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Original article

Pitcairnia mineira (Bromeliaceae): A new rheophytic species from the Espinhaço Range, Brazil

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ABSTRACT

Pitcairnia is a species-rich genus with about 400 species distributed mainly in the Neotropics. We propose and diagnose a new rheophytic species of *Pitcairnia*, *P. mineira*, found in *campos rupestres* vegetation in the Southern Espinhaço Province (Minas Gerais State). We provide a description, including anatomical characters, illustration, distribution map, photographs, preliminary conservation assessment and comments on the distribution, habitat, phenology, and taxonomy of the new species. We also include an identification key to all species of *Pitcairnia* in the Espinhaço Range, Minas Gerais, Brazil.

Keywords: *campos rupestres*, Pitcairnioideae, Brazilian flora, endemism, leaf anatomy

Introduction

Pitcairnia is one of the largest genera of Bromeliaceae and comprises *ca.* 400 species (Gouda *et al.* cont. upd.). It occurs in Mexico, Central America, the Antilles, and South America, with higher species richness in the Andean region; and there is one disjunct species in West Africa (Smith & Downs 1974; Benzing 2000). The genus comprises terrestrial and rupicolous herbs, which presents leaves with sheaths that never form a tank, and linear-lanceolate blades; spike, raceme, or panicle-type inflorescences; commonly zygomorphic flowers, with long, showy, and varied colors corolla; capsule fruits; and bicaudate or winged seeds, rarely naked (Smith & Downs 1974; Saraiva 2013). *Pitcairnia* is recovered as monophyletic with molecular and morphological data (Givnish *et al.* 2014; Saraiva *et al.* 2015). The morphological phylogeny indicated seven synapomorphies for the genus: presence of fibers in the phloem; stomata at the same level as epidermal cells; rounded adaxial water-storage parenchyma cells; patent pedicel in anthesis; flower patent in post-anthesis; narrow-elliptical petals; and petals with apex erect to slightly falcate in anthesis (Saraiva *et al.* 2015).

Currently, there are 54 known species of *Pitcairnia* in Brazil, of which 40 are endemic (Saraiva & Forzza 2020). These species often have well-defined distribution patterns within specific phytogeographic domains, mainly the Atlantic Forest (23 spp.), Cerrado (13 spp.) and Amazon (23 spp.),

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where they generally occur in mountain areas, on rocky outcrops and close to rivers (rheophytes) (Martinelli & Forzza 2006; Saraiva & Forzza 2012; Saraiva *et al.* 2015; Saraiva & Forzza 2020). Rheophytic species are recognized by their occurrence on riverbanks and waterfalls, where they are subject from periods of rain and floods to periods of drought and high sun exposure (van Steenis 1981; 1987). Despite being a recognized feature for other families, rheophytism is a rare condition in Bromeliaceae, with only a few species of *Dyckia*, *Pitcairnia* and *Guzmania* (Santos-Silva 2015). In a phylogenetic study, Saraiva *et al.* (2015), discuss the evolution of this strategy in *Pitcairnia*, using it to delimit some species within the genus. Furthermore, among the species of the genus, 20 % can present themselves as rheophytes throughout the Brazilian territory, being found in the Amazon (7 spp.), Atlantic Forest (4 spp.) and Cerrado (3 spp.) (Saraiva 2013).

Campos rupestres is a vegetation type found on ancient mountain tops above 900 m elevation in two disjunct areas in Brazil, the Espinhaço Range and Chapada dos Veadeiros (Colli-Silva *et al.* 2019). These areas include a rich flora of angiosperms (mainly monocots) and a high degree of endemism for several botanical families (Pirani & Giulietti 1988; Giulietti & Pirani 1997; Versieux *et al.* 2008; Alves *et al.* 2014). Recently, *campos rupestres* in the Espinhaço Range were recognized as unique and distinct bioregions from the domains in which they occur and were designated as two new provinces: Chapada Diamantina Province (Bahia State) and Southern Espinhaço Province (Minas Gerais State) (Colli-Silva *et al.* 2019). Bromeliaceae are well represented in *campos rupestres* in the Espinhaço Range. The Southern Espinhaço Province is an important area of endemism for the family, especially subfamilies Tillandsioideae and Pitcairnioideae (Versieux *et al.* 2008; Colli-Silva *et al.* 2019).

