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Bulbostylis itremoensis (Abildgaardieae, Cyperaceae), a new sedge species from Madagascar

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Summary. An endemic species of *Bulbostylis* (Abildgaardieae, Cyperaceae) from Madagascar is described as new to science. *Bulbostylis itremoensis* is only known from two localities: the Itremo and Isalo massifs in the province of Fianarantsoa. The species can be recognised by its habit with numerous crowded culms, leaves and thick, soft roots with an outer mycorrhizal layer. Its culm is hairy, angular with about 10 rounded longitudinal ridges without conspicuous surface cells. The leaf sheaths are light brown to straw-coloured with numerous longitudinal nerves, densely short-hairy on the nerves but with numerous flexuose whitish hairs at their oblique orifices. Its inflorescence is a dense hemispherical head of c. 15 crowded spikelets with many erect or spreading involucral bracts. Its glumes are ovate, densely scabrid of which medium-reddish brown with a prominent 1 – 3-nerved green midrib ending below the obtuse apex or excurrent into a short mucro. This species is described, illustrated and compared to the other species of *Bulbostylis* that occur in the Itremo Massif Protected Area.

Key Words. Conservation status, new species, taxonomy.

Introduction

Species of genus *Bulbostylis* Kunth (Abildgaardieae, Cyperaceae) are small to medium-sized annuals or tufted perennials, rarely with an elongated rhizome and rarely forming a caudex. Their culms are scapose and their leaves generally eligulate, with two lateral tufts of long white hairs at the sheath mouth. Rarely, the leaves are reduced to a sheath. Inflorescences are terminal, rarely pseudolateral, anthelate or capitate with few to many spikelets, or reduced to a single spikelet. The primary bracts are short, not sheathing, rarely the lowermost bract leaf-like and erect. Their spikelets are often with many densely spirally (rarely distichously) arranged, usually deciduous glumes (exceptions are the species previously placed in *Nemum* Desv.), each subtending a flower. *Bulbostylis* flowers are bisexual without bristles. The number of stamens is 1 – 3. The style is 3-fid (rarely 2-fid) and the style base is distinct, thickened, persistent, rarely only slightly thickened or deciduous. The nutlet is obovoid to obpyriform, rounded trigonous, rarely dorsiventrally lenticular, surface with various ornamentations, rarely smooth. Additionally, *Bulbostylis* species use C_4 photosynthesis (Bruhl & Wilson 2007). Currently, 23 species of *Bulbostylis* are known to occur on the island of Madagascar, 15 of which are endemic (Larridon *et al.* 2021; POWO 2021).

Two studies led to the discovery of this new species to science. The first study was by Kåre Arnstein Lye who wrote a preliminary taxonomic revision of the species of *Bulbostylis* of Madagascar (Lye unpubl. data), and who annotated several specimens with "*Bulbostylis itremoensis* Lye" in the P and TAN herbaria (herbarium acronyms follow Thiers 2021, continuously updated). The second study is that by the current authors, focussed on the Cyperaceae of the Itremo Massif Protected Area.

The Itremo Massif Protected Area is located 117 km West of Ivato-Ambositra, in the district of Ambatofinandrahana, region of Amoron'i Mania, province of Fianarantsoa, between 20°35'40"S and 20°36'10"S, and between 46°38'10"E and 46°14'35"E. The protected area covers c. 24,000 ha (Ralimanana *et al.* 2018) and is managed by the Kew Madagascar Conservation Centre. The area is composed of a range of vegetation types (humid forest (1.3% of total surface), Tapia woodland (6.4%), grasslands (70.4%), xerophytic vegetation (10.5%) and wetlands (0.4%) (KMCC 2012) found between 1400 – 1900 m in elevation. The recent MSc project by the first author revealed that in the Itremo Massif Protected Area, we find one subfamily of Cyperaceae (subfamily Cyperoideae), 10 tribes (Abildgaardieae, Cariceae, Cypereae, Eleocharideae, Fuireneae, Rhynchosporeae, Schoeneae, Schoenoplecteae,

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Sclerieae, and Trilepideae), 12 genera (*Bulbostylis*, *Carex* L., *Coleochloa* Gilly, *Costularia* C.B.Clarke, *Cyperus* L., *Eleocharis* R.Br, *Fimbristylis* Vahl, *Fuirena* Rottb., *Rhynchospora* Vahl, *Schoenoplectiella* Lye, *Schoenoplectus* (Rchb.) Palla, and *Scleria* P.J.Bergius), and 66 species (Rasaminirina 2021). Of the 66 species, 46 are native but not endemic to Madagascar, 16 are endemic to Madagascar and 4 are endemic to the high plateau of Madagascar. The species here described as new to science is endemic to the high plateau of Madagascar (Rasaminirina 2021). After *Cyperus*, *Bulbostylis* is the most species-rich genus. Including the new species, eight species of *Bulbostylis* occur in the Itremo Massif Protected Area of which four are endemic to Madagascar and one is endemic to the high plateau of Madagascar (Rasaminirina 2021). Below, the new species is described, illustrated and compared to the other species of *Bulbostylis* which occur in Itremo Massif Protected Area.

Material and Methods

Morphological study

Specimens were newly collected for this study during fieldtrips to the Itremo Massif Protected Area (4 localities: Analandramanjato, Tsimahabeomby, Andohanantanimena and Ambatomenaloha) in December 2019 and February 2020. The literature survey carried out before the fieldtrip collections allowed the author to recognise the here described species as new to science during the fieldtrip, later confirmed by detailed observations. The newly collected material and existing herbarium material held at the TAN herbarium at Parc Botanique et Zoologue de Tsimbazaza was examined first-hand by the first author. Dried and newly collected specimens were studied using a LEICA S9E microscope to study the vegetative organs, a CARSON MicroBrite 60 – 120× LED Lighted Pocket Microscope and Meiji Techno EMZ-TR binocular microscope allowed observations of the nutlets. Measurements were taken by hand with a standard ruler or using a hand lens with graticule for smaller characters (such as glume, style and nutlet length). The nutlet of the newly described species was photographed by a Motic™ MOTICAM S3 digital USB camera 3.0 MP for Microscopy, and photos illustrating the specimens were taken by a high-resolution camera. Digitised collections from the Muséum national d'Histoire naturelle, Paris (P) were studied remotely to develop encompassing descriptions for each species. Specimens seen by the authors are indicated by !, specimens seen online are indicated by *.

Distribution and conservation assessment

Herbarium specimens for which coordinates were not yet available, were georeferenced using the *Gazetteer to Malagasy Botanical Collecting Localities* (Schatz *et al.* 2003) and Google Earth. Conservation assessments were produced following the guidelines set out in the IUCN Categories and Criteria v.3.1 (IUCN 2012). To generate threat categories, the minimum Area of Occupancy (AOO) and estimated Extent of Occurrence (EOO) for each species was calculated using GeoCAT (Bachman *et al.* 2011).

Taxonomic Treatment

Bulbostylis itremoensis *Lye ex Rasam.* **sp. nov.** Type: Madagascar, Along road between Finandrahana and Itremo, 27 – 40 km W of Finandrahana, 1400 – 1500 m, 16 Jan. 1975, *T. B. Croat* 29845 (holotype: P 01868145*; isotypes: MO, TAN!).

http://www.ipni.org/urn:lsid:ipni.org:names:77295612-1

A densely tussocky perennial with numerous crowded culms, leaves and 0.5 – 2.0 mm thick, soft *roots* with an outer mycorrhizal layer. *Culms* 5 – 20 cm long and 0.3 – 0.6 mm thick, angular to almost terete with about 10 rounded longitudinal ridges and without conspicuous surface cells, with few – numerous, 0.3 – 0.7 mm long spreading or somewhat adpressed whitish hairs (on old culms with mature nutlets almost all the hairs are sometimes torn away); the lower part of the plant is usually densely white-woolly: the basal prophylls about 10 mm long, reddish-brown with two prominent scabrid ribs. Leaves from the lower 4 cm only and 4 – 6 leaves per culm; sheaths light brown (ferrugineus) to straw-coloured with numerous longitudinal nerves, densely short-hairy on the nerves (hairs 0.2 mm long), but with numerous 2 – 4 mm long flexuose whitish hairs at their oblique orifices; blades to 10 cm long and 0.3 – 0.6 mm wide, flat when wet, but strongly incurved when dry, with 3 – 5 longitudinal nerves on lower surface and no nerves on upper surface, which has about 10 longitudinal cell rows, scabrid to short-hairy particularly on margin; large rectangular surface cells often prominent on both surfaces. *Inflorescence* is a dense hemispherical head to about 10 mm in diam. consisting of c. 15 crowded spikelets, but young developing inflorescences may appear as being composed of a few spikelets only; occasionally one of the spikelets is set on an up to 7 mm long peduncle. Involucral bracts many, at least one (often 2 – 3) conspicuous with green midrib excurrent into a green scabrid leaf-like blade longer than the inflorescence; the largest 5 – 20 mm long, erect or spreading; its basal part, however, glume-like, reddish-brown with numerous long flexuose hairs along its margins. *Spikelets* 3 – 5 mm long and 1.5 – 2.5 mm long. Scale below glume absent. *Glumes*

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3.0 – 4.0 mm long and 1.0 – 1.5 mm wide, ovate, densely scabrid (hairs 30 – 40 µm long), but up to 120 µm long hairs on margin, medium reddish-brown with no lateral nerves, but with a prominent 1 – 3-nerved green midrib ending below the obtuse apex or (in the lower-most glumes) excurrent into a short mucro; epidermis cells of glumes elongate and rectangular, mostly 30 – 60 µm long and 15 – 20 µm wide, with prominently sinuate cell walls; more than half of the cells strongly cutinised, other cells with 5 – 15 prominent papillae with satellites. *Stamens* 3, filaments about 4 mm long and 0.1 – 0.2 mm wide, flattened whitish to light reddish-brown; anther about 2.5 mm long and 0.6 – 0.7 mm wide, light reddish-brown (after anthesis) with the connective excurrent into a prominent about 0.2 mm long darker (reddish-brown) acute mucro; the four basal horns about 0.1 mm long, of the same colour as the anther. *Style* about 4 mm long, medium reddish-brown and ending in three 2.0 – 2.5 mm long papillose stigmas of the same colour as the lower part of the style. *Nutlet* 0.9 – 1.0 mm long and 0.6 – 0.7 mm wide, obovate, obtusely triangular, pale grey to light reddish-brown with a dark reddish-brown persistent style base, with 5 – 10 transverse wrinkles on each of the three sides; the angles prominent, papillose; outermost cells to pericarp linear with sinuate cell walls, 90 – 120 µm long to 20 µm wide, with a prominent papilla in the centre of each cell (top of wrinkle); the style base persisting on the mature nutlet as a flattened reddish-brown knob about 0.15 mm wide and 1.0 mm long. Figs 1, 2.

RECOGNITION. *Bulbostylis itremoensis* has numerous crowded culms, leaves and thick, soft roots with an outer mycorrhizal layer. Its culm is hairy, angular with about 10 rounded longitudinal ridges without conspicuous surface cells. Sheaths light brown to straw-coloured with numerous longitudinal nerves, densely short-hairy on the nerves but with numerous flexuose whitish hairs at their oblique orifices. Its inflorescence is a dense hemispherical head of crowded spikelets with many erect or spreading involucral bracts. *Bulbostylis itremoensis* glumes are ovate, densely scabrid of which medium reddish-brown with a prominent 1 – 3-nerved green midrib ending below the obtuse apex or excurrent into a short mucro.

DISTRIBUTION. *Bulbostylis itremoensis* is found in two localities in Madagascar's Fianarantsoa province: (1) the Itremo Massif, in the Amoron'i Mania region and Ambatofinandrahana district; and (2) Isalo Massif, in the Ihorombe region and Ihosy district.

SPECIMENS EXAMINED. MADAGASCAR. Mountains W of [Itremo] Betsileo on gneiss and quartzites in forest on eastern slopes, 1500 – 1700 m, 17 – 22 Jan. & 18 – 22 April 1955, *H. Humbert* 28211 (P 01868144*); Mountains W of [Itremo] Betsileo on gneiss and quartzites in forest on eastern slopes, 1500 – 1700 m, 17 – 22 Jan. & 18 – 22 April 1955, *H. Humbert* 30065 (P 01868143*); Itremo, in grass steppe on sand, Jan. 1964, *J. Bosser* 18950 (P 01868146*, TAN!); Along road between [Ambato-]Finandrahana and Itremo, 27 – 40 km W of [Ambato-]Finandrahana, 1400 – 1500 m, 16 Jan. 1975, *T. B. Croat* 29845 (MO, P 01868145*, TAN!); Fianarantsoa province, Itremo mountains c. 1 km E of the highest point of the road, 20°36'S, 46°35'E, 1600 m, 17 March 1995, *K. A. Lye & R. Rolland* 20892 (NLH, TAN!); Itremo mountains, near the highest point of the road, 20°36'S, 46°35'E, 1680 m, 17 March 1995, *K. A. Lye & R. Rolland* 20904 (NLH, TAN!); Fianarantsoa, Ihorombe, Ihosy, Isalo Mt 4 km S Ranohira, mountain road, 22°35'S, 45°26'E, 800 m, 19 March 1995, *K. A. Lye & R. Rolland* 20919 (NLH, TAN!); Fianarantsoa, Amoron'i Mania, Ambatofinandrahana, Itremo, Ambatomenaloha, 18 km W of Itremo, road to Amboropotsy along the RN 35, Wetland formation with Cyperaceae and Poaceae, 20°37'10"S, 46°33'29"E, 10 Feb. 2009, *M. Andriamahay & S. E. Rakotoarisoa* 2226 (K, SNGF, TAN!, TEF); Fianarantsoa, Amoron'i Mania, Ambatofinandrahana, Itremo Massif, Analandramanjato, 20°33'45.80"S 46°33'23.00"E, 1533 m , 5 Dec. 2019, *F. Rasaminirina* 14 (TAN!); Fianarantsoa, Amoron'i Mania, Ambatofinandrahana, Itremo Massif, Analandramanjato, 20°56'09"S, 46°57'04"E, 1663 m, 5 Dec. 2019, *F. Rasaminirina* 15 (TAN!); Fianarantsoa, Amoron'i Mania, Ambatofinandrahana, Itremo Massif, Tsimahabeomby, 20°37'09"S, 46°34'14"E, 1693 m, 27 Feb. 2020, *F. Rasaminirina* 62 (TAN!); Fianarantsoa, Amoron'i Mania, Ambatofinandrahana, Itremo Massif, Tsimahabeomby, 20°37'37"S 46°34'07"E, 1681 m, 27 Feb. 2020, *F. Rasaminirina* 71 (TAN!); Fianarantsoa, Amoron'i Mania, Ambatofinandrahana, Itremo Massif, Andohanantanimena, 20°31'06"S, 46°34'07"E, 1608 m, 27 Feb. 2020, *F. Rasaminirina* 83 (TAN!); Fianarantsoa, Amoron'i Mania, Ambatofinandrahana, Itremo Massif, Ambatomenaloha, 20°37'09"S, 46°34'06"E, 1676 m, 28 Feb. 2020, *F. Rasaminirina* 97 (TAN!).

HABITAT. *Bulbostylis itremoensis* is found among grassland on sandy soils, bare soil or in open forest on gneiss or quartzite rocks, humid or dry vegetation, 800 – 1700 m.

CONSERVATION STATUS. According to the IUCN Categories and Criteria v.3.1 (2012), the newly described species is Endangered based on a minimum Area of Occupancy 28 km^2, an estimated Extent of Occurrence of c. 715 km^2, and occurring at c. 3 locations. Threats include increased frequency of fire which reduces quality of habitat although the direct impact on the species is unknown, requiring further study.

ETYMOLOGY. The species has mostly been found and collected from the Itremo Massif, and Lye originally thought it was endemic to this area, hence he suggested the species epithet "itremoensis".

NOTES. *Bulbostylis itremoensis* does not show much infraspecific morphological variation. The late J. Raynal identified the specimen *Croat* 29845 which belongs to the new species as *B. pseudocollina* Cherm. However, these species are

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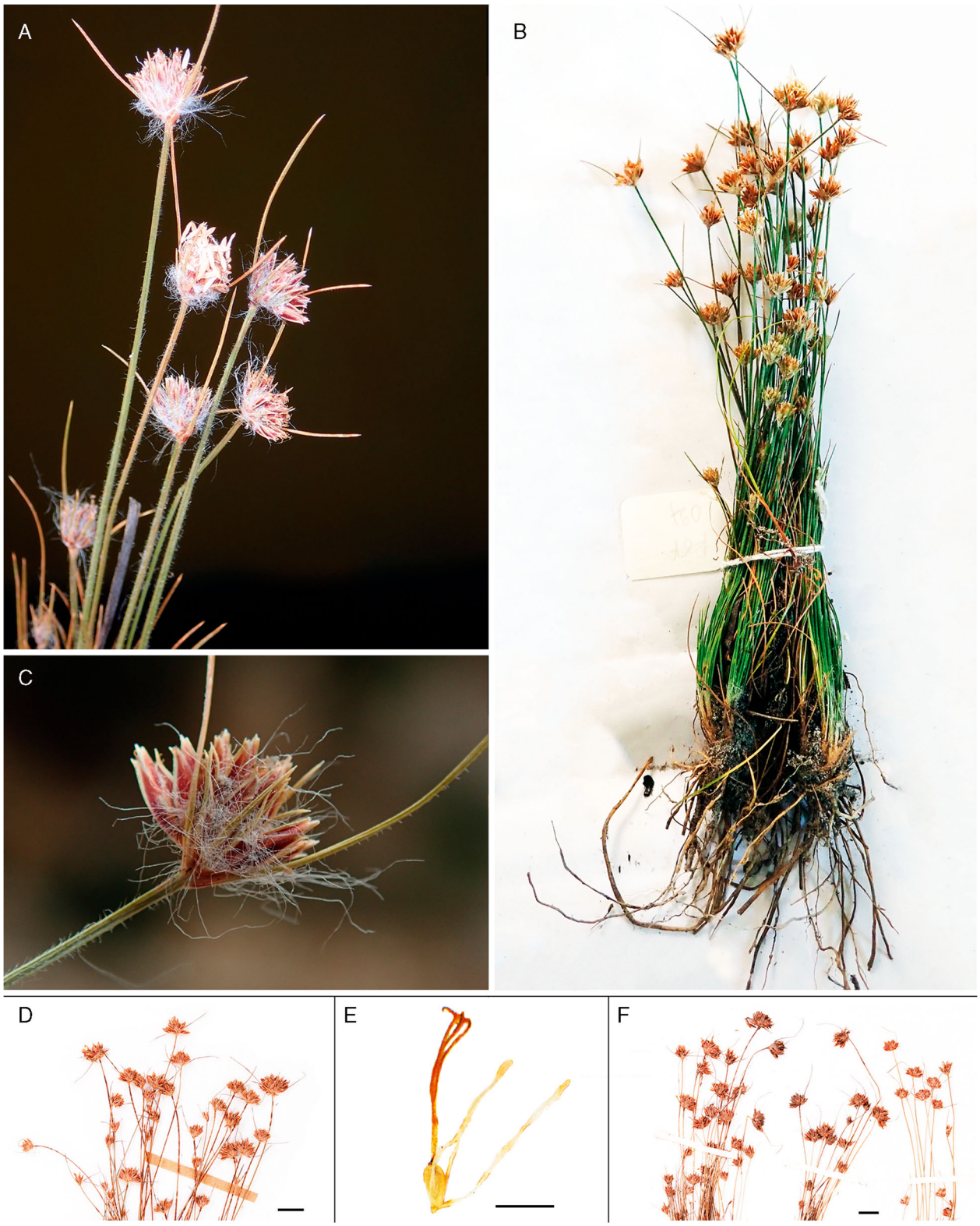

Fig. 1. *Bulbostylis itremoensis*. **A** inflorescences; **B** habit; **C** detail of inflorescence head; **D** inflorescences (young); **E** flower with 3 style branches, 3 stamens and a young fruit; **F** inflorescences (old). **A**, **C** from *Rasaminirina* 14 (TAN); **B**, **E** from *Rasaminirina* 97 (TAN); **D** from *Lye & Rolland* 20919 (TAN); **F** from *Lye & Rolland* 20892 (TAN). Scale bars: **D**, **F** = 1 cm; **E** = 1 mm.

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Fig. 2. *Bulbostylis itremoensis*, *Lye & Rolland* 20892 (TAN).

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Table 1. Morphological comparison between *Bulbostylis itremoensis* and the most similar species.

	Bulbostylis itremoensis	*Bulbostylis pseudocollina*	*Bulbostylis firingalavensis*
Culms	5 – 20 cm long, 0.3 – 0.6 mm thick with few – numerous whitish hairs	10 – 30 cm long, 0.5 – 1.0 mm thick glabrous	15 – 35 cm long, 0.4 – 0.8 mm thick glabrous
Leaf sheaths	light brown to straw-coloured with numerous longitudinal nerves, densely short-hairy on the nerves	greyish to light reddish-brown with 10 – 20 longitudinal ridges, densely set with white straight hairs	light reddish-brown or greyish with distinct longitudinal ridges, glabrous
Leaf blades	up to 10 cm long and 0.3 – 0.6 mm wide, flat when wet, strongly incurved when dry, with 3 – 5 longitudinal nerves on lower surface, no nerves on upper surface, scabrid to short-hairy particularly on margin	up to 5 – 10 cm long and 0.5 – 1.0 mm wide, flat to canaliculate, young blades with incurved margins when dry, with 3 – 7 longitudinal ridges on the lower side and 1 indistinct midrib on upper side, both sides densely set with erect white hairs	2 – 12 cm long and 0.2 – 0.5 mm wide, flat, folded or canaliculate, minutely scabrid at least on margin near the tip, lower surface with three distinct longitudinal ridges; upper surface without ridges
Inflorescence	a dense hemispherical head to c. 10 mm in diam. consisting of c. 15 crowded spikelets	a terminal head c. 1.5 cm in diam. consisting of 6 – 20 crowded spikelets or anthelate up to 8 cm long	a terminal globose head 4 – 12 mm in diam. consisting of 5 – 40 sessile spikelets
Involucral bracts	many, the largest 5 – 20 mm long	1 – 5, the largest 0.5 – 3.0 cm long	1 – 3, the largest 5 – 20 mm long
Spikelet size	3 – 5 mm long × 2.5 mm wide	5 – 8 mm long × 2 – 3 mm wide when flowering, stretching to c. 16 mm long and 5 mm wide when fruiting	3 – 4 mm long × c. 1.5 mm wide
Glume size (mm)	3.0 – 4.0 × 1.0 – 1.5	2.5 – 3.0 × c. 1.5	1.5 – 2.5 × 0.7 – 1.2
Stamen filaments (mm)	c. 4 × 0.1 – 0.2	c. 3 – 4 × 0.1	c. 1.5 – 2.0 × 0.1
Anthers (mm)	c. 2.5 × 0.6 – 0.7	1.5 – 2.0 × 0.2 – 0.3	c. 1.0 × 0.2
Anther connective	excurrent into a prominent c. 0.2 mm long acute mucro	ending in a short acute point	not prominently excurrent
Style length (mm)	c. 4	c. 2.5	c. 1.5
Stigmas	3, 2.0 – 2.5 mm long, papillose	3, c. 0.7 mm long, hairy	3, c. 0.7 mm long, hairy
Style base (mm)	0.15 × 1.0	0.1 × up to 0.1	much smaller, flattened
Nutlet size (mm)	0.9 – 1.0 × 0.6 – 0.7	0.8 – 0.9 × 0.6 – 0.7	0.6 – 0.8 × c. 0.5
Nutlet surface	with 5 – 10 transverse wrinkles on each of the three sides	smooth (perhaps immature) or minutely papillose	appears smooth, but is in fact micropapillate (only seen with high magnification)

morphologically clearly different (Table 1). In summary, *Bulbostylis pseudocollina* has thin roots, a thicker glabrous culm, wider and more hairy leaf blades, a larger inflorescence, larger spikelets, thicker glumes, a smaller style and a nutlet which is not transversely wrinkled. Also, while *B. itremoensis* grows in grasslands between 800 – 1700 m in the Itremo and Isalo massifs of central Madagascar, *B. pseudocollina* is native to dunes and other sandy habitats, from near sea-level to about 50 m in northwestern Madagascar. Additionally, we compare *B. itremoensis* with *B. firingalavensis* Cherm. which it resembles to some extent, e.g. both species have capitate inflorescences, but differs in *B. firingalavensis* having glabrous culms and leaf sheaths, narrow spikelets, smaller glumes and nutlets without transverse wrinkles (Table 1). The latter species is fairly widely distributed in Madagascar and overlaps in distribution range with the newly described species in the Isalo massif.

Lye (unpubl. data) intended to indicate a sheet of the collection *Lye & Rolland* 20892 as type. However, he was unable to distribute the duplicates to a range of herbaria before his death. Here, we opt to select a sheet from a different collection (*Croat* 29845) as type as it is available online to view by the global scientific community.

Identification key to *Bulbostylis* species occurring in the Itremo Massif

1. Annual plants; leaf length ≤ 2.5 cm. **2**
1'. Tussocky perennials or sometimes annual; leaf length ≥ 3 cm **4**
2. Inflorescence a solitary terminal spikelet . . . . . **B. densa**

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2'. Inflorescence a lax anthela. **3**
3. Spikelets 1.5 – 3.0 mm long . . . . . **B. micranthera**
3'. Spikelets 3 – 7 mm long . . . . . **B. densa**
4. Plants with thick, soft roots or a thick woody rhizome **5**
4'. Plants with a weak, slender or minute root system **7**
5. Spikelets 3 – 5 mm long and 1.5 – 2.5 mm wide . . . . . **B. itremoensis**
5'. Spikelets ≥ 5 mm long and usually wider **6**
6. Spikelets 5 – 8 mm long and 2 – 3 mm wide; filaments 2.5 – 3 mm long . . . . . **B. trichobasis**
6'. Spikelets 7 – 15 mm long and 4 – 5 mm wide; filaments 3.5 – 4.5 mm long . . . . . **B. schoenoides**
7. Inflorescence usually a simple or compound lax anthela, 1 – 5 cm wide . . . . . **B. hispidula**
7'. Inflorescence a solitary spikelet, one sessile spikelet subtended by one stalked spikelet, or a sessile group of spikelets, ≤ 1 cm wide **8**
8. Leaf sheaths light reddish-brown (cinnamon-coloured) without prominent nerves, glabrous but with numerous 3 – 5 mm long slender hairs at the oblique orifice; leaf blades up to 6 cm long . . . . . **B. viguieri**
8'. Leaf sheaths purplish with prominent pale longitudinal ridges, glabrous except for 1 – 2 mm long very slender and flexuose hairs at its orifice; leaf blades up to 2 cm long . . . . . **B. perrieri**

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We thank the late Kåre Arnstein Lye for all he did to increase the knowledge of African Cyperaceae, and for sharing his manuscript in preparation on the genus *Bulbostylis* in Madagascar with us so we can continue his work on this taxonomically complex sedge group. He was a very passionate and active Cyperologist and much appreciated by the international Cyperaceae research community now united in the recently formed International Sedge Society.

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