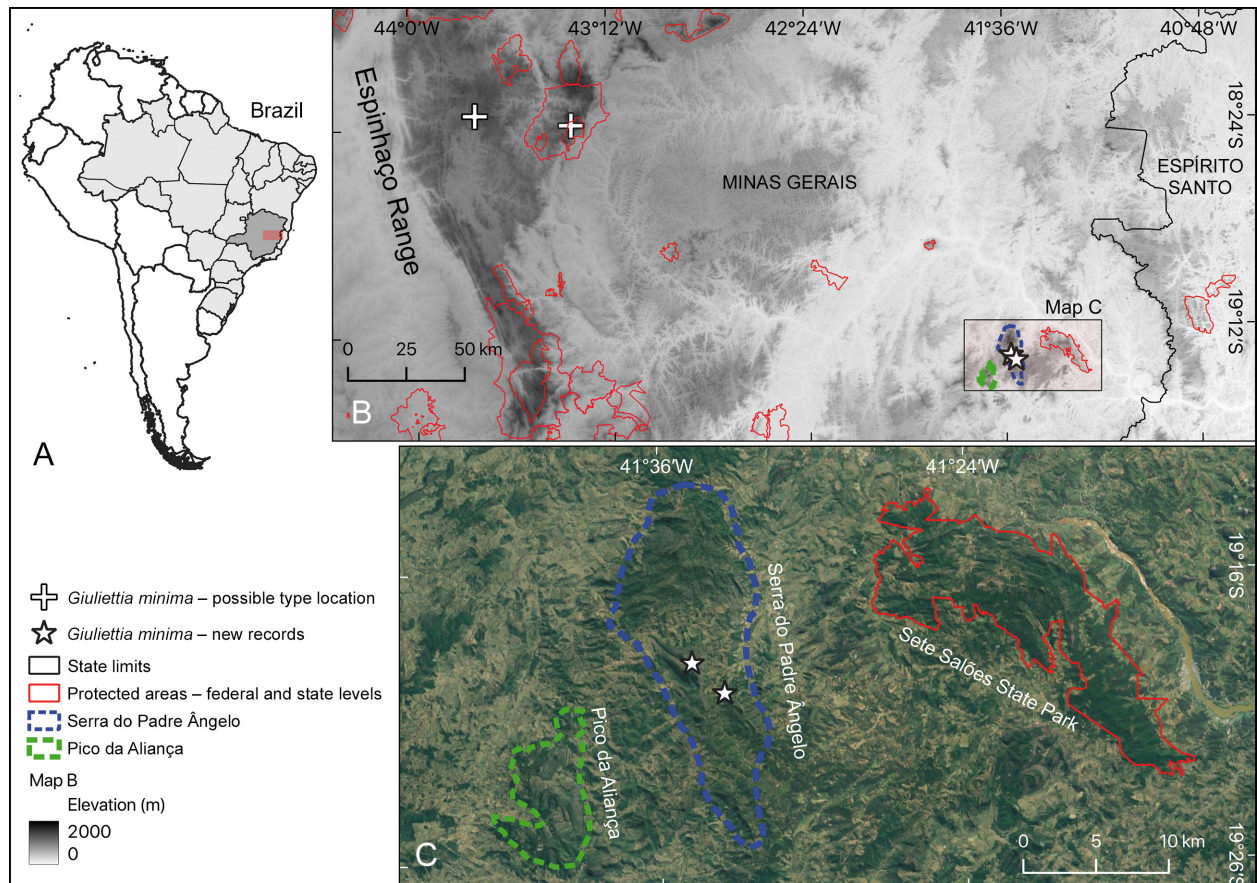


Fig. 1. Distribution map of *Giulietta minima*. – A: reference map of South America highlighting Brazil and Minas Gerais; B: approximate occurrence of type collection of *G. minima* and new records reported here; C: main regions of João Pinto formation.

