

# Up on the table mountains in Brazil: new Bromeliaceae and Eriocaulaceae (Poales) from the Pantepui in the Guayana Shield

Rafael G. Barbosa-Silva<sup>1,2</sup>, Marcelo Trovó<sup>3</sup>, Gustavo Martinelli<sup>1</sup> & Rafaela Campostrini Forzza<sup>1,\*</sup>

<sup>1</sup>Jardim Botânico do Rio de Janeiro, Pacheco Leão 915, 22460–030, Rio de Janeiro, Rio de Janeiro, Brazil

<sup>2</sup>Programa de Pós-Graduação em Botânica, Universidade Estadual de Feira de Santana, Avenida Transnordestina, Novo Horizonte, 44036-900, Feira de Santana, Bahia, Brazil

<sup>3</sup>Universidade Federal do Rio de Janeiro, Av. Carlos Chagas Filho 373, 21941–590, Rio de Janeiro, Brazil

\*Author for correspondence: rafaela@jbrj.gov.br

**Background and aims** – As “islands in the sky” of northern South America, the isolated ecosystems of the Pantepui province include a distinct flora with high levels of endemism and which are ancestral areas for many angiosperm lineages. About one fifth of Pantepui angiosperm species are distributed in Poales, a highly diverse angiosperm order.

**Methods** – Recent field trips were carried out on two Brazilian tepuis, by foot and helicopter. Herbarium collections were consulted and compared with the proposed new species.

**Key results** – Four new species of Poales, three *Navia* Schult. & Schult.f. (Bromeliaceae) and one *Paepalanthus* Mart. (Eriocaulaceae) were found. Descriptions, illustrations, and distribution maps of the new species, as well as an identification key to Brazilian *Navia* species, are provided.

**Key words** – *Navia*, *Paepalanthus*, endemism, new species, tepui.

## INTRODUCTION

Pantepui is a unique biogeographic province commonly referred to as “islands in the sky” due to its exuberant biota isolated on the tops of table mountains known as tepuis (Huber 1987, 1988, McCormack et al. 2009). Tepui summits are isolated ecosystems, influenced by abundant rainfall, and have a distinct flora with high levels of endemism (Maguire 1970, Steyermark 1974, Berry & Riina 2005, Huber 2006). They are also representative of old, climatically buffered, infertile landscapes (OCBILs, Hopper 2009, Hopper et al. 2016) that are ancestral areas for many groups, including some ancient angiosperm lineages (Givnish et al. 2000, 2007, Ruhfel et al. 2011, Schneider et al. 2014, Saraiva et al. 2015).

Poales is one of the angiosperm orders with high diversity and endemism levels in the Pantepui province, including endemic genera in several families (Maguire 1970). Of the 2 108 species of angiosperms reported for this region, around 20% belong to Poales (Berry & Riina 2005). Unlike Venezuela and the Guianas, in the recent past there has been a lack of focus on studying the botany of Brazilian tepuis and, consequently, there had previously been only one published inventory of vascular plants for Serra do Aracá (Prance & Johnson 1992), among the Brazilian tepuis listed by Huber

(1988). For instance, Huber (1988) does not include several of the mountains that are part of the Pantepui province, such as Monte Caburaí, Serra do Tapericó, Serra do Imeri, Serra Urutanin, and Pico Guimarães Rosa (Brasil 1975).

Fortunately, recent field efforts have expanded the number of species reported for the Brazilian portion of the Pantepui (Rodrigues & Flores 2010, Coelho et al. 2015, Barbosa-Silva et al. 2016, Costa 2017), and recent studies of previously collected specimens deposited in Amazonian herbaria have revealed new species and new records for this region (e.g. Rodrigues & Flores 2010, Michelangeli & Goldenberg 2014, Fritsch 2015, Barbosa-Silva et al. 2016). However, the tepuis of northern Brazil and the mountains surrounding them are still relatively unknown.

In the Pantepui, there are c. 117 species of Bromeliaceae; of the 75 endemic species, 86% are distributed in the genera *Navia* and *Lindmania* Mez (Berry & Riina 2005). Another significantly diverse family in the Pantepui is Eriocaulaceae that is represented by 47 species, of which 68% are endemic (Berry & Riina 2005). This study reports and describes four new Poales species (three *Navia* and one *Paepalanthus*) from Brazilian tepuis and provides a key to the *Navia* species in Brazil.

## MATERIALS AND METHODS

The specimens were collected during recent expeditions to Monte Caburaí, in the state of Roraima, and Serra do Aracá, by foot and helicopter, in the state of Amazonas (fig. 1), during a project entitled “Montanhas da Amazônia” (Coelho et al. 2015). Herbarium specimens at INPA, MG, NY, RB, and US (acronyms following Thiers 2016) were consulted to identify collections and make comparisons with the new species. The detailed species descriptions follow Radford et al. (1974) and Smith & Downs (1974). Comments about morphological variation and distribution, photos, and illustrations are provided. Conservation assessments of the species were made by CNCFlora following IUCN Red List Categories and Criteria (<http://cncflora.jbrj.gov.br>).

## TAXONOMIC TREATMENT

## Eriocaulaceae

*Paepalanthus* is the most diverse genus of Eriocaulaceae in the Pantepui flora and the 15<sup>th</sup> largest genus in the province, where it is represented by 26 species, of which most are endemic (Berry & Riina 2005). It is also the largest genus of Brazilian monocots (BFG 2015, Flora do Brasil 2020 under construction). The species described here represents the northernmost occurrence of the genus in Brazil, where the genus is mostly diversified, though some species are found as far north as Central America.

*Paepalanthus septentrionalis* Trovó, sp. nov.

*Paepalanthus septentrionalis* is distinguished from *P. fulgidus* Moldenke and *P. squamuliferous* Moldenke by its dimerous flowers. It can also be distinguished from *P. fulgidus* by its shorter stem (0.5–5 vs. 7–20 cm), shorter and narrower leaves (1.5–3.5 × 0.2–0.3 vs. 3–5.3 × 0.4–0.6 cm), and shorter scapes (4.5–14 vs. 15–30 cm). It is differentiated from *P. squamuliferous* by its chartaceous leaves (vs. semi-succulent), shorter scapes (4.5–14 vs. 11–40 cm), and narrower capitula (0.6–1 vs. 0.8–1.2 cm). – Type: Brazil, Roraima, Uiramutã, Parque Nacional do Monte Roraima. Monte Caburaí, 5°11'54"N, 60°10'20"W, 1350 m elev., 7 Nov. 2014, Forzza 8202 (holo-: RB; iso-: B, INPA, NY, SPF).

Perennial herbs. Roots whitish, slightly spongy. Rhizome short. Stem restricted to the rosette at initial stages, then shortly elongated, unbranched, not forming a caudex, 0.5–5 cm long. Leaves restricted to the rosette at early stages, then along the elongated stem, persistent, amplexicaul, linear-lanceolate, chartaceous, markedly veined on abaxial surface, 1.5–3.5 × 0.2–0.3 cm, green to castaneous, sparsely pilose on abaxial surface, glabrescent on older leaves, margin slightly revolute, sparsely ciliate to glabrescent on old leaves, apex acuminate to mucronate. Spathes adpressed, chartaceous, 2–3.5 cm long, with persistent T-shaped trichomes, apex acuminate, densely ciliate. Scapes free, c. 2–10 per individual, apparently terminal, 4.5–14 cm long, multicostate, densely pilose. Capitula whitish, 0.6–1 cm diam., obconic to hemispheric. Involucral bracts in 3–4 series, deltoid to ovate, c. 3 mm long, castaneous, densely pilose to glabrescent on old capitula, densely ciliate toward the acute apex. Flowers

2-merous, c. 20–60 per capitula (with 5× more staminate than pistillate flowers). Floral bracts oblong, c. 3 mm long, castaneous, pilose on the abaxial surface, ciliate toward the obtuse, tufted apex. Staminate flowers c. 3 mm long; pedicels c. 0.25 mm long, with long trichomes; sepals free at the base, oblong to navicular, castaneous, c. 2.5 mm long, pilose on the abaxial surface to glabrescent, ciliate toward the margin, apex acute, tufted; corolla tubular, slightly 2-lobed, membranaceous, glabrous, hyaline; stamens c. 2.5–3 mm long, anthers hyaline; carpellodes 2, papillose. Pistillate flowers c. 3.5 mm long, sessile to shortly pedicellate, pedicel c. 0.2 mm long, with long trichomes; sepals free at the base, elliptic to oblong, c. 3 mm long, castaneous, pilose on the distal part of the abaxial surface, ciliate toward the margin, apex acute, tufted; petals membranaceous, elliptic, c. 2.5 mm long, golden, glabrous, apex acute; gynoecium c. 2.5 mm long; ovary castaneous, stigmatic branches single, sometimes irregularly fused, c. 2.5× longer than the nectariferous branches; staminodes 2, scale-like. Fruits juvenile. Seeds not seen. Fig. 2.

**Paratypes** – Brazil: Roraima; Uiramutã, Parque Nacional do Monte Roraima, Monte Caburaí, campos úmidos de Rapateaceae e matas de altitude, 1350 m elev., 5°10'22"N, 60°12'57"W, 8 Nov. 2014, Martinelli 18452 (RB); ibid., 1380 m elev., 5°09'32"N, 60°10'20"W, 7 Nov. 2014, Martinelli 18446 (RB).

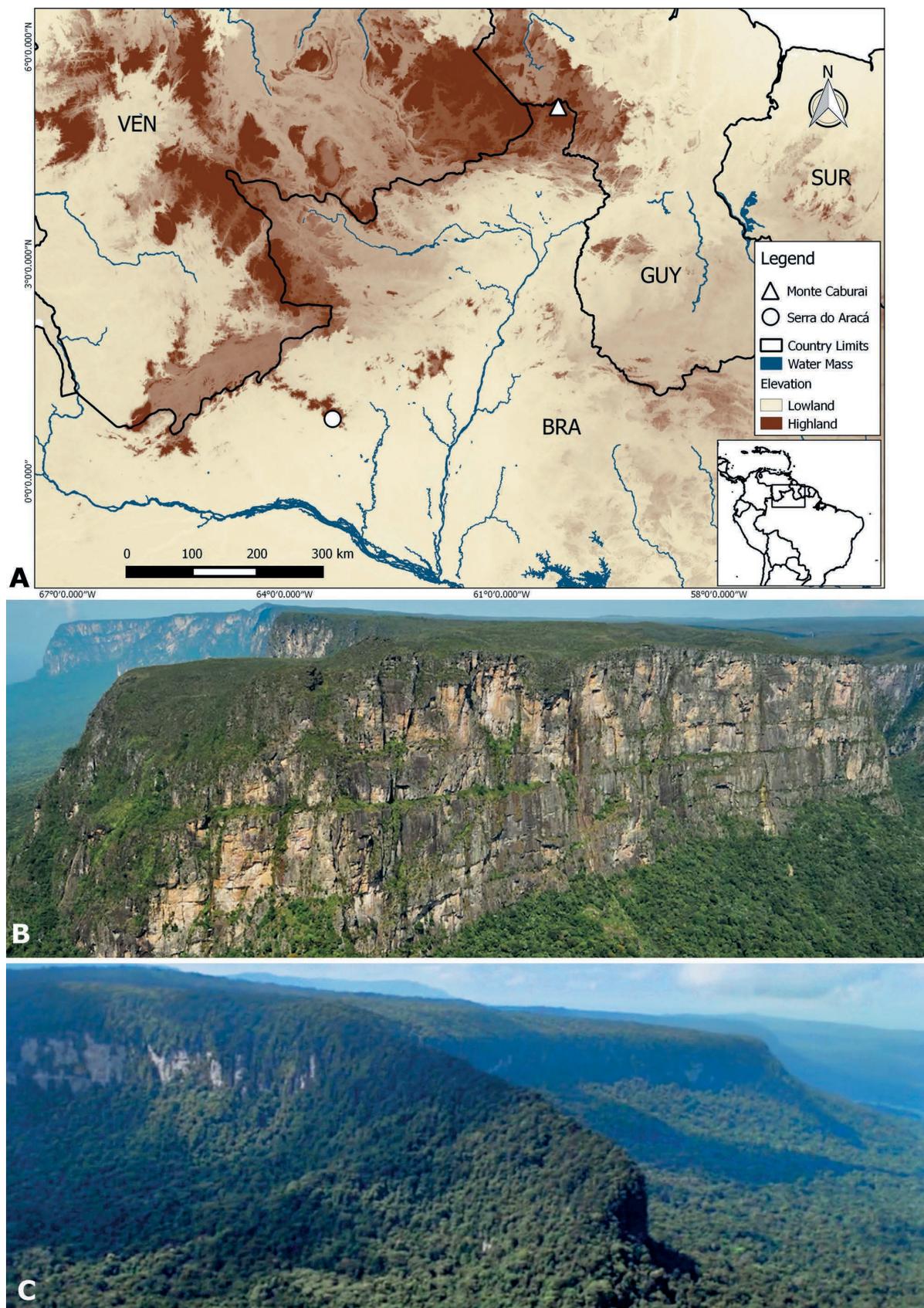
**Distribution and conservation status** – *Paepalanthus septentrionalis* grows in humid open fields in mountainous areas of Monte Caburaí, inside Roraima National Park (Coelho et al. 2015), along the border with Guyana at 1350–1380 m a.s.l. The species forms dense populations growing intermixed with moss species in a habitat dominated by Rapateaceae. Despite the narrow geographical distribution of *P. septentrionalis*, the species occurs inside a national park in a very remote area that is difficult to access and far from human disturbances. Therefore, it is considered of Least Concern (LC) (Amaro 2018a).

**Etymology** – The epithet “*septentrionalis*” refers to the distribution of the species. *Paepalanthus septentrionalis* is restricted to the municipality of Uiramutã, Monte Caburaí, close to the boarder of Guyana. This is the northernmost site of occurrence for *Paepalanthus* in Brazil.

**Notes** – *Paepalanthus septentrionalis* is quite a unique species with features rarely observed in *Paepalanthus* from tepuis. Its small habit, dimerous flowers, and scapes covered with T-shaped trichomes are enough to clearly identify *P. septentrionalis* among congeneric species.

N. Hensold (The Field Museum of Natural History, pers. comm.) pointed out that the new species shares morphological similarities with *P. fulgidus* and *P. squamuliferous*. *Paepalanthus septentrionalis* can be distinguished from *P. fulgidus* and *P. squamuliferous* by the features enumerated in the diagnosis above.

Along with *Rondonanthus* Herzog, *Paepalanthus* subg. *Monosperma* Hensold is the most diverse Eriocaulaceae group in the tepuis (Hensold 1991). *Paepalanthus septentrionalis* might belong to *P.* subg. *Monosperma* but this needs to be verified (Hensold, pers. comm.) because the species has dimerous flowers, uncommon flower pilosity, and sometimes an irregularly developed gynoecium. Studying fully developed fruits and including the species in a comprehensive



**Figure 1** – Study area and tepuis showing where the new species were found: A, map showing study area; B, Serra do Aracá; C, Monte Caburai. B & C by R. Azoury.

phylogenetic analysis are important to confirm the position of the species in *Paepalanthus*.

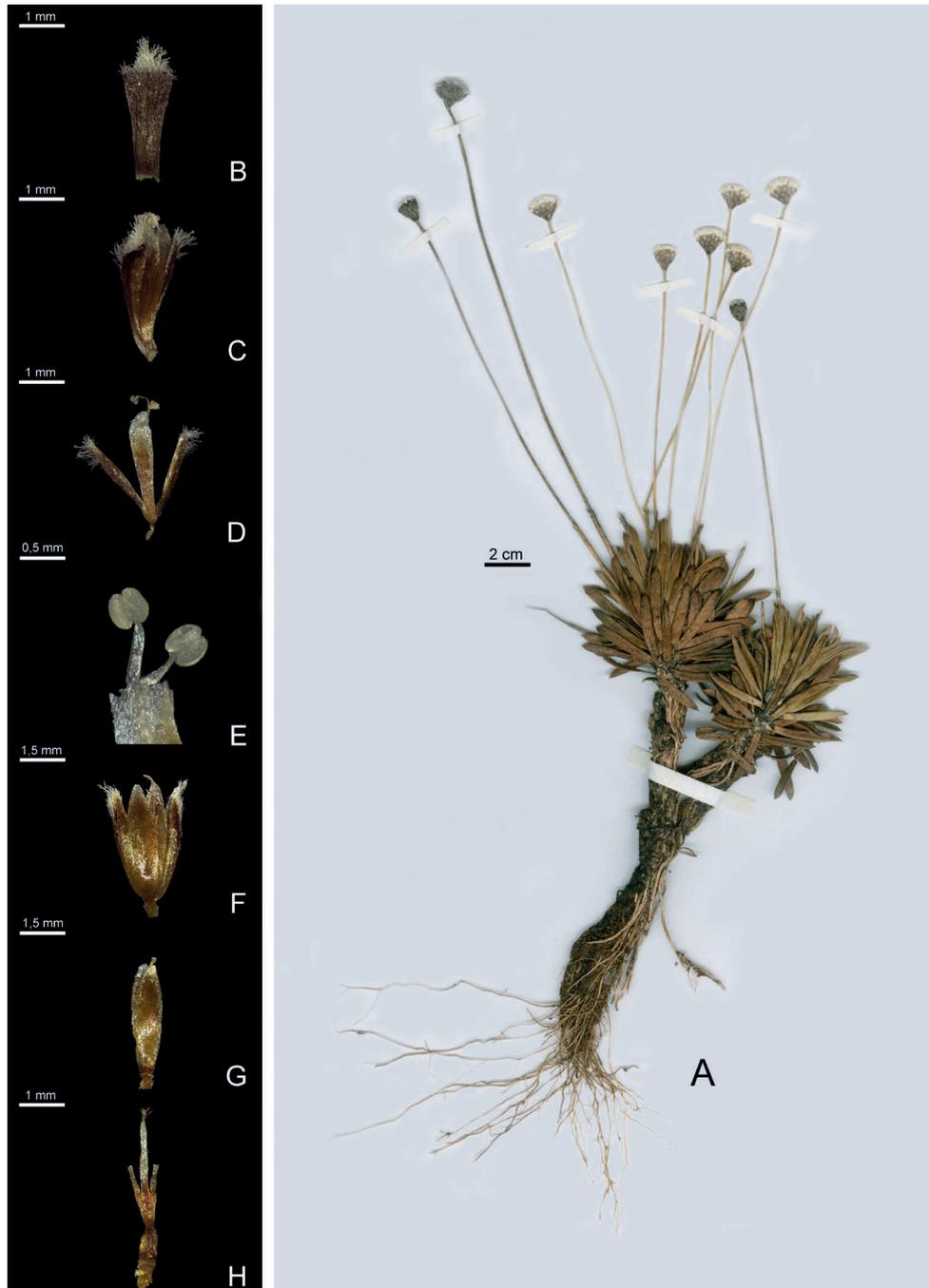
**Bromeliaceae**

*Navia* comprises 33 species and is the sixth largest genus in the Pantepui flora (Berry & Riina 2005). Before this study only four species had been recorded for Brazil, including only one for Serra do Aracá (*Navia piresii* L.B.Sm., Steyerm.

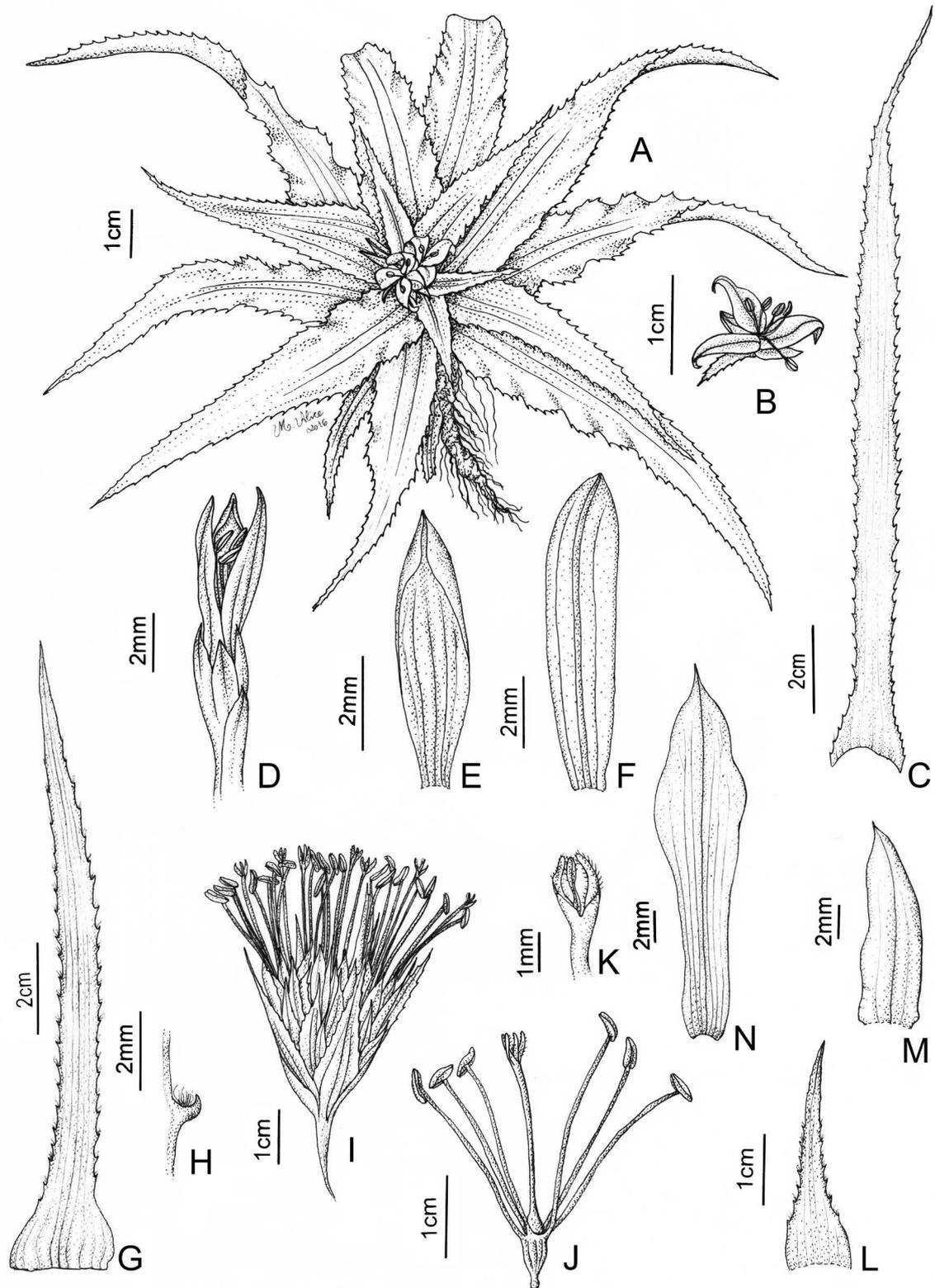
& H.Rob.) (BFG 2015, Flora do Brasil 2020 under construction).

***Navia corrugata* Barbosa-Silva & Martinelli, sp. nov.**

*Navia corrugata* is similar to *N. glauca* L.B.Sm., but differs by its larger size, floral bract shape (elliptic vs. lanceolate), smaller sepals (11–12 vs. 14 mm), smaller petals (14 vs. 23 mm), and non-glaucous leaves (vs. glaucous). – Type: Brazil, Amazonas, Barcelos, Parque Estadual da Serra do



**Figure 2** – *Paepalanthus septentrionalis*: A, habit; B, floral bract; C, staminate flower; D, staminate flower with floral bract removed; E, detail of stamens; F, pistillate flower; G, pistillate flower with floral bract and sepals removed; H, gynoeceum with irregular stigmatic branches. A–H from Forzza 8202.



**Figure 3** – *Navia corrugata*: A, flowering habit; B, open flower; C, leaf; D, flower with floral bracts; E, floral bract; F, sepals. *Navia eldorado*: G, leaf; H, detail of axillary trichomes of the spine on the leaf margin; I, inflorescence; J, stamens and gynoecium; K, stigma; L, primary bracts; M, sepal; N, petal. A–F from Martinelli 17019; G–N from Forzza 8010. Drawn by M. Alice.

Aracá, Serra do Aracá, formação campestre, igarapé Preto, acima da cachoeira do Eldorado, 0°52'23"N, 63°20'29"W, 960 m elev., 16 Aug. 2011, *Martinelli* 17019 (holo-: RB; iso-: INPA, US).

Plants rupicolous, stem 3–13 cm long. Leaves slightly curved, forming rosettes 11–30 cm in diam.; sheaths 1–1.3 × 1.4–1.8 cm, broader than the blades, depressed-ovate, brown, glabrous, all margins with minute spines; blade 6–16 × 0.7–1.2 cm, green, not glaucous, glabrous, linear-triangular or narrowly-triangular, corrugated, erect when small and divergent with recurved middle and apex when larger, not basally white at anthesis, apex attenuate, margins with minute spines; spines less than 1 mm long. Inflorescence compound, capituliform, c. 2 cm long, c. 1 cm in diam., sunk in the center of the rosette, rachis white; peduncle erect, 0.4 cm long, white; primary bracts 15–20 × 1.5 mm, lanceolate, fo-

liaceous, glabrous, margins with minute spines, occasionally with trichomes in the axillae, apex apiculate. Floral bracts c. 9 mm long, elliptic, symmetric, white, carinate, glabrous, entire, apex acute. Flowers 1.6 cm long, sessile; sepals 11–12 × 2 mm, narrowly elliptic, free, slightly carinate, symmetric, white, glabrous, entire, apex acute; petals 14 × 1.8 mm, oblanceolate, patent to reflexed, white, glabrous, without callosities, apex large and acuminate, margins entire; stamens exerted, 1.4 cm long, free; anthers sagittate, 3 mm long, dorsifixed, yellow; ovary superior, 3–4 mm long, elliptic, white; style 1.1 cm long, white; stigma exerted, 4 mm long, trilobate-erect, white. Fruits unknown. Figs 3A–F & 4.

**Paratype** – **Brazil**: Amazonas, Barcelos, Parque Estadual da Serra do Aracá, Serra do Aracá, platô sul, Trilha de acesso ao topo, encostas de paredão rochoso, 6 May 2016, *Nogueira* 514 (MG).

**Distribution and conservation status** – *Navia corrugata* grows on rock walls in mountainous areas of Serra do Aracá,



**Figure 4** – *Navia corrugata*: A, habitat; B, rosette; C, inflorescence with flowers at anthesis; D, flower, frontal view. A & B by L. Freitas; C by E. Fernandez; D by A. Stival; 4B–D from *Martinelli* 17019.

Key to the species of *Navia* in Brazil

1. Sepals c. 8 mm long ..... 2
- 1'. Sepals more than 9 mm long ..... 3
2. Leaf blade lanceolate, 1.5–2.5 mm wide, (4–)5–7 cm long, petals yellow ..... *Navia tenuifolia* (Serra do Aracá)
- 2'. Leaf blade linear, 12(–15) mm wide, 24 cm long, petals white ..... *N. crispa* (Serra de Tunuí, Serra Pirapucú)
3. Leaf blade 3–4 mm wide, sepals less than 1 cm long ..... *N. piresii* (Serra do Aracá)
- 3'. Leaf blade 7–12 mm wide, sepals at least 1.1 cm long ..... 4
4. Primary bracts broadly ovate, less than 1 cm long ..... *N. myriantha* (Serra do Padre = Cerro DIMITI)
- 4'. Primary bracts elliptic or linear, more than 1.5 cm long ..... 5
5. Primary bracts linear, more than 2 cm long, petals yellow-orange ..... *N. eldorado* (Serra do Aracá)
- 5'. Primary bracts elliptic, 1.5 cm long or less, petals white ..... 6
6. Leaf blade plane, 25–39 cm long, c. 1 cm wide, primary bracts 1.5 cm long ..... *N. affinis* (Serra Pirapucú)
- 6'. Leaf blade corrugated, 6–16 cm long, 0.7–1(–1.2) cm wide, primary bracts 0.9 cm long ..... *N. corrugata* (Serra do Aracá)

inside Serra do Aracá State Park (Coelho et al. 2015) at 750–960 m a.s.l. The species forms dense populations (fig. 4A) growing intermixed with moss species, ferns, and commonly with *N. tenuifolia*. Despite the narrow geographical range of *N. corrugata*, the species occurs inside of a state park in a very remote area that is difficult to access and far from human disturbances. Therefore, it is considered of Least Concern (LC) (Amaro 2018b).

**Etymology** – The epithet refers to the corrugated leaf surface (fig. 4B & C).

**Notes** – *Navia corrugata* is the first species of the genus to be found when climbing on Serra do Aracá. This species first appears near 750 m a.s.l. on rock walls and forms large populations. Although there are only two collections, we have observed *N. corrugata* in many areas on Serra do Aracá. This species is closely related to *N. glauca*, which is endemic to upper elevations of Cerro Duida (c. 2100 m) in Amazonas State, Venezuela (c. 350 km from Serra do Aracá). *Navia corrugata* differs from *N. glauca* by the features enumerated in the diagnosis above; in addition, *N. corrugata* is rupicolous whereas *N. glauca* is terrestrial.

***Navia eldorado*** Barbosa-Silva & Forzza, **sp. nov.**

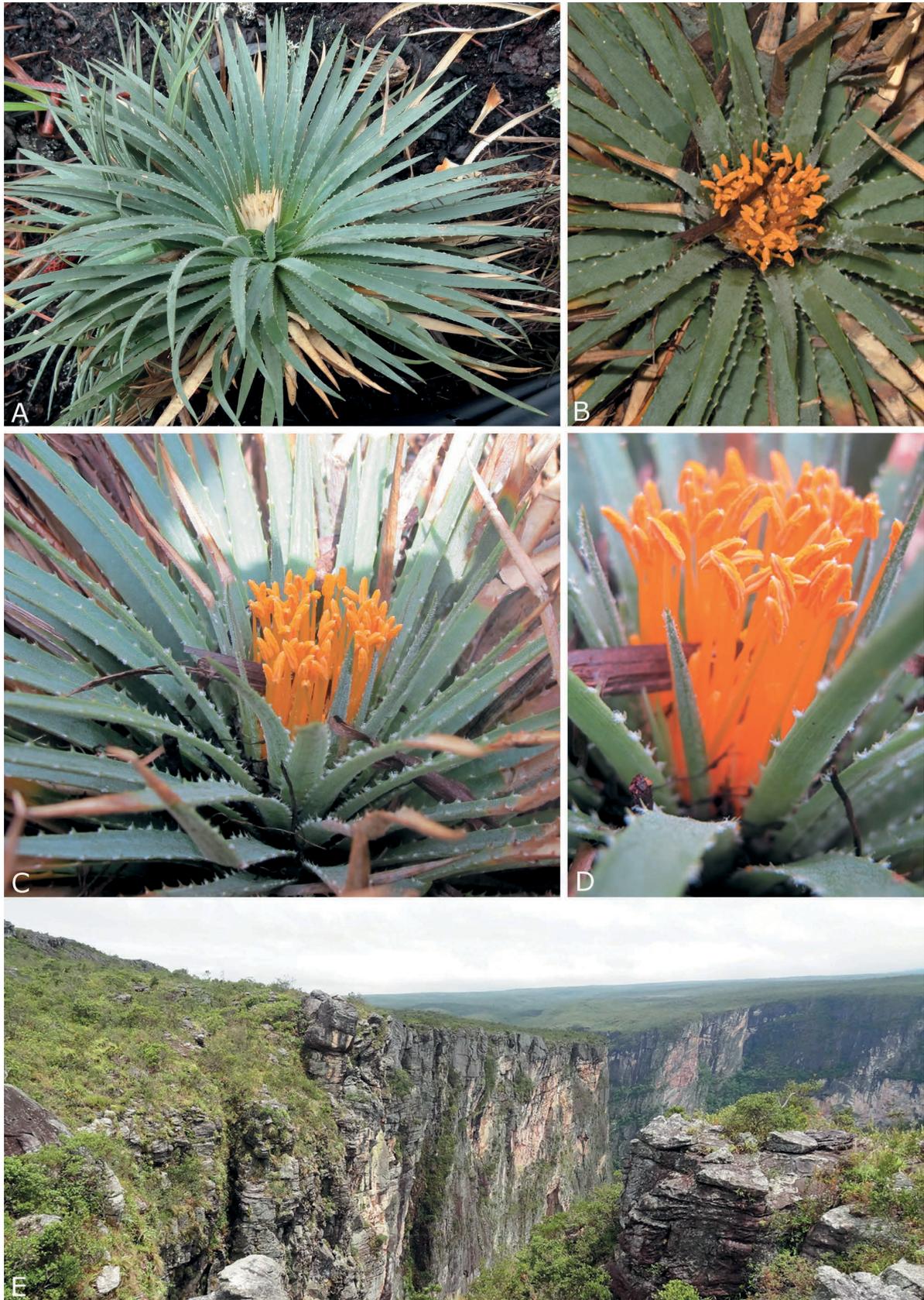
*Navia eldorado* is similar to *N. scopulorum* L.B.Sm., but differs by its leaf blades that are glaucous (vs. non-glaucous), lanceolate (vs. linear) and lepidote (vs. glabrous), with margins densely spinose with trichomes in the axillae (vs. margins spinose without trichomes in the axillae), primary bract 3–3.6 cm long (vs. 2 cm), and corolla with two conspicuous callosities (vs. callosities absent). – Type: Brazil, Amazonas, Barcelos, Parque Estadual da Serra do Aracá, Serra do Aracá, 0°51'48"N, 63°19'59"W, 990 m elev., 20 Apr. 2014, fl. cult. May 2014, Forzza 8010 (holo-: RB).

Plants rupicolous, 17–25 cm tall, clustering or solitary, not caulescent. Leaves erect, numerous, forming rosettes

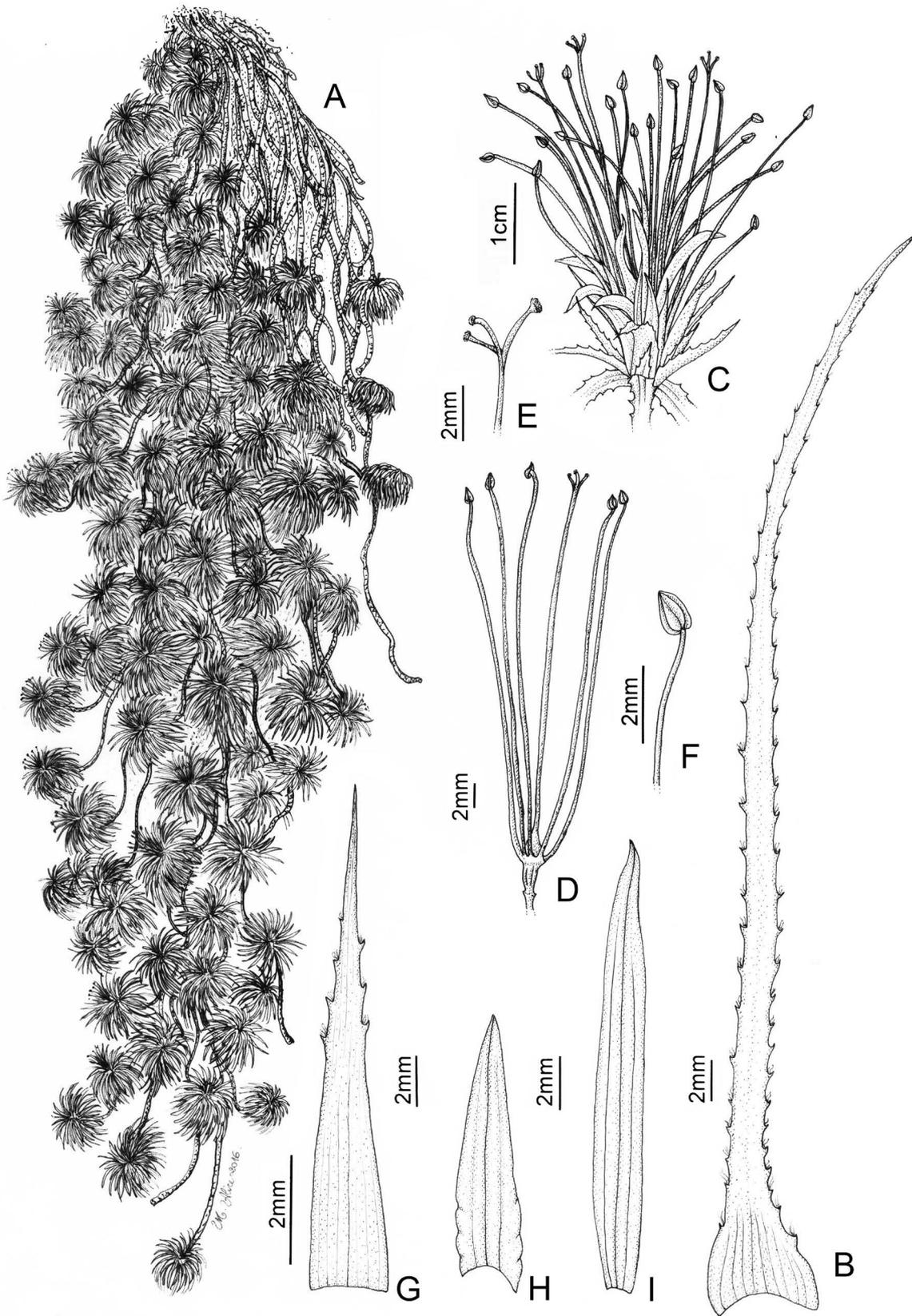
22–24 cm in diam.; sheaths 1–1.5 × 1.8–2.2 cm, much broader than the blades, depressed-ovate, brown, margins entire; blades 7–14 × (0.3–)0.5–0.8 cm, lanceolate, apex acuminate, coriaceous, green to glaucous, with lepidote indumentum on both sides, margins densely spinose; spines c. 1 mm long, with trichomes in the axillae. Inflorescence compound, nidular, capituliform, 5–7.7 cm long, 1.4–2.8 cm diam.; peduncle included in rosettes, 1.4–2 cm long, white, glabrous; primary bracts 3–3.6 × 0.3–0.9 cm, lanceolate, coriaceous, orange, apex apiculate, glabrous to inconspicuously white lepidote, margins inconspicuously entire to spinulose with trichomes in the axillae; fascicles with 2 flowers. Floral bracts much shorter than the flowers, 1.2–1.4 × 0.1–0.2 cm, linear, orange, apex apiculate, symmetric, carinate, lepidote to floccose, margins entire. Flowers 3.8–4 cm long, polystichous, sessile; sepals 1.4–1.7 × 0.5–0.7 cm, lanceolate to ovate, apex acuminate, free, strongly carinate, symmetric, orange, sparsely lepidote in the middle, margins entire; petals c. 23–27 × 6 mm, obtrullate-spatulate, apex acuminate, orange, glabrous, with two conspicuous callosities, margins entire; stamens exserted, 3–4.7 cm long, free, yellow; anthers linear, 3 mm long, dorsifixed, yellow; ovary semi-inferior, c. 6 mm long, oval, yellow; style 1.8–4.6 cm long, yellow; stigma exserted, 2 mm long, trilobate-erect, yellow. Fruits unknown. Figs 3G–N & 5A–D.

**Paratype** – Brazil: Amazonas, Barcelos, Parque Estadual da Serra do Aracá, Serra do Aracá, trilha do acampamento do fosso para a Cachoeira do Eldorado, passando pelo mirante, 0°51'48"N, 63°19'59"W, 990 m elev., 20 Apr. 2014, Forzza 8029 (INPA, RB).

**Distribution and conservation status** – *Navia eldorado* is known only from a single population, which grows on rock walls in mountainous areas of Serra do Aracá, inside Serra do Aracá State Park (Coelho et al. 2015) at 990 m a.s.l. It was collected on an almost inaccessible precipice (fig. 5E) and data about its distribution, abundance, and population status are lacking. Despite the narrow geographical distribution of *N. eldorado*, the species occurs inside of a state park



**Figure 5** – *Navia eldorado*: A, plant after anthesis; B, inflorescence, top view; C, inflorescence, lateral view; D, details of flowers and axillary trichomes of the spine on the leaf margin; E, habitat showing rupicolous plants in canyon. A–E by R.G. Barbosa-Silva; 5A–D from Forzza 8010.



**Figure 6** – *Navia tenuifolia*: A, flowering habit; B, leaf with axillary trichomes of the spine on the margin; C, inflorescence with flowers at anthesis; D, stamens and gynoecium; E, stigma; F, stamen; G, primary bracts; H, sepal; I, petal. A–I from *Forzza 8006*. Drawn by M. Alice.



**Figure 7** – *Navia tenuifolia*: A, rosette; B, large pendent colony on wall; C, detail of flowers and axillary trichomes of the spine on the leaf margin; D, habitat. A–D by R.G. Barbosa-Silva; 7A–C from 5A–D from Forzza 8006.

in a very remote area that is difficult to access and far from human disturbances. Therefore, it is considered of Least Concern (LC) (Amaro 2018c).

**Etymology** – The name of the species refers to the canyon of the Eldorado waterfall (fig. 5E), where the type was collected, which is one of the greatest free-falling waterfalls in Brazil, and also of the Eldorado legend.

**Notes** – This species was collected without flowers in the field and taken to cultivate, where it flowered shortly thereafter. *Navia eldorado* is closely related to *N. scopulorum*, which is endemic to the tepui Macizo del Chimantá (1100–1700 m elevation) in Bolívar State, Venezuela (c. 500 km from Serra do Aracá). *Navia eldorado* differs from *N. scopulorum* by the features enumerated in the diagnosis above.

***Navia tenuifolia* Barbosa-Silva & Forzza, sp. nov.**

*Navia tenuifolia* is distinguished from *N. parvula* L.B.Sm. var. *parvula* by its thin, 4–5 mm long sheaths (vs. 7 mm), leaves 1.5–2.5 mm wide (vs. 3–4 mm), sepals with an entire apex (vs. serrulate), anterior sepal always present (vs. aborted), and petals 17 mm long (vs. 15 mm). – Type: Brazil, Amazonas, Barcelos, Parque Estadual da Serra do Aracá, Serra do Aracá, trilha do acampamento do fosso para a cachoeira do Eldorado, passando pelo mirante, 0°51'48"N, 63°19'59"W, alt. 990 m, 20 Apr. 2014, Forzza 8006 (holo-: RB; iso-: INPA, US).

Plants rupicolous, c. 8 cm tall, caulescent. Leaves curved, numerous, forming rosettes 12 cm in diam.; sheaths 4–5 × 6–7 mm, broader than the blades, ovate, brown, glabrous, margins entire; blade (4–)5–7 × 0.15–0.25 cm, green, apex acuminate, abaxial surface with trichomes simple and sparse (dried specimens sometimes appearing glabrous because the trichomes fall off), lanceolate, not basally white at anthesis; spines less than 1 mm long, with trichomes in the axillae. Inflorescence compound, capituliform, 4–5 cm long, c. 1 cm in diam., sunk in the center of the rosette; peduncle erect, short, c. 5 mm long, white, glabrous; peduncle bracts foliaceous, c. 3 × 2 mm; primary bracts similar to the peduncle bracts, linear-triangular, glabrous, spines with trichomes in the axillae, apex acuminate. Floral bracts c. 6 × 1 mm, linear, very thin, symmetric, yellow, glabrous, entire, apex apiculate. Flowers 4–4.5 cm long, sessile; sepals always present, c. 8 × 2 mm, lanceolate, free, carinate, symmetric, orange, glabrous, entire, apex attenuate; petals 17–19 × 3 mm, linear, orange, glabrous, with two callosities, margins entire, apex attenuate; stamens exerted, c. 4.3 cm long, free, anthers sagittate, c. 1 mm long, dorsifixed, yellow; ovary semi-inferior, c. 4 mm long, obovate, yellow; style c. 4 cm long, yellow; stigma exerted, c. 2 mm long, trilobate-erect, yellow. Fruits unknown. Figs 6 & 7A–C.

**Paratypes** – Brazil: Amazonas, Barcelos, Platô da Serra do Aracá, parte SE da Serra Norte, Mata de galeria e campo rupestre ao longo do rio Grande, 1150–1250 m elev., 16 Feb. 1984, Amaral 1609 (INPA, NY, RB); Serra do Aracá, 200 km ao norte de Barcelos, Mar. 1984, Silva 7147 (INPA, NY); Serra do Aracá, W slope of central range, 0°40'N, 63°18'W, humid montane forest on large sandstone rocks below wall, 21 Mar. 1984, Pipoly 6869<sup>a</sup> (INPA, NY); Serra do Aracá, paredões rochosos da base do tepui para o alto da Serra, 750 m elev., 0°51'33"N, 63°20'01"W, 17 Aug. 2011, Martinelli 17051 (RB).

**Distribution and conservation status** – *Navia tenuifolia* grows on rock walls in mountainous areas of Serra do Aracá, inside Serra do Aracá State Park (Coelho et al. 2015) at 990–1250 m elev. The species forms dense, rupicolous populations growing (“hanging”) on moist walls (fig. 7B & D). This habitat type is frequent in species of *Navia* (e.g. *N. schultesiana* L.B.Sm., *N. semiserrata* L.B.Sm.). Despite the narrow geographical distribution of *N. tenuifolia*, the species occurs inside a state park in a very remote area that is difficult to access and far from human disturbances. Therefore, it is considered of Least Concern (LC) (Amaro).

**Etymology** – The epithet refers to the narrow leaves of the new species (fig. 6B).

**Notes** – *Navia tenuifolia* forms large, hanging colonies on rock walls and has long stems. Vouchers of this species may vary according to the way they were collected and can be caulescent (Silva 7147) or not (Amaral 1609). *Navia tenuifolia* differs from *N. parvula* var. *parvula* by the features enumerated in the diagnosis above. Smith (1957) described *N. parvula* based only on material collected in the Venezuelan part of Pico da Neblina, and also described it as having a short stem and 7 mm long, free, triangular, and acute sepals. The flower material he used was incomplete so only the calyx was described. Shortly thereafter, Smith (1960) broadened the concept of the species describing *N. parvula* var. *expansa* based on material from the same mountain (Maguire 42246, 42502 and 42536). *Navia parvula* var. *expansa* differs from the typical variety because it is larger, has a long stem, and occurs at lower elevations. Smith (1960) completely described the floral parts of this variety and noted that, as with the typical variety, the posterior sepal is absent.

#### ACKNOWLEDGEMENTS

We would like to thank Anita Stival, Eduardo Fernandez, Leandro Freitas, Ricardo Azoury for the photographs and Maria Alice for the drawings. RSBS would like to thank CNPq for the undergraduate research scholarship from 2012–2016 and CAPES for the current master’s scholarship. Financial support was provided to MT by the Alexander von Humboldt Foundation and FAPERJ (E-26/203.269/2016—JCNE). Most of our expeditions for the “Montanhas da Amazônia” project were funded by Natura. M.T. and R.C.F. received a Research Productivity Fellowship from CNPq (proc. 301832/2016-1 and proc. 303420/2016-2).

#### REFERENCES

- Amaro R. (2018a) *Paepalanthus septentrionalis*. Lista Vermelha Centro Nacional de Conservação da Flora (CNCFlora). Available from [http://cncflora.jbrj.gov.br/assessments/novas\\_especies/assessment/5e05211b-ecaa-4d94-9a5b-549f8ab31de2](http://cncflora.jbrj.gov.br/assessments/novas_especies/assessment/5e05211b-ecaa-4d94-9a5b-549f8ab31de2) [accessed 11 Jan. 2018].
- Amaro R. (2018b) *Navia corrugata*. Lista Vermelha Centro Nacional de Conservação da Flora (CNCFlora). Available from [http://cncflora.jbrj.gov.br/assessments/novas\\_especies/assessment/7558cb03-ce49-4ff0-bbf8-7cbff8d2b17e](http://cncflora.jbrj.gov.br/assessments/novas_especies/assessment/7558cb03-ce49-4ff0-bbf8-7cbff8d2b17e) [accessed 11 Jan. 2018].
- Amaro R. (2018c) *Navia eldorado*. Lista Vermelha Centro Nacional de Conservação da Flora (CNCFlora). Available

- from [http://cncflora.jbrj.gov.br/assessments/novas\\_especies/assessment/99d6609e-4c01-4c90-b823-fed3b6d9906e](http://cncflora.jbrj.gov.br/assessments/novas_especies/assessment/99d6609e-4c01-4c90-b823-fed3b6d9906e) [accessed 11 Jan. 2018].
- Amaro R. (2018d) *Navia tenuifolia*. Lista Vermelha Centro Nacional de Conservação da Flora (CNCFlora). Available from [http://cncflora.jbrj.gov.br/assessments/novas\\_especies/assessment/0ac2486e-e760-4464-a7b7-04bd977cdaaf](http://cncflora.jbrj.gov.br/assessments/novas_especies/assessment/0ac2486e-e760-4464-a7b7-04bd977cdaaf) [accessed 11 Jan. 2018].
- Barbosa-Silva R.G., Labiak P.H., Gil A.S.B., Goldenberg R., Michelangeli F.A., Martinelli G., Coelho M.A.N., Zappi D.C., Forzza R.C. (2016) Over the hills and far away: new plant records for the Guayana Shield in Brazil. *Brittonia* 68: 397–408. <https://doi.org/10.1007/s12228-016-9435-3>
- BFG (The Brazil Flora Group) (2015) Growing knowledge: an overview of seed plant diversity in Brazil. *Rodriguésia* 55: 1085–1113. <https://doi.org/10.1590/2175-7860201566411>
- Brasil (1975) Folha NA. 21 Tumucumaque e parte da folha Nb. 21; geologia, geomorfologia, pedologia, vegetação e uso potencial da terra. Rio de Janeiro, (Levantamento de Recursos Naturais, 9). Ministério das Minas e Energia, Secretaria-Geral. Projeto RADAMBRASIL.
- Berry P.E., Riina R. (2005) Insights into the diversity of the Pantepui flora and the biogeographic complexity of the Guayana Shield. *Biologiske Skrifter* 55: 145–167.
- Coelho M.N., Costa D.P., Martinelli G., Moraes M.D., Forzza R.C. (2015) Expedições às Montanhas da Amazônia. Andrea Jakobson Estúdio Editorial Ltda. Santo André, Iphis. Available from [http://aplicacoes.jbrj.gov.br/divulga/montanhas\\_amazonia.pdf](http://aplicacoes.jbrj.gov.br/divulga/montanhas_amazonia.pdf) [accessed 14 Aug. 2017].
- Costa D.P. (2017) Bryophyte results from a botanical expedition to Serra do Aracá, State Amazonas, Brazil: diversity, distribution, and endemism. *The Bryologist* 120: 45–50. <https://doi.org/10.1639/0007-2745-120.1.045>
- Flora do Brasil 2020 (under construction) *Navia*. Flora do Brasil 2020. Jardim Botânico do Rio de Janeiro. Available from <http://floradobrasil.jbrj.gov.br/reflora/floradobrasil/FB34371> [accessed 15 Apr. 2017].
- Fritsch P.W. (2015) Two new species of *Styrax* (Styracaceae) from South America. *Novon* 24: 9–13. <https://doi.org/10.3417/2014030>
- Givnish T.J., Evans T.M., Zjhra M.L., Patterson T.B., Berry P.E., Sytsma K.J. (2000) Molecular evolution, adaptive radiation, and geographic diversification in the amphiatlantic family Rapateaceae: evidence from *ndhF* sequences and morphology. *Evolution* 54: 1915–1937. <https://doi.org/10.1111/j.0014-3820.2000.tb01237.x>
- Givnish T.J., Millam K.C., Berry P.E., Sytsma K.J. (2007) Phylogeny, adaptive radiation, and historical biogeography of Bromeliaceae inferred from *ndhF* sequence data. *Aliso* 23: 3–26. <https://doi.org/10.5642/aliso.20072301.04>
- Hensold N. (1991) Revisionary studies in the Eriocaulaceae of Venezuela. *Annals of the Missouri Botanical Garden* 78: 424–440. <https://doi.org/10.2307/2399571>
- Hopper S.D. (2009) OCBIL theory: towards an integrated understanding of the evolution, ecology and conservation of biodiversity on old, climatically buffered, infertile landscapes. *Plant and Soil* 322: 49–86. <https://doi.org/10.1007/s11104-009-0068-0>
- Hopper S.D., Silveira F.A.O., Fiedler P.L. (2016) Biodiversity hotspots and Ocbil theory. *Plant and Soil* 403: 167–216. <https://doi.org/10.1007/s11104-015-2764-2>
- Huber O. (1987) Consideraciones sobre el concepto de Pantepui. *Pantepui* 2: 2–10.
- Huber O. (1988) Vegetación y flora de Pantepui, Región Guayana. *Acta Botanica Brasilica* (suppl.) 1: 41–52. <https://doi.org/10.1590/S0102-33061987000300005>
- Huber O. (2006) Herbaceous ecosystems on the Guayana Shield, a regional overview. *Journal of Biogeography* 33: 464–475. <https://doi.org/10.1111/j.1365-2699.2005.01454.x>
- Maguire B. (1970) On the flora of the Guayana Highland. *Biotropica* 2: 85–100. <https://doi.org/10.2307/2989766>
- McCormack J.E., Huang H., Knowles L.L. (2009) Sky islands. In: Gillespie R.G., Clague D. (eds) *Encyclopedia of Islands*: 839–843. Berkeley, CA University of California Press.
- Michelangeli F.A., Goldenberg R. (2014) A new species of *Graffenrieda* (Melastomataceae) from the northern Amazon basin. *Brittonia* 66: 170–173. <https://doi.org/10.1007/s12228-013-9321-1>
- Prance G.T., Johnson D.M. (1992) Plant collections from the plateau of Serra do Aracá (Amazonas, Brazil) and their phylogeographic affinities. *Kew Bulletin* 47: 1–24. <https://doi.org/10.2307/4110765>
- Radford A.E., Dickison W.C., Massey J.R., Bell C.R. (1974) *Vascular plant systematics*. New York, Harper & Row.
- Rodrigues R.S., Flores A.S. (2010) Novas ocorrências de Rapateaceae para o Brasil. *Acta Botanica Brasilica* 24: 1096–1099. <https://doi.org/10.1590/S0102-33062010000400025>
- Ruhfel B.R., Bittrich V., Bove C.P., Gustafsson M.H.G., Philbrick C.T., Rutishauser R., Xi Z., Davis C.C. (2011) Phylogeny of the clusoid clade (Malpighiales): evidence from the plastid and mitochondrial genomes. *American Journal of Botany* 98: 306–325. <https://doi.org/10.3732/ajb.1000354>
- Saraiva D.P., Mantovani A., Forzza R.C. (2015) Insights into the evolution of Pitcairnia (Pitcairnioideae-Bromeliaceae), based on morphological evidence. *Systematic Botany* 40: 726–736. <https://doi.org/10.1600/036364415X689186>
- Schneider J.V., Bissengou P., Amaral M.C.E., Tahir A., Fay M.F., Thines M., Sosef M.S.M., Zizka G., Chatrou L.W. (2014) Phylogenetics, ancestral state reconstruction, and a new infrafamilial classification of the pantropical Ochnaceae (Medusagynaceae, Ochnaceae s.str., Quiinaceae) based on five DNA regions. *Molecular Phylogenetics and Evolution* 78: 199–214. <http://doi.org/10.1016/j.ympev.2014.05.018>
- Smith L.B. (1957) Bromeliaceae. In: Maguire B., Wurdack J.J. and Collaborators (eds) *Botany of the Phelps' Venezuelan Guayana Expeditions-II Ujapan-tepui, Estado Bolivar*. *Memoirs of the New York Botanical Garden* 9(3): 283–318.
- Smith L.B. (1960) Bromeliaceae. In: Maguire B., Wurdack J.J. and Collaborators (eds) *The Botany of the Guayana Highland – Part IV*. *Memoirs of the New York Botanical Garden* 10(2): 1–37.
- Smith L.B., Downs R.J. (1974) Pitcairnioideae (Bromeliaceae). *Flora Neotropica* 14(1). New York, Hafner Press.
- Steyermark J.A. (1974) The summit vegetation of Cerro Autana. *Biotropica* 6: 7–13. <https://doi.org/10.2307/2989692>
- Thiers B. (2016) *Index Herbariorum: a global directory of public herbaria and associated staff*. New York Botanical Garden's Virtual Herbarium. Available from <http://sweetgum.nybg.org/science/ih/> [accessed 10 May 2017].

Manuscript received 14 Aug. 2017; accepted in revised version 11 Jan. 2018.

Communicating Editor: Elmar Robbrecht.