In this paper, we describe a new rheophytic species of *Pitcairnia* from the Espinhaço Range in Minas Gerais State. A description, illustration, distribution map, photographs, preliminary conservation assessment and comments on the distribution, habitat, phenology, and taxonomy of the new species are provided. We also include an updated identification key to all species of *Pitcairnia* in the Espinhaço Range.

Materials and Methods

The specimens were examined under a stereo dissecting microscope and the morphological descriptions are based on live and dry material. Vegetative structures, inflorescence and fruit measurements are based on herbarium specimens, which were prepared from fruiting plants collected in the field; while flower measurements are based on live material, which were collected in field in 2007 but kept under cultivation in Rio de Janeiro Botanical Garden until blooming in 2013. Comparisons and the identification key are based on the analysis of herbarium specimens from RB (Thiers 2016, cont. upd.), using additional information from the literature (*i.e.*, Smith & Downs 1974; Saraiva 2013; Saraiva *et al.* 2015). To analyze anatomical characters, leaf samples were previously fixed in 70 % alcohol. Freehand cross sections were made in the middle region of intermediate, healthy leaf blades (Pita 1997). The sections were stained with 1 % Astra Blue and 1 % Safranin (Bukatsch 1972) and mounted between a slide and coverslip with 50 % glycerin. The slides were analyzed with an Olympus BX 50 optical microscope and photographed using an attached digital camera. The morphological terminology follows Smith & Downs (1974), Radford *et al.* (1974) and Saraiva *et al.* (2015), and anatomical terminology follows Tomlinson (1969) and Saraiva *et al.* (2015). The distribution map was prepared using QGIS 3.12.2 (2020). The preliminary conservation assessment is based on IUCN criteria (IUCN 2012).

Results and discussion

Taxonomic treatment

Pitcairnia mineira B.M.Carvalho & Forzza, *sp. nov.* Type: BRAZIL. Minas Gerais: Botumirim, estrada para o Rio do Peixe, em frente à fazenda Botafogo (4 km do início da estrada), 16°53'12" S, 42°59'30" W, 785 m, 18/XI/2007, (fl., fr.), *R.C. Forzza 4892, R. Mello-Silva, R.F. Monteiro & M.M. Saavedra* (holotype: RB (RB00515365); isotypes: K, SPF, US). (Figs. 1, 2, 3).

Pitcairnia mineira is most similar to *P. bradei* Markgr., but differs by the following: thin peduncle, 0.3-0.5 cm in diam. (*vs.* 1-2 cm in diam.); lepidote peduncle, floral bracts and sepals (*vs.* glabrescent peduncle, floral bracts and sepals); erect to erect-patent flowers post-anthesis (*vs.* patent flowers post-anthesis); red calyx and corolla (*vs.* yellow-orange calyx and greenish-yellow corolla); narrow-elliptical petals with obtuse to rounded apex (*vs.* oblanceolate petals with acute apex); and ovary more than 1/2 inferior (*vs.* ovary more than 1/2 superior).

Plant rupicolous, rheophytic, propagating by short, slender, underground rhizomes; 60-80 cm tall when flowering. Leaves rosulate, monomorphic, not narrow at base; sheaths triangular, 1.2-3 × 2-3.5 cm, brownish, glabrous, entire; blades long linear-lanceolate, persistent, suberect-arched, 15-56 × 0.8-1.2 cm, nerved, midrib absent, light green, densely white lepidote abaxially, glabrescent adaxially, apex acute, coriaceous, canaliculate, entire. Peduncle thin, 0.3-0.5 cm diam., terete, 31-46 cm long, partially covered by bracts, dark red, densely woolly white lepidote proximally, becoming sparsely so distally; internodes with 6-3 cm long. Peduncle bracts thin, coriaceous, the basal ones narrowly triangular, exceeding the internodes, 4-15 × 0.6-1 cm, the upper ones narrowly triangular-lanceolate, acute, erect, shorter than the internodes,

Figure 1. *Pitcairnia mineira* B.M.Carvalho & Forzza. **A.** Habit**. B.** Leaf. **C.** Sheath. **D.** Infructescence. **E.** Floral bract. **F.** Flower. **G.** Immature fruit. **H.** Sepal. **I.** Petal. **J.** Fruit with floral bract. **K-L.** Seeds. Drawn by Maria Alice de Rezende. (A-E, G, J-L based on RB00515365 and F, H, I based on RB00815370).

2-2.5 × 0.4-0.5 cm, light green, with white floccose indumentum; rachis slightly slender, 0.2-0.3 cm diam., terete, dark red, sparsely white floccose. Inflorescence simple, raceme, erect, 16-30 cm long. Floral bracts ovate-lanceolate, apex acuminate, 0.5-1.5 × 0.2-0.5 cm, thin and rough in texture, dark red, shorter than the pedicels, white lepidote, entire. Flowers 5.5-6 cm long, sub-laxly arranged, zygomorphic, erect to erect-patent at anthesis and post-anthesis; pedicels 1.5-2 cm long, slender, dark red, with sparse white floccose indumentum; sepals narrowly triangular with broad obtuse apex, *ca.* 1.5 × 0.6 cm, erect, dark red, free, ecarinate, sparsely white floccose abaxially; petals narrowly elliptical, apex rounded, 4.6-4.8 × 1 cm, bright red, free, erect with recurved apex, ecarinate, membranous, appendaged, glabrous; stamens slightly shorter than the petals, 4-4.5 cm long, free, included; filaments white, 3.4-4 cm; anthers linear, 0.5-0.6 cm long, attached near the base, the apex obtuse, yellow; stigma capitate, conduplicate-spiral, included at anthesis, slightly exceeding the petals, the stigmatic lobes dark red; ovary fusiform, *ca.* 7/12 inferior, glabrous, placentation axial; ovules numerous, winged. Fruits in septicidal capsule, 2-3 cm long, petals persistent. Seeds fusiform, 0.15-0.2 cm long, winged, lateral wing small.

Leaf anatomy: thin cuticle present on the adaxial and abaxial surfaces; abaxial surface slightly grooved, with stomata in the grooves (Fig. 2A-C); epidermis uniseriate (Fig. 2B-D); leaf hypostomatic, with subsidiary and guard cells at the same level as the epidermis; peltate scales absent on the adaxial surface and present on the abaxial surface (Fig. 2D); stalk cells three to four; mechanical hypodermis present on the adaxial surface and absent on the abaxial surface; abaxial and adaxial epidermal cells with a reduced lumen, a strongly thickened inner periclinal wall and both anticlinal wall U-shaped (Fig. 2B-D); water-storage parenchyma adjacent to the hypodermis, with more than 10 layers,

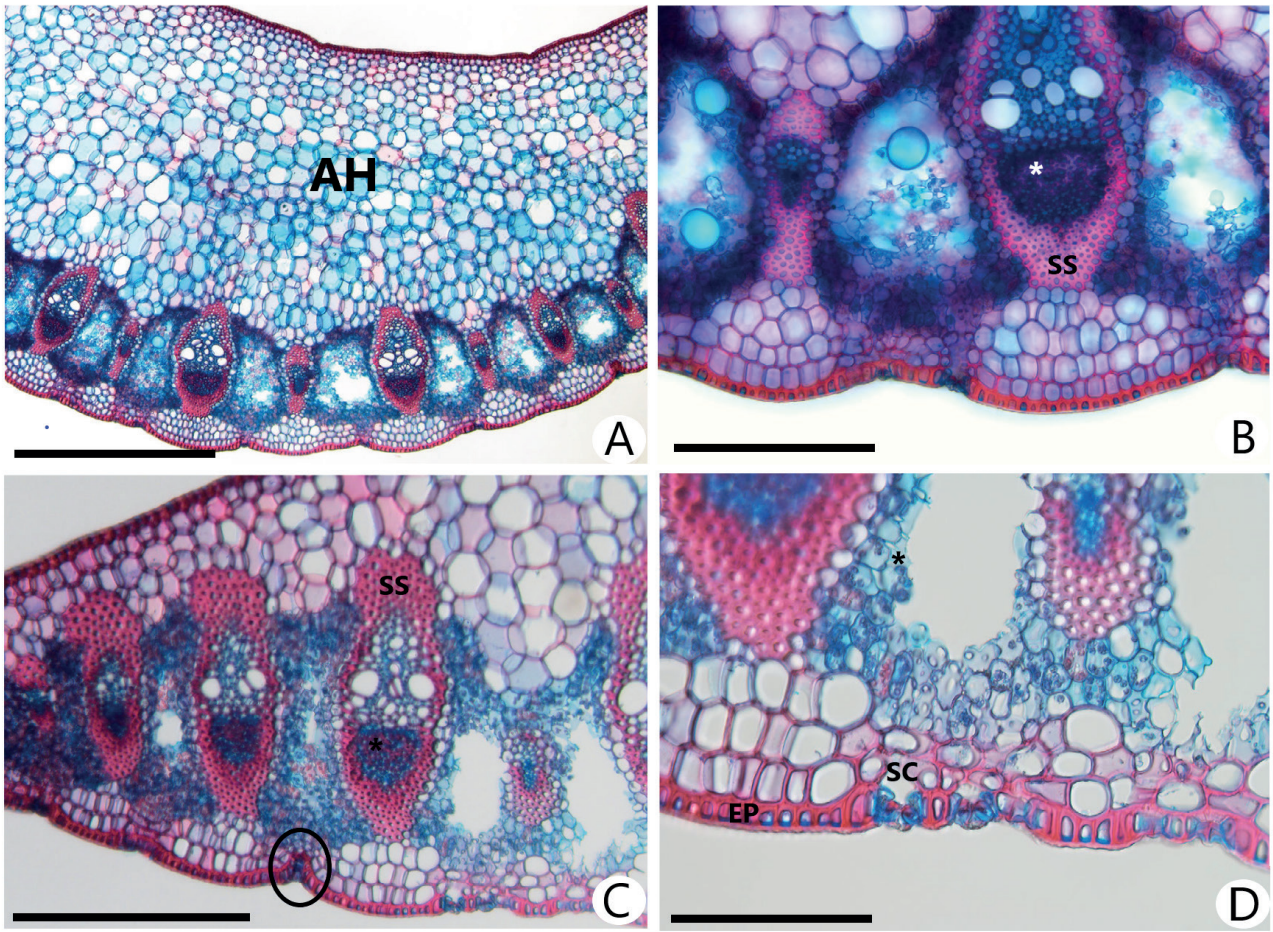

Figure 2. *Pitcairnia mineira* B.M.Carvalho & Forzza leaf in cross section. **A.** General aspect of the leaf with slightly grooved abaxial and smooth adaxial surface. **B.** Stomata in a groove; sclerenchyma fibers in direct contact with the water-storage tissue in the abaxial position; and presence of phloem fibers (asterisk). **C.** Detail of vascular bundles sheathed by sclerenchyma fibers; sclerenchyma in direct contact with the water-storage parenchyma in the adaxial position; presence of fibers in the phloem (asterisk); and peltate scale with stalk cells on the abaxial surface (circled). **D.** Uniseriate abaxial epidermis and stomata detail with substomatic chamber; brachyform intervascular chlorenchyma cells (asterisk). AH – aquiferous hypodermis (water-storage parenchyma); EP – epidermis; SC – substomatic chamber; SS – sclerenchymatic sheaths. Scale bars: A – 100 µm; B – 20 µm; C – 50 µm; D – 10 µm.

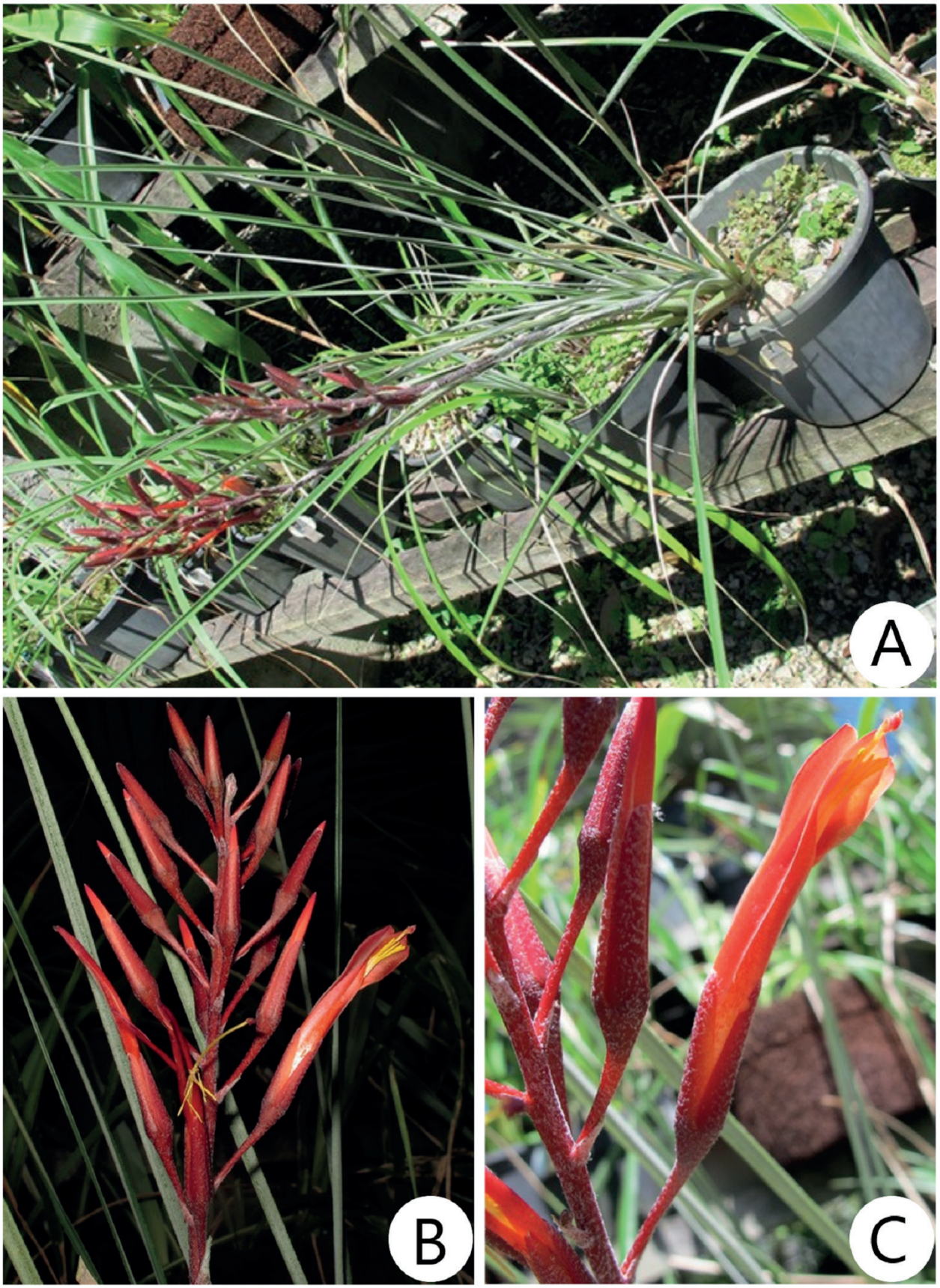

Figure 3. *Pitcairnia mineira* B.M.Carvalho & Forzza in cultivation at the Rio de Janeiro Botanical Garden **A.** Habit. **B.** Inflorescence. **C.** Flower with floral bract. Photos by Nara Vasconcellos, RBvb00575749, available at Jabot (http://jabot.jbrj.gov.br/. 14 Aug. 2021).

with rounded thin-walled cells found mostly in the adaxial surface (Fig. 2A); chlorenchyma cells anticlinally elongated (palisade), giving the appearance of an abrupt transition between the water-storage parenchyma and the chlorenchyma on both abaxial and adaxial surfaces (Fig. 2A, C); collateral vascular bundles surrounded by sclerenchyma fibers (Fig. 2B, C), arranged alternately with a very distinct air-lacunae; brachyform intervascular chlorenchyma cells, with no space between the cells (Fig. 2D); sheath of sclerified cells in direct contact with the water-storage parenchyma in the adaxial and abaxial surfaces (Fig. 2B, C); fibers present in the phloem (Fig. 2B, C).

Additional specimen examined (*paratype*). BRAZIL. MINAS GERAIS. Botumirim: estrada para o Rio do Peixe, em frente à fazenda Botafogo, 16°53'12" S, 42°59'30" W, 785 m, *R.C. Forzza et al. 4892*, flowered in cultivation X/2013 (RB00815370).

Etymology: The species was named *Pitcairnia mineira* because it was collected in the state of Minas Gerais, which is one of the main center of diversity and endemism of the Bromeliaceae, especially in the Espinhaço Range.

Habitat, distribution, and phenology: Pitcairnia mineira is only known from one locality in the Espinhaço Range, in the municipality of Botumirim, Minas Gerais State (Fig. 4). It occurs at *ca*. 785 m elevation as a rheophyte on the bank of a stream that was dry at the time of collection, in *campos rupestres* in the Cerrado domain. *Pitcairnia mineira* was found with old flowers and fruits in November 2007, and later flowered in cultivation in October 2013 (RBvb00575749).

Preliminary conservation status: *Pitcairnia mineira* is only known from the type collection, which is cultivated at the Rio de Janeiro Botanical Garden. Thus, it is not possible to infer its extent of occurrence and area of occupancy. According to IUCN (2012) criteria, the species is here classified as Data Deficient (DD), since additional fieldwork could help explain the real extent of occurrence. Like *P. bradei*, *P. mineira* occurs in a watercourse as a rheophyte and is dependent on this resource and subject to anthropogenic pressure on it (Forzza *et al.* 2013). Furthermore, *P. mineira* does not occur in a protected area.

Notes: Pitcairnia mineira and *P. bradei* are similar, since they share several morphological characters, and have overlapping geographic distributions in the Espinhaço Range (Fig. 4). For example, they have marcescent, canaliculate, strongly coriaceous leaves and seeds with a small lateral wing. Anatomically, these taxa have a grooved abaxial surface contour, with stomatal apparatuses in the grooves, and a reduced lumen in the abaxial and adaxial epidermal cells.

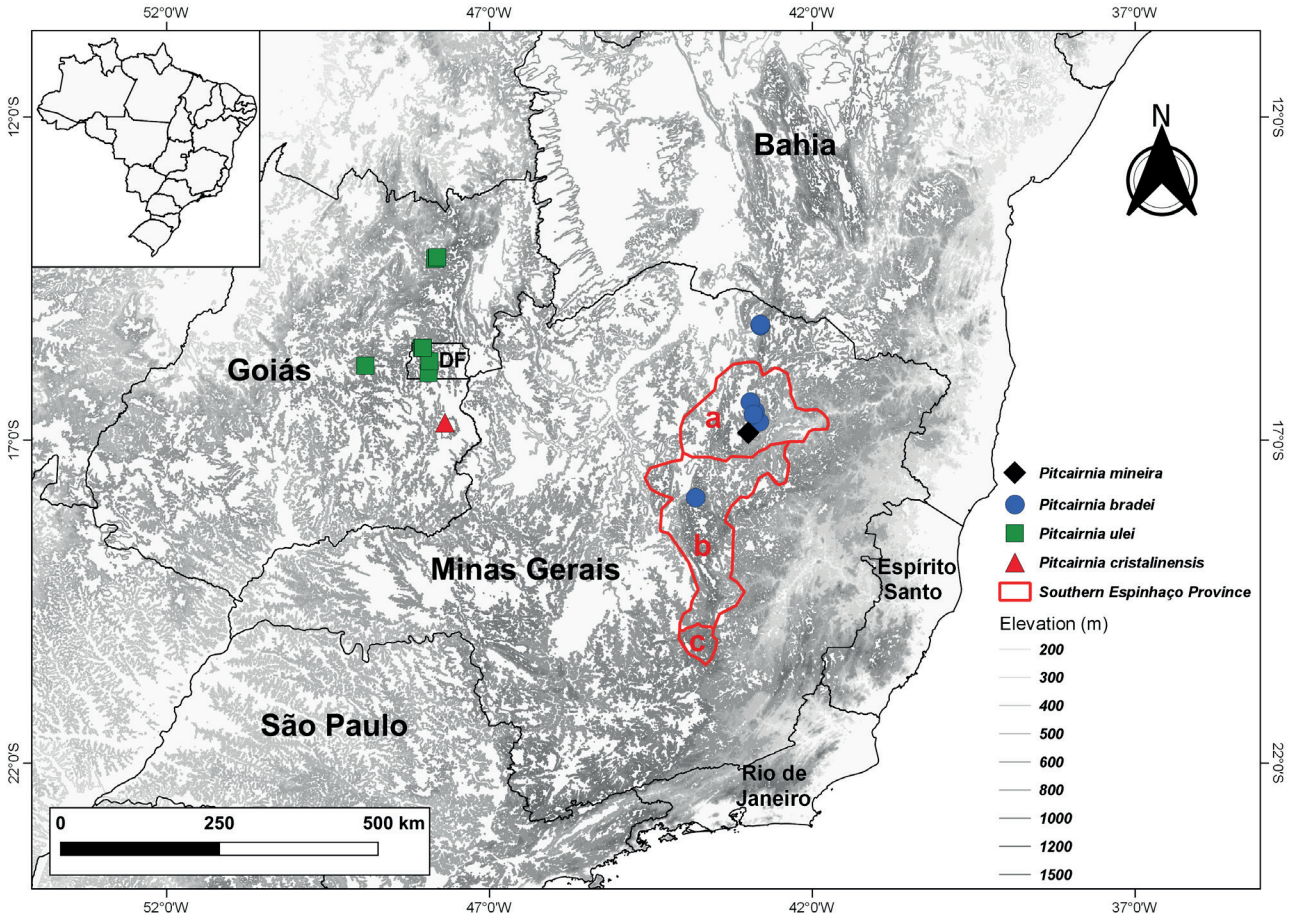

Figure 4. Distribution of *Pitcairnia mineira* B.M.Carvalho & Forzza, *P. bradei* Markgr., *P. cristalinensis* (Leme) D.C.Taylor & H.Rob. and *P. ulei* L.B.Sm. The Southern Espinhaço Province is in red and divided into the (**A**) Grão-Mogol district, (**B**) Diamantina Plateau district and (**C**) Iron Quadrangle district (*sensu* Colli-Silva *et al.* 2019). DF – Distrito Federal.

These characteristics are cited by Saraiva *et al.* (2015) as synapomorphies for the group of *Pitcairnia* species that are rheophytic, endemic to the Cerrado domain and have yellow corolla (*P. bradei*, *P. cristalinensis* (Leme) D.C.Taylor & H.Rob. and *P. ulei* L.B.Sm.) (Fig. 4).

Pitcairnia mineira and *P. bradei* can be distinguished mainly by the color of floral parts. In *P. bradei*, the flowers have an orange-yellow calyx and a greenish-yellow corolla (Saraiva 2013; Saraiva *et al.* 2015), while in *P. mineira* the flowers have a red calyx and corolla. In the Cerrado domain, this is the first rheophytic species of the genus that has this coloration, which stands out and can be used as a diagnostic character for the species. *Pitcairnia mineira* can be further differentiated because it has a thin peduncle, 0.3-0.5 cm in diam. (*vs.* thick peduncle, 1-2 cm in diam.), lepidote peduncle, floral bracts and sepals (*vs.* glabrescent peduncle, floral bracts and sepals), erect to erect-patent flowers post-anthesis (*vs.* patent flowers post-anthesis), narrow-elliptical petals with obtuse to rounded apex (*vs.* oblanceolate petals with acute apex) and ovary more than 1/2 inferior (*vs.* ovary more than 1/2 superior). Anatomically, it can be distinguished by having a water-storage parenchyma with more than 10 layers in the adaxial portion (*vs.* water-storage parenchyma with 6 to 9 layers in the adaxial portion).

Moreover, it is important to highlight that, when in cultivation, *P. mineira* showed an interesting variation in terms of the size of its leaves. While the plant that flowered in the habitat appears to have its inflorescence exceeding the leaves (RB00515365), the plant that flowered in cultivation had its inflorescence slightly shorter than the leaves (Fig. 3A).

In addition to *P. mineira* and *P. bradei*, three other species also occur in the Southern Espinhaço Province (Minas Gerais State): *P. burchellii* Mez, *P. curvidens* L.B.Sm. & Read and *P. decidua* L.B.Sm. *Pitcairnia burchellii* stands out for being the most widely distributed species in Brazilian territory. *Pitcairnia curvidens* and *P. decidua* occur only in southeastern Brazil, mainly in the Atlantic Forest domain, with the Espinhaço Range as the western limit of occurrence. On the other hand, in the Chapada Diamantina Province (Bahia State) we do not record any species of *Pitcairnia*.

Key to **Pitcairnia** *species in the Espinhaço Range*

1. Leaf blades herbaceous and flat.

2. Leaves with midrib evident; margin of the basal portion of the inner blades densely aculeate; petals with appendage ..... *Pitcairnia burchellii*

2'. Leaves with midrib not evident; blades entire; petals unappendaged.

3. Persistent dry leaf sheaths present, forming a small bulb; sepals ecarinate ..... *Pitcairnia decidua*

3'. Persistent dry leaf sheaths absent; sepals carinate ..... *Pitcairnia curvidens*

1'. Leaf blades coriaceaous and narrowly canaliculate, forming fully open rosettes.

4. Peduncle 1–2 cm in diam., glabrescent; flowers with orange-yellow calyx and greenish-yellow corolla .... *Pitcairnia bradei*

4'. Peduncle 0.3–0.5 cm in diam., woolly lepidote; flowers with dark red calyx and red corolla ..... *Pitcairnia mineira*

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