Like other species of *Giulietta*, *G. minima* is an annual species (therophyte), which means it has a generation time of a few months, with seeds germinating in the early rainy season and individuals dying by the early dry season after setting seeds for the next generation (Andrino & al. 2023a). A second, even shorter-lived generation may also occur, as implied by the small flowering specimens attached to the capitula of larger individuals, suggesting vivipary (e.g. the specimen *P. M. Gonella* & al. 3588; Fig. 3A). The durability of the seed bank in the soil is unknown for this species, although it has been estimated to last for at least two years in other *Eriocaulaceae* species (Garcia & al. 2014).

**Preliminary conservation status** — Critically Endangered: CR B1ab(iii)+B2ab(iii). *Giulietta minima* was first collected in 1918, either near Barão de Guaçu (district of Gouveia) or in the Pico do Itambé, but was never found again in this region, even though both localities were visited by many botanists over the last century, including the authors of this paper and several *Eriocaulaceae* specialists. Although the lack of new specimens from this region could be due to the diminutive size and specific habitat of the plants, which could have hindered their being refound, it is also possible that the species could have gone locally extinct as a result of habitat alterations

in the past century. Because of the lack of precise information on the collection site of the type specimen, it is not possible to assess the current situation of the habitat where it was first collected, nor include it in the calculations of AOO and EOO. Pico do Itambé is located in a state-level protected area, the Pico do Itambé State Park.

The situation of the known population is alarming, however, with continuing threats and an observed decline in habitat quality (Fig. 4, 5). The region of Serra do Padre Ângelo was once surrounded by a matrix of semideciduous seasonal forest, now largely degraded and converted into pastures or agricultural land (Fig. 4G, 5B; MapBiomass Project 2023). The removal of the forest buffer around the campos rupestres areas in addition to the common use of fire for pasture renovation has favoured the invasion by alien species, especially molasses grass, *Melinis minutiflora* P. Beauv. (*Poaceae*; Fig. 4E), and bracken fern, *Pteridium aquilinum* (L.) Kuhn (*Dennstaedtiaceae*; Fig. 4F), representing a severe threat to the quality of the habitat, especially for the micro-endemic species, which have very specific and restricted habitats (Gonella & al. 2015; Andrino & Gonella 2021; Couto & al. 2023). At both sites where the species was found at Serra do Padre Ângelo (AOO of 8 km<sup>2</sup>; EOO polygon cannot be calculated given the reduced number of sites), the habitat is altered by human activities (e.g. fire, defor-

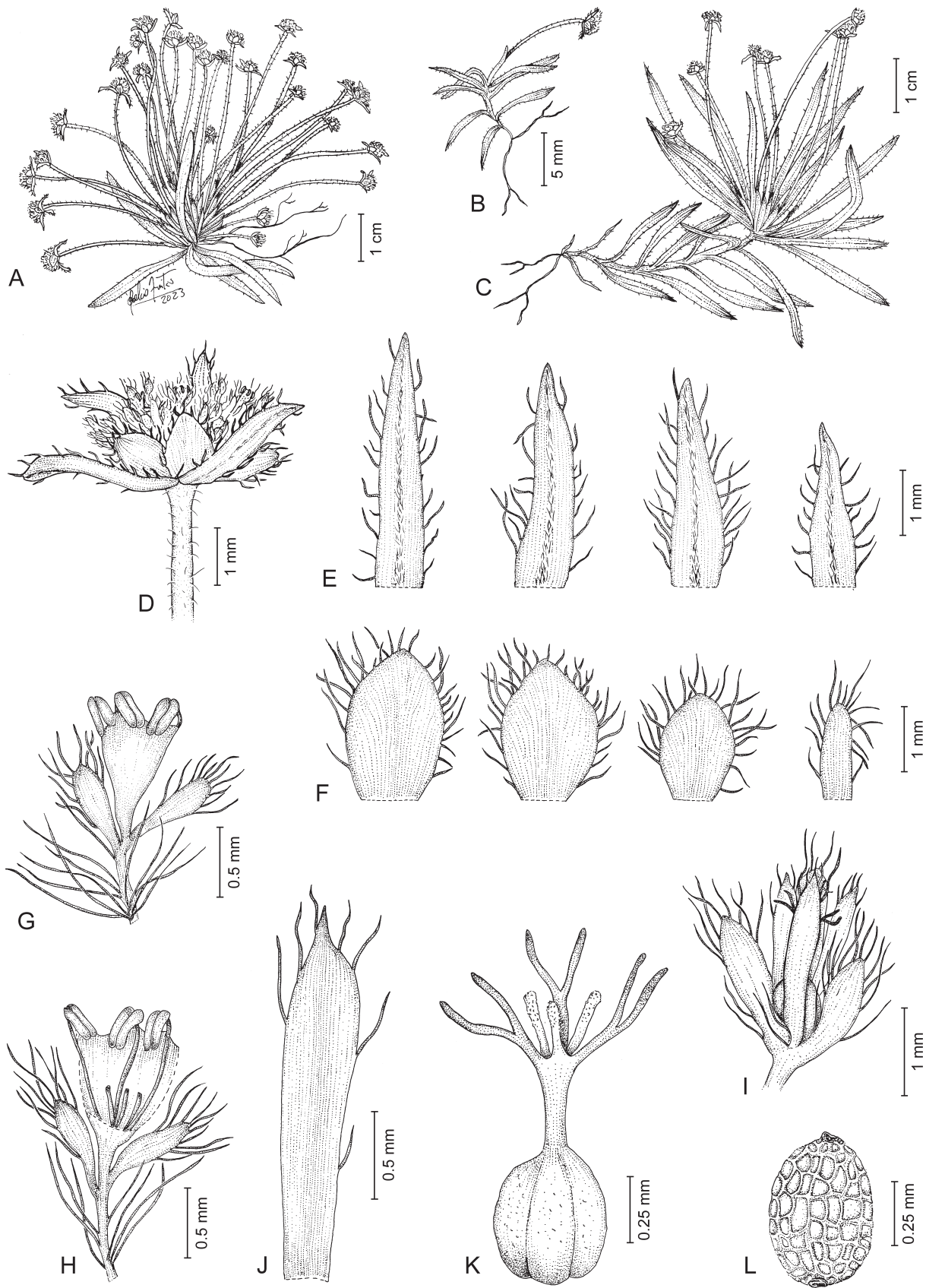


Fig. 2. *Giuliettia minima*. – A–C: habit showing variation in size, stem and number of scapes per plant; D: capitulum, side view; E: involucral bracts of external series; F: involucral bracts of internal series; G: staminate flower, one sepal removed for observation; H: staminate flower with corolla sectioned for observation of pistillodes and stamens; I: pistillate flower; J: petal of pistillate flower; K: gynoecium; L: seed. – Based on *P. M. Gonella 3474*. – Drawn by Joelcio Freitas.





Fig. 3. *Giuliettia minima*. – A: habitat on shaded rock crevices, with some capitula presenting apparent vivipary; B: habitat under rocks in shade with mosses; C: close-up of plants in habitat; D: plants in a humid rock crevice with organic matter in more exposed site; E: collected specimen, *P. M. Gonella* 3474; F, G: capitula; F: posterior view, showing involucre bracts; G: front view. – Photographs: A: Serra da Palha Branca, March 2023, by Júlio César Ribeiro; B, C: Serra da Palha Branca, June 2020, by Gabriele A. da Silva; D–G: Pico da Bela Adormecida, May 2022, by Paulo Minatel Gonella.

estation; Fig. 4) and severely invaded by the aforementioned invasive species. Furthermore, both areas are still subject to constant, uncontrolled wildfires originating from farming activities (Fig. 5C), such as the one that affected the Bela Adormecida population in late 2020 (Fig.

4D, 5D). The population of Serra da Palha Branca already shows signs of decline due to the history of fire and the presence of invasive species, because it is extremely localized even though the area presents several similar habitats that are not occupied by the species. Given the



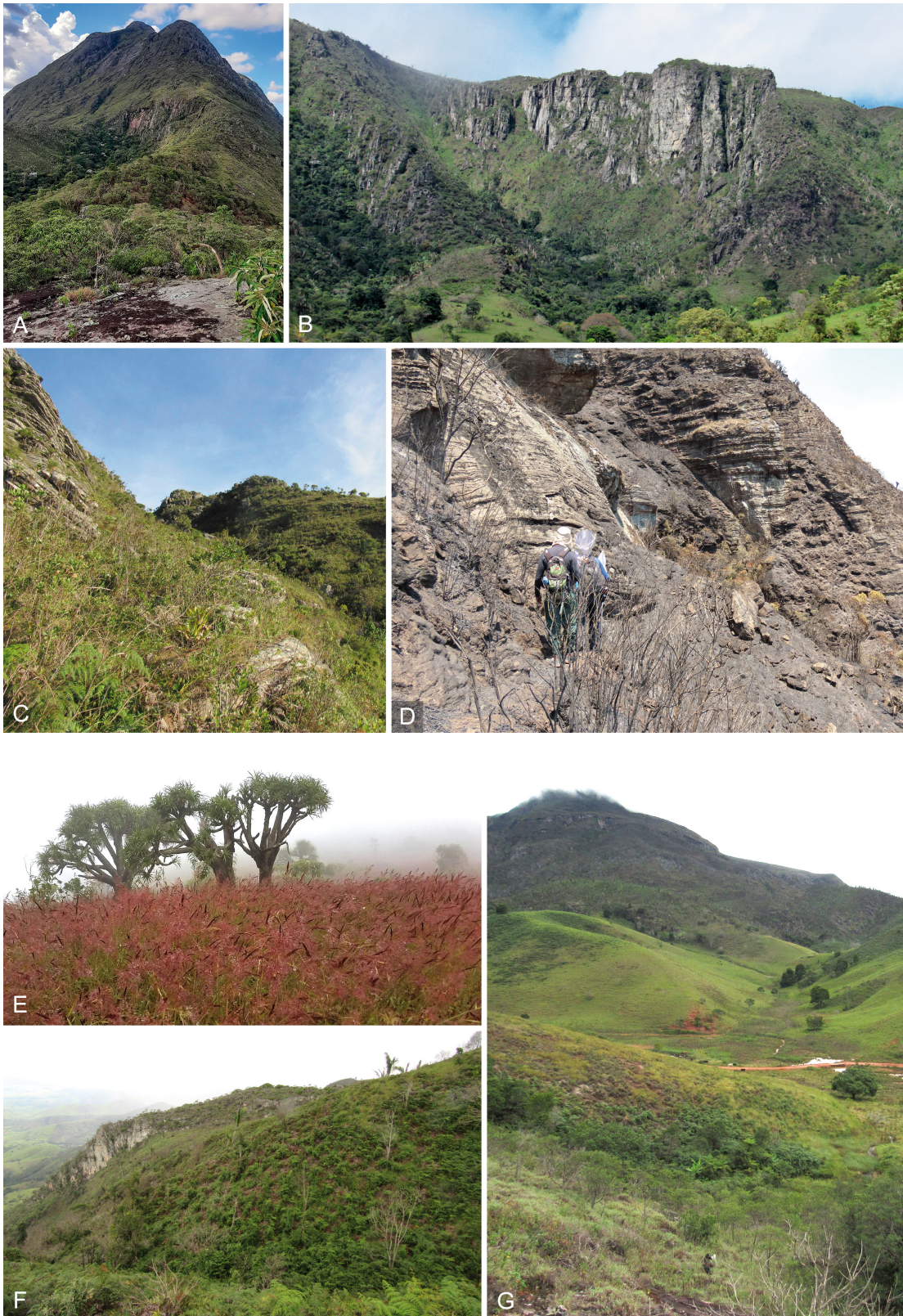


Fig. 4. Habitat of *Giulietta minima* and conservation threats. – A: Pico da Bela Adormecida, one of the highest peaks of Serra do Padre Ângelo and habitat of *G. minima*, May 2022; B: Serra da Palha Branca, part of Serra do Padre Ângelo, August 2022; C: habitat of Pico da Bela Adormecida population in June 2020, before the fire; D: same area as C in October 2020, immediately after the fire; E: invasion of molasses grass, *Melinis minutiflora*, in Pico da Bela Adormecida, with individuals of *Vellozia gigantea* in background, July 2017; F: area of Serra da Palha Branca invaded by bracken fern, *Pteridium aquilinum*, February 2021; G: pastures and degraded areas surrounding Pico da Bela Adormecida, April 2023. – All photographs by Paulo Minatel Gonella.



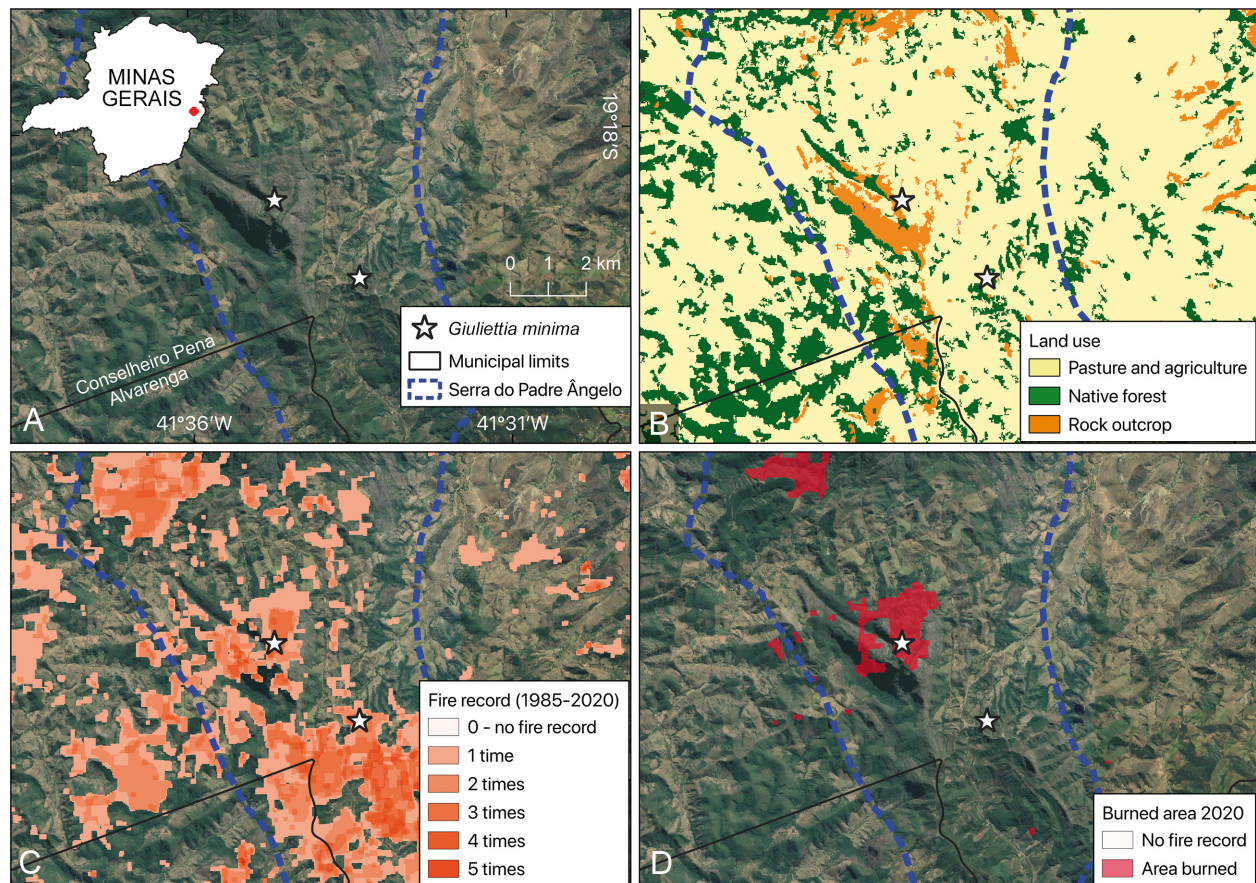


Fig. 5. Distribution of *Giulietta minima* at Serra do Padre Ângelo and conservation threats. – A: occurrence map of *G. minima* at Serra do Padre Ângelo; B: land use of region; C: fire record in region between 1985 and 2020; D: fire record in region in 2020, when a wildfire affected Pico da Bela Adormecida. – Data on land use and fire from MapBiomass Project (2023).

annual growing cycle (which means yearly fluctuation of the number of individuals), the complex topography of the habitat, the likely existence of a seed bank and the capacity of the species to flower at a small size, estimation of population size is very difficult. Considering the fragile habitat and the annual life cycle of the species, its generation time is very short in a way that a stochastic event, such as an intense fire or an extreme climatic event like a drought, could cause local extinction or a dramatic reduction of population size within a year.

Considering the reduced known population, restricted occurrence, a narrow habitat preference that is susceptible to several threats to its quality and the fact that none of its known subpopulations are within a protected area, we recommend that *Giulietta minima* should be categorized as Critically Endangered based on the aforementioned IUCN (2012) criteria.

**Proposed vernacular name** — “sempre-viva-mínima” (Portuguese). Following the suggestion of Marinho & Scatigna (2022), we propose a vernacular name for this species as a way to promote knowledge about it to the local communities and to address the urgency of promoting conservation actions to protect the species and its habitat. The proposed name considers the common name

of many *Eriocaulaceae* species in Brazil (“sempre-viva” – Portuguese for “everlasting”) plus the specific epithet, which is easily relatable in Portuguese, meaning “minimal” or “very small”.

**Taxonomic remarks** — The morphologically most similar species to *Giulietta minima* is *G. bifida* (Schr.) Andrino & Sano, both species sharing the small, delicate habit and green involucre bracts surpassing the height of the flowers in the capitula. However, *G. bifida* presents a cylindric, erect, stiff, often brownish stem (vs acaulescent, or rarely with a filiform, slender, green stem in *G. minima*; Fig. 2A–C, 3), leaves chartaceous with long trichomes and multiple parallel nerves (vs membranous, with short trichomes and a single central nerve) and the involucre bracts lanceolate to linear-lanceolate, both internal and exterior series with an acute apex, the external series green and the internal series bronze-coloured with hyaline margins (vs involucre bracts linear-lanceolate to narrowly ovate with an acute to obtuse apex in the exterior series [Fig. 2E] and ovate with an obtuse apex in the interior series [Fig. 2F], the external series green and the interior series hyaline [Fig. 3F–G]).

When describing *Paepalanthus minimus*, Silveira (1928) compared it with *P. pullus* Körn., which was kept

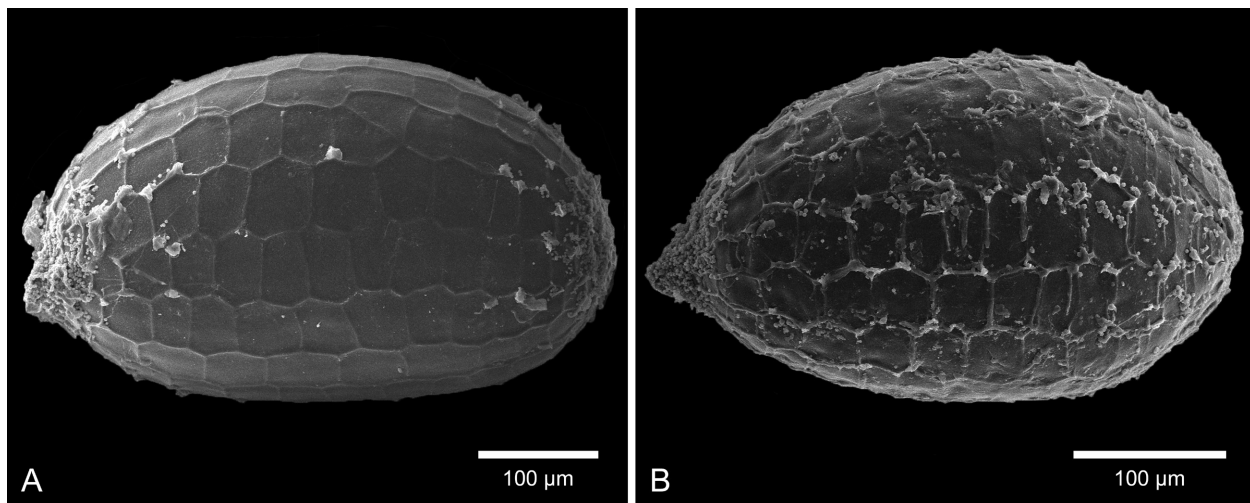


Fig. 6. Scanning electron micrographs of seeds of *Giulietta minima*. – A: from specimen *P. M. Gonella* 3588 (UB); B: from specimen *A. Silveira* 697 (UB isotype).

in the genus *Paepalanthus* in the classification of Andrino & al. (2023a). *Paepalanthus pullus* is distinct in having a dense rosette of glabrous leaves, scapes glabrous, involucre and floral bracts dark castaneous and stigmatic branches simple (Andrino & al. 2023b).

**Additional specimens examined** — BRAZIL, MINAS GERAIS: Conselheiro Pena, Serra do Padre Ângelo, Pico da Bela Adormecida, 19°19'0.07"S, 41°34'46.67"W, 1400 m, 15 Mar 2021 (fl./fr.), *P. M. Gonella* & al. 2303 (UB); *ibid.*, 23 Feb 2022 (fl.), *L. H. Rocha* & al. 46 (UB); *ibid.*, 11 May 2022 (fl./fr.), *P. M. Gonella* & al. 3474 (MBML, UB); *ibid.*, 9 Oct 2022 (fr.), *P. M. Gonella* & al. 3588 (UB); Serra da Palha Branca, 19°20'19.5"S, 41°33'26.3"W, 1080 m, 9 Jun 2020 (fl./fr.), *P. M. Gonella* & al. 1286 (UB).

## Discussion

The specimen *Silveira* 697, the type of *Giulietta minima*, is a gathering of several small plants in poor condition. Nevertheless, the comparison of these plants with the newly collected plants showed great morphological similarities, such as the acaulescent habit, thin, delicate leaves, similar spathe morphology including the presence of a tuft of trichomes at the base, similar involucre bracts and similar seed morphology (Fig. 6). Seed morphology is especially important in the delimitation of *Giulietta*. The seeds of this genus lack the appendages characteristic of *Paepalanthus* seeds (Andrino & al. 2023a). Seeds of *G. minima* show typical morphology of the genus, and a comparison of seeds of the type specimen with a new specimen show similar shape and seed coat ornamentation (Fig. 6). The plants from Serra do Padre Ângelo are usually larger than those of the type specimen, but the smallest plants were also recorded at the new location (Fig. 2B), showing the phenotypic variation range of the

species. The plants from Serra do Padre Ângelo also show the presence of long, green bracts in the external series (Fig. 3F–G), which is not observed in the type specimen of *G. minima*. However, this characteristic is also not observed in all specimens from the rediscovery site and may be considered part of the phenotypic variation of the species. Despite the great distance between the type locality and the new specimens reported here, the extensive morphological similarities corroborate the assignment of these new specimens to *G. minima*. Rediscovery of taxa far from the type locality is not uncommon in Brazil and especially in the megadiverse state of Minas Gerais (e.g. Menezes & al. 2022). These rediscoveries are usually associated with taxa with very specific habitats. However, they can also be influenced by collection bias, because areas near larger cities, research institutes, universities and especially roads are more frequently sampled than remote locations (Oliveira & al. 2016) such as Serra do Padre Ângelo (Gonella & al. 2021).

The delimitation of genera within subfamily *Paepalanthoidae* has been challenging over the past decades due to the recognition of a non-monophyletic *Paepalanthus*. Historically, tiny *Eriocaulaceae* species with delicate habit used to be grouped in the genus *Blastocaulon* Ruhland (now synonymous with *Paepalanthus*) and in *P. ser. Leptocephali* Ruhland (Ruhland 1903). Recent molecular phylogenetic studies, however, found that none of the two taxa were monophyletic and the features used to define these groups were homoplasies (Giulietti & al. 2012; Andrino & al. 2021). Notwithstanding, these same studies have shown that some species within those taxa were phylogenetically close and formed clades defined by other morphological characteristics. Species with slender and delicate habit with unbranched stems, leaves spiralled along the stem, trimerous flowers, seed coat without appendages (Fig. 6) and inhabiting open rocky or white sand areas formed a highly supported group (Andrino & al. 2021), which was recently recognized as the



genus *Giuliettia*, comprising 30 species and one variety (Andrino & al. 2023a). *Giuliettia minima* is the 31<sup>st</sup> species of the genus and the first to be reported to the campos rupestres of the João Pinto formation. The putative closest species, *G. bifida*, presents a broad distribution from the Pantepui region in the Guiana Shield, including Venezuela, Colombia, Brazil and Suriname, extending farther south in Brazil, where it also occurs in the campinas and campinaranas (white sand ecosystems) of Pará, in the Cerrado (Brazilian savanna) in Tocantins and in the campos rupestres of the Espinhaço range in Minas Gerais and Bahia (Andrino & al. 2023b). Such a distribution represents an intriguing connection between the Brazilian Shield, which includes the campos rupestres of eastern Brazil, with the Guiana Shield and the Pantepui. The morphological similarity between *G. minima* and *G. bifida* supports our hypothesis of phylogenetic proximity between them and strengthens another hypothesis, that of the recent colonization of Serra do Padre Ângelo by *Eriocaulaceae* species (Andrino & Gonella 2021). The early-branching lineages of *Giuliettia* occur in the Caribbean islands, more specifically in eastern Cuba, followed by a lineage endemic to the Pantepui and later lineages that diversified in the white sand ecosystems of Amazonia and central and eastern Brazil, including the campos rupestres and coastal ecosystems (restingas; Andrino & al. 2021; Vasconcelos & al. 2020). Generally, such a pattern is observed in other endemic-rich lineages of the campos rupestres of eastern Brazil (Fiaschi & Pirani 2009; Riina & al. 2019; Barbosa-Silva 2020).

The disjunction pattern between the Espinhaço range and the João Pinto formation observed in *Giuliettia minima* is also reported in other campos rupestres lineages, including in *Eriocaulaceae* (Andrino & Gonella 2021). In that case, a new species belonging to a lineage endemic to the Espinhaço range was found in the João Pinto formation, similar to that reported for new species of *Asteraceae*, *Begoniaceae*, *Droseraceae* and *Lamiaceae* (Gonella & al. 2015; Siniscalchi & al. 2016; Loeuille & al. 2019; Antar & al. 2021a; Kollmann & Gonella 2021). Cases of the same species being found in the two mountain complexes have also been reported in the literature, for *Velloziaceae* (Mello-Silva 2018), but also for a species of bird (Lopes & al. 2016), and many other cases were found during the studies for the floristic inventory of Serra do Padre Ângelo (in prep.). This biogeographic pattern can be explained by past temperature fluctuations that allowed the migration of mountaintop campos rupestres species toward the east when lowland forests of the Atlantic forest domain were replaced by open vegetation of the Cerrado domain during drier and cooler periods, followed by the isolation of such species on higher elevations during wetter and warmer periods (Behling 2002), resulting in the disjunction currently observed and even eventual speciation in some lineages (Siniscalchi & al. 2016; Andrino & Gonella 2021). Future phylogeographic studies could aid in understanding

this pattern and in answering when and how many times the campos rupestres species colonized the João Pinto formation.

The rediscovery of *Giuliettia minima* in Serra do Padre Ângelo adds to the increasing list of new species and new records for these mountains. Despite such a relevant number of endemic and threatened taxa found in the region in the past decade, the campos rupestres of the region are poorly served by protected areas, and only those within the Sete Salões State Park are formally protected (Fig. 1C). Even so, this park still lacks the infrastructure and personnel for effective conservation action (IEF 2021). These mountaintop campos rupestres harbour some of the very few areas of native vegetation that have not been converted into pastureland or plantations in the east of Minas Gerais, also safekeeping forest remnants and their species increasingly threatened by fire, deforestation and fragmentation, such as *Araucaria angustifolia* (Bertol.) Kuntze (*Araucariaceae*; Moura 1975). This tiny rediscovery reinforces the urgency of a broad discussion with the community, local government, environmental agencies and scientific academy for a conservation strategy for this region to protect its endemic species as well as vital natural resources.

## Author contributions

COA and PMG designed the study. COA wrote the first draft of the manuscript. LHR and PMG conducted field observations and collections. PMG prepared the map and performed the conservation status assessment. COA, LHR and PMG revised and edited the manuscript.

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