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RESEARCH ARTICLE

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Reestablishment of *Pycreus* section *Tuberculati* (*Cyperaceae*)

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Key words

Africa
Cyperaceae
Pycreus sect. *Tuberculati*
Pycreus africanus
Pycreus divulsus
scanning electron microscopy
taxonomy

Abstract *Pycreus* sect. *Tuberculati* was created by Chermezon to contain a single species with derived nutlets: *P. divulsus*, a Malagasy endemic. Kükenthal transferred this species to his new section *Muricati*. However, a detailed study of the nutlet epidermis shows *P. divulsus* is not closely related to the other species Kükenthal placed in the latter section. In addition *P. divulsus* subsp. *africanus* is upgraded to the species level based on its larger, smooth nutlets and African continental range.

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INTRODUCTION

The genus *Pycreus* P.Beauv. consists of around 120, mainly African species, all characterised by their combination of indehiscent spikelets with distichous glumes and laterally compressed pistils with only two style branches. Along with several other genera, *Pycreus* is nested within the C_4 clade of *Cyperus* (Muasya et al. 2001, 2002), showing many typical characteristics of this clade, such as an anthela composed of spikes and chlorocyperoid anatomy (Bruