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The genus *Tristachya* (Poaceae: Panicoideae) in Madagascar

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Summary. We present a revision of the three species of *Tristachya* in Madagascar. The tussock-forming *T. betsileensis* is a rare endemic of the quartz outcrops in the Itremo Protected Area. The rhizomatous *T. isalensis* and *T. humbertii* are common components of the sandstone outcrop vegetation in the Isalo National Park. A new combination is made. Descriptions, conservation assessments, illustrations, and a distribution map are presented.

Key Words. Africa, conservation, grass, identification key, new combination, savanna, Tristachyideae.

Introduction

The genus *Tristachya* sensu lato (sometimes including *Dilophotriche, Loudetiopsis*, and *Zonotriche*) unites an estimated forty primarily African tropical savanna grasses that are usually easy to recognise by their large spikelets arranged in groups of three (Clayton & Renvoize 1986; Kellogg 2015; Soreng *et al.* 2017). Variability in the spikelet arrangement, upper floret callus, and indumentum has led to a complex history of generic classifications within this group, all members of which are currently recognised within the tribe Tristachyideae Sánchez-Ken & L.G.Clark, subfamily Panicoideae (Clayton & Renvoize 1986; Sánchez-Ken & Clark 2010; Kellogg 2015; Soreng *et al.* 2017). Like many African grasses, no monographic or revisionary work has recently been attempted beyond regional floras (e. g. Clayton *et al.* 1974; Fish *et al.* 2015), and to date there is no agreement on the delimitation of the genus *Tristachya* between Clayton *et al.* (2016), Kellogg (2015) and Soreng *et al.* (2017). Glumes of the African and Malagasy *Tristachya* exhibit macrohairs with distinctive black pustules at the base (Figs 1F, 2A; Kellogg 2015): these are usually referred to as bulbous-based or tubercle-based hairs (Clayton *et al.* 1974; Fish *et al.* 2015).

The ancestors of Malagasy *Tristachya* arrived on the island from Africa an estimated 5 – 7 Ma (Hackel *et al.* 2018), during the early part of the Miocene C4 grassland expansion (Edwards *et al.* 2010). The first two species were described by Aimée Camus in the genus *Tristachya* (Camus 1926, 1957). The third was described in the genus *Danthoniopsis* (Camus 1958, 1960) and has no combination in *Tristachya*. All three were united into the endemic Malagasy genus *Isalus* by Phipps (1966), distinguished by its 6 – 8 tufts of hair and bristled lobes on the upper lemma. The genus *Isalus* was accepted by Bosser (1969). This Malagasy radiation was then shown to be embedded within *Tristachya* by Hackel *et al.* (2018). We therefore follow Clayton & Renvoize (1986) in recognising these three species within the larger genus *Tristachya*.

Grass surveys of the Itremo Protected Area (Nanjarisoa *et al.* 2017) and the Isalo National Park (Rakotomalala *et al.* 2021) have enabled us to compile field observations suggesting that all three species are associated with rocky outcrops and adapted to fires, with rapid resprouting after fire; herbarium specimens of all the species commonly exhibit charring. A full specimen survey was carried out at K, P, and TAN herbaria. We summarise the current knowledge of *Tristachya* in Madagascar and publish the missing combination, alongside an identification key, typifications, species descriptions, illustrations, and a distribution map. All specimens cited were seen by the authors.

Tristachya *Nees* (Nees von Esenbeck 1829: 458). Lectotype: *Tristachya leiostachya* Nees, designated by Swallen (in Hitchcock *et al.* 1939: 578).
Isalus J.B.Phipps (1966: 232).

Long-lived perennials with contracted or elongated woody underground rhizomes. Inflorescence terminal, a simple or branched panicle. Spikelets bisexual, arranged in dense triads of 3 identical spikelets subtended by an inflorescence branch. Glumes persistent, chartaceous. Lower glume positioned on the outside of the triad, long-acuminate, 3-nerved, with

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bulbous-based hairs. Upper glume similar to the lower glume but with few or no bulbous-based hairs. Lower floret sterile. Lower lemma membranous to chartaceous, shorter or somewhat longer than the glumes, 3 – 5-nerved. Upper floret bisexual, disarticulating on maturity. Upper lemma cylindrical, crustaceous, inrolled, with a fringe of white cilia c. 2/3 of the way up, the callus pungent, the apex bilobed with the awn originating between the two mucronate lobes. Awn twisted, geniculate.

Key to Malagasy *Tristachya* species

1. Tussock-forming (rhizomes contracted); leaves originate from the base of the plant, leaf blades more than 5 cm long..... **T. betsileensis**
1'. Rhizomatous (rhizomes elongated); leaves on leafy culms, most leaf blades less than 5 cm long…….....
2. Leaf blades 1 – 2.5 mm wide at base; apical lobes of the upper lemma c. 1 mm long.....**T. isalensis**
2'. Leaf blades (2 –) 3 – 4.5 mm wide at base; apical lobes of the upper lemma 2 – 3 mm long….....**T. humbertii**

Tristachya betsileensis *A.Camus* (1957: 160). *Isalus betsileensis* (A.Camus) J.B.Phipps (1966: 233). Type: Madagascar, Fianarantsoa: western slopes of the western Itremo mountains, on gneiss and quartz, 1500 – 1700 m, 17 Jan. 1955, *Humbert* 30085 (holotype P00446275!; isotypes K001323697! [fragment], P00446276!, P00446277!).

Tussock-forming perennial, the culms 30 – 70 cm tall. Rhizomes contracted, 3 – 4 mm wide. Culms sometimes branched, erect, glabrous, the leaves appearing basal. Basal leaf sheaths glabrescent. Leaf sheaths glabrous. Ligule a fringe of hairs (not bulbous-based). Leaf blades linear, rolled, 5 – 15 cm long, c. 1 mm wide at base, straight to gently curled, glabrous. Inflorescences unbranched, 4 – 9 cm long, composed of 3 – 6 triads of spikelets in a lax panicle with 1 – 2 triads at the lowermost branching point. Inflorescence branches subtending the triads filiform, often curved. Spikelet triads 9 – 14 mm long not including awns. Lower glume 9 – 12 mm long, glabrous, with bulbous-based trichomes on the nerves and the area between the nerves. Upper glume and lower lemma glabrous. Upper lemma brown, hirsute in the lower c. 2/3, the callus hirsute, with white callus hairs exceeding the base of the lemma, the lobes with a mucro 1 – 2 mm long. Awn 12 – 15 mm. Fig. 2.

DISTRIBUTION. Madagascar: Fianarantsoa, Itremo Protected Area. Map 1.
SPECIMENS EXAMINED. MADAGASCAR. Fianarantsoa: Itremo massif, Andohantanimenaha, 1600 m, 25 Feb. 2013, *Vorontsova et al.* 1003 (K, TAN); Itremo, April 1964, *Bosser* 19536 (P); Itremo, Andohatanimena, flanc de montagne avant d'entrer dans la forêt galérie, 1550 m, 19 Feb. 2014, *Nanjarisoa et al.* 144 (K, TAN).
HABITAT. Rare endemic restricted to open gneiss and quartzite outcrops at 1500 – 1700 m altitude.
CONSERVATION STATUS. Assessed here as Critically Endangered (CR) due to its extent of occurrence below 100 km^2, a total of just four known collections, and its apparent dependence on gneiss and quartz rocky habitats which are under direct threat from illegal mining both outside and within the Itremo Protected Area (IUCN 2001; Kew Madagascar Conservation Centre 2012).
NOTES. Unusual, easy to recognise bunchgrass. Its populations, habitats, relationships with grazers, and seed dispersal mechanisms remain poorly known and are in need of study.

Tristachya isalensis *(A.Camus) Voronts. & Rakotom.* **comb. nov.**

http://www.ipni.org/urn:lsid:ipni.org:names:77219675-1

Isalus isalensis (A.Camus) J.B.Phipps (1966: 233). *Danthoniopsis isalensis* A.Camus (1958 : 245). Type: Madagascar, Toliara: Isalo, plateaus and valleys west of Ranohira, 800 – 1250 m, 29 Jan. – 10 April 1955, *Humbert* 28663 (holotype P00446278!; isotype P00446279!).

Creeping mat-forming perennial, the culms reaching up to 60 – 70 cm above ground level. Rhizomes usually at least 5 cm long, 2 – 5 mm wide. Culms not branched, prostrate or ascending, glabrous, with leaves evenly distributed over the culms. Basal leaf sheaths glabrescent. Leaf sheaths glabrous or with bulbous-based hairs on and near the margins. Ligule a fringe of hairs, sometimes with bulbous-based hairs around the ligule area. Leaf blades linear, flat or rolled, 1.5 – 5 (– 8) cm long, 1 – 2.5 mm wide at base, straight to gently curled, glabrescent to hirsute, often with bulbous-based hairs on and near the margins. Inflorescences un-

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Fig. 1. *Tristachya* in the Isalo National Park, Madagascar: **A, B, D, F** *Tristachya isalensis.* **C, D, E** *Tristachya humbertii*. **D** young shoots of both species growing together: *T. isalensis* with narrow leaf blades is seen in the middle between *T. humbertii* with broader leaf blades. PHOTOS: **A – E** M. S. VORONTSOVA, **F** N. RAKOTOMALALA.

branched or branched, 4 – 11 cm long, composed of 3 – 15 triads of spikelets in a condensed panicle, the panicle branches opening at maturity with 1 – 6 triads at the lowermost branching point. Inflorescence branches subtending the triads straight. Spikelet triads 8 – 12 (– 15) mm long not including awns. Lower glume 7.5 – 11.5 (– 17) mm long, glabrous, with bulbous-based trichomes on the nerves. Upper glume and lower lemma glabrous. Upper lemma white becoming brown, hirsute to glabrescent in the lower c. 2/3, the callus hirsute, with white callus hairs exceeding the base of the lemma, the lobes with a mucro c. 1 mm long. Awn 10 – 17 mm. Figs 1A, B, D, F, 3, 4.

DISTRIBUTION. Madagascar: Fianarantsoa. Map 1.

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Fig. 2. *Tristachya betsileensis*. A spikelet triads; B habit. PHOTOS: M. S. VORONTSOVA, PLATE COMPOSITION: SARAH Z. FICINSKI.

SPECIMENS EXAMINED. MADAGASCAR. Fianarantsoa: sud de Madagascar, entre Ambalavao et l'Isalo, 14 Oct. 1970, *Keraudren-Aymonin et al.* 24657 (P); Isalo, 23 May 1930, *Basse* s.n. (P); Isalo, Feb. 1956, *Bosser* 8979

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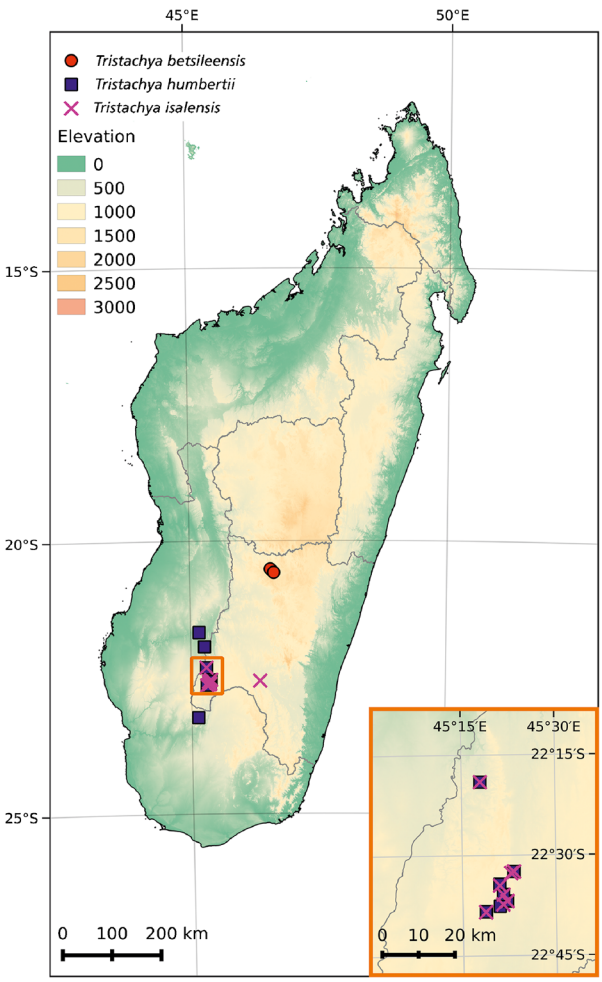

Map 1. Distribution of *Tristachya* in Madagascar. Elevation data from Jarvis *et al.* (2008). DRAWN BY SARAH Z. FICINSKI.

(P, TAN); col des tapias, Isalo, Dec. 1959, *Bosser* 13838 (P, TAN); Ilakatra, Isalo, Feb. 1962, *Bosser* 15623 (P, TAN); près de Ranohira, Isalo, Feb. 1962, *Bosser* 15628 (P); environs de Ranohira, Isalo, Dec. 1963, *Bosser* 17393 (P, TAN); Ranohira, Isalo, Jan. 1964, *Bosser* 19107 (P, TAN); col du Tapias, Isalo, 11 March 1970, *Bosser* 19891 (P); near Ranohira, Isalo, Feb. 1962, *Bosser* 15628 (TAN); Isalo, 3 July 1972, *Bosser* 8977 (TAN); District d'Ihosy, poste de Ranohira, entre Tametsoa et Sahanafo au nord de l'Isalo, Sahanafa, 700 – 1100 m, 30 Jan. 1955, *Cours* 5063 (P); Isalo (Ranohira), 4 March 1943, *Decary* 18944 (P); plateaux et vallées de l'Isalo a l'Ouest de Ranohira, 800 – 1250 m, 29 Jan. 1955, *Humbert* 28663 (P); plateaux et vallées de l'Isalo a l'Ouest de Ranohira, 800 – 1250 m, 29 Jan. 1955, *Humbert* 29865 bis (P); 2e col des tapia (entre Ranohira et Sakaraha), 31 Oct. 1960, *Leandri* 3502 (P); 2e col des tapias (entre Ranohira et Sakaraha), 31 Oct. 1960, *Leandri* 3509 (P); 2e col des tapia (entre Ranohira et Sakaraha), même forme que 3502, 31 Oct. 1960, *Leandri* 3511 (P); Isalo, Feb. 1967, *Morat* 2611 (P, TAN); col des tapias, Isalo, Feb. 1967, *Morat* 2612 (P); (Vohidolo côte 700 m) entre la Menarahaka et Ihosy, 700 m, May 1973, *Morat* 4243 (P); Ilakaka (Isalo), 21 Feb. 1961, *Peltier et al.* 2986 [a] (P); Isalo National Park, trail to the Piscine Naturelle, 300 m from the car park, 875 m, April 2018, *Rakotomalala et al.* 179 (TAN, K, P); Isalo, 18 April 1968, *Rakotozafy* 743 bis (P, TAN); near Isalo Interpretation Centre, outside Isalo Rock Lodge, 22°37'21"S, 45°21'27"E, 850 m, 26 Feb. 2017, *Vorontsova et al.* 2115 (TAN); Isalo National Park, Malaso circuit, W of Isalo boot, 22°35'55"S, 45°21'32"E, 900 m, 27 Feb. 2017, *Vorontsova et al.* 2145 (K, MO, P, TAN); Isalo National Park, end of the Malaso circuit towards the Malaso caves, 22°34'32"S, 45°20'58"E, 900 m, 2 March 2017, *Vorontsova et al.* 2187 (TAN); Isalo National Park, Fenetre de Isalo, 22°38'28"S, 45°18'41"E, 850 m, 2 March 2017, *Vorontsova et al.* 2212 (TAN).

HABITAT. Sandstone outcrops and crevices, under tapia canopy as well as in open savanna; frequently burned habitats as well as those sheltered from fire; 700 – 1250 m.

CONSERVATION STATUS. Assessed here as Vulnerable (VU) due to its extent of occurrence below 5,000 km^2, distribution apparently limited to sandstone substrates, and long-term protection within the boundaries of the Isalo National Park (IUCN 2001; Madagascar National Parks 2017).

NOTES. *Tristachya isalensis* is distinguished from *T. humbertii* by its narrower leaf blades. *Tristachya isalensis* and *T. humbertii* commonly occur together (Fig. 1D) and are frequently collected together. *Tristachya isalensis* has been collected more frequently than *T. humbertii* due to its apparently more common occurrence near the roads and paths of Isalo National Park — although it is less widespread across western Madagascar.

Tristachya humbertii *A.Camus* (1926: 401). *Isalus humbertii* (A.Camus) J.B.Phipps (1966: 233). *Danthoniopsis humbertii* (A.Camus) Conert (1957: 324). Type: Madagascar, Toliara: Isalo, Sakamarekely and Sambalinieto gorges, 500 – 100 m, 19 – 25 Oct. 1924, *Humbert* 2851 (holotype P00446280!; isotypes B 10 0168867!, G00022712!, GH00024562!, K001323699!, K001323700!, K001323701!, P00446281!, US00141971!).

Creeping mat-forming perennial, the culms reaching up to 30 (– 60) cm above ground level. Rhizomes usually at least 5 cm long, 3.5 – 6 mm wide. Culms not branched, prostrate or ascending, glabrous, with leaves evenly distributed over the culms. Basal leaf sheaths hirsute. Leaf sheaths glabrous or with bulbous-based hairs on and near the margins. Ligule a fringe of hairs, sometimes with bulbous-based hairs around the ligule area. Leaf blades lanceolate, flat or rolled,

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Fig. 3. *Tristachya isalensis*: plant base with knotty rhizomes and bases of culms. From *Rakotomalala et al.* 179. DRAWN BY N. RAKOTOMALALA.

2.5 – 5 (– 6) cm long, (2 –) 3 – 4.5 mm wide at base, straight when young, stiff and curling back strongly with age, glabrescent to hirsute, often with bulbous-based hairs on the margins. Inflorescences unbranched, 6 – 11 cm long, composed of 10 – 12 triads of spikelets in a lax to condensed panicle with 1 – 6 triads at the lowermost branching point. Inflorescence branches subtending the triads straight. Spikelet triads 8.5 – 14 mm long not including awns. Lower glume (6.5 –) 9.5 – 13.5 mm long, glabrous, with bulbous-based trichomes on the nerves. Upper glume and lower lemma glabrous. Upper lemma brown, hirsute in the lower 2/3, the callus hirsute, with white callus hairs exceeding the base of the lemma, the lobes with a mucro 2 – 3 mm long. Awn 7 –14 mm. Figs 1C, D, E, 5.

DISTRIBUTION. Madagascar: Fianarantsoa and Toliara. Map 1.

SPECIMENS EXAMINED. MADAGASCAR. Fianarantsoa: Isalo, Feb. 1956, *Bosser* 8978 (P); massif de l'Isalo, 31 Oct. 1940, *Decary* 16307 (P); bassin de la Malio près d'Ambalabe, 400 – 450 m, 23 Nov. 1946, *Humbert* 19388 (P); Isalo, 3 July 1972, *Humbert* 2891 (TAN); plateau de l'Isalo, col des tapias au S-W de Ranohira, 0 – 1000 m, Oct. 1933, *Humbert* 11216 (P); plateaux et vallées de l'Isalo, partie Nord, au S de Sahanafo, Sahanafa, 1000 m, 28 Nov. 1946, *Humbert* 19510 (P); Isalo, May 1965, *Morat* 1154 (P, TAN); col des tapias, Isalo, Feb. 1967, *Morat* 2613 (P, TAN); Isalo National Road, circuit Malaso, 878 m, 21 April 2018, *Rakotomalala et al.* 102 (K, TAN); *Trachypogon* grassland outside Isalo; c. 5 km from Ranohira towards Llakaka, 820 m, 20 April 2014, *Vorontsova et al.* 1369 (TAN); Isalo National Park, Malaso circuit W of Isalo boot, 900 m, 27 Feb. 2017, *Vorontsova et al.* 2150 (K, MO, P, TAN); Isalo National Park, end of the Malaso circuit towards the Malaso caves, west Ampasimaiky, 850 m, 2 March 2017, *Vorontsova*

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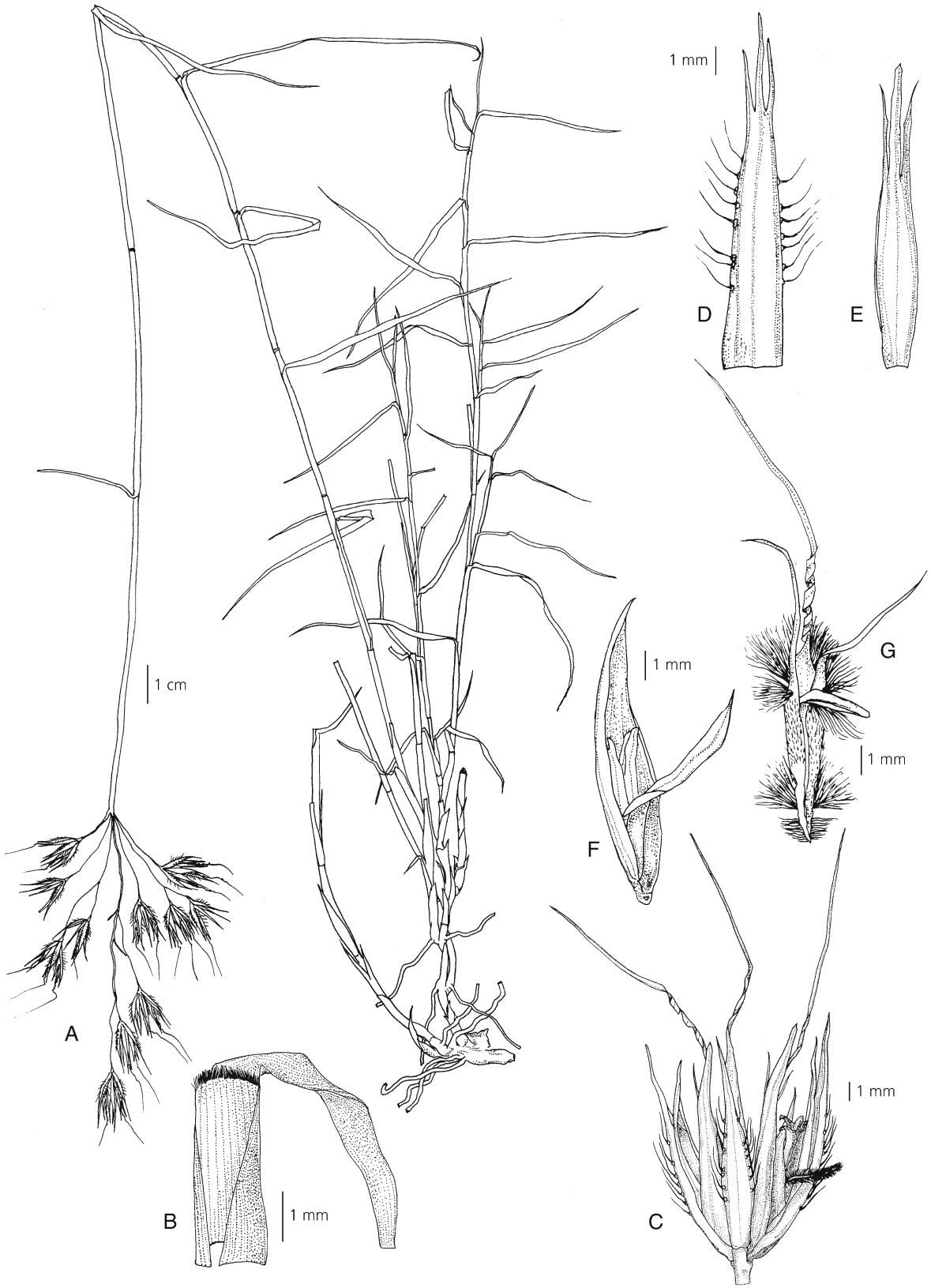

Fig. 4. *Tristachya isalensis*: **A** habit; **B** ligule; **C** spikelet triad; **D** lower glume, dorsal view; **E** upper glume, dorsal view; **F** lower floret, ventral view; **G** upper floret with bilobed awned lemma, ventral view. From *Rakotomalala et al.* 179. DRAWN BY N. RAKOTOMALALA, PLATE COMPOSITION BY SARAH Z. FICINSKI.

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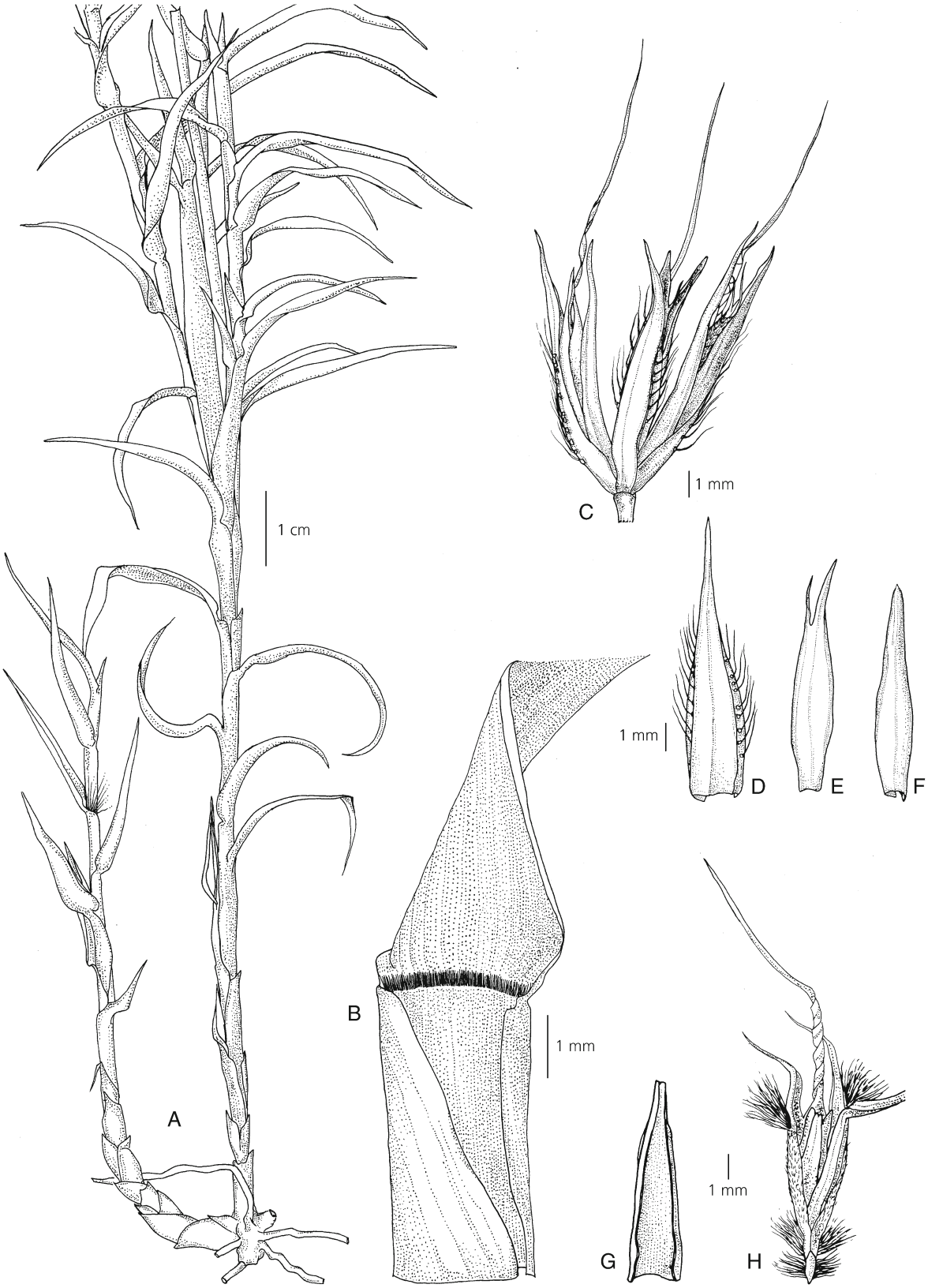

Fig. 5. *Tristachya humbertii*: **A** habit; **B** ligule; **C** spikelet triad; **D** lower glume, dorsal view; **E** upper glume, dorsal view; **F** lower lemma, dorsal view; **G** lower palea, ventral view; **H** upper floret with bilobed awned lemma, ventral view. From *Rakotomalala et al.* 102. DRAWN BY N. RAKOTOMALALA, PLATE COMPOSITION BY SARAH Z. FICINSKI.

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et al. 2190 (K, MO, P, TAN); Isalo National Park, Fenetre de Isalo, 850 m, 2 March 2017, *Vorontsova et al.* 2201 (TAN). **Toliara:** plateaux et vallées de l'Isalo, gorges de la Sakamarekely et de la Sambalinieto, Sakamarekely gorge, 700 – 1000 m, 19 Oct. 1924, *Humbert* 2851 (P); vallées du Mangoky et de l'Isahaina, aux environs de Beroroha, 0 – 300 m, Oct. 1933, *Humbert* 11351 (P).

HABITAT. Sandstone outcrops and crevices, under tapia canopy as well as in open savanna; frequently burned habitats as well as those sheltered from fire; 700 – 1000 m.

CONSERVATION STATUS. Assessed here as Vulnerable (VU) due to its extent of occurrence below 5,000 km^2, distribution apparently limited to sandstone substrates, and long-term protection within the boundaries of the Isalo National Park (IUCN 2001; Madagascar National Parks 2017).

NOTES. *Tristachya humbertii* is distinguished from *T. isalensis* by its broader and stiffer leaf blades that curl as the plant dries. It has a broader distribution across southwestern Madagascar.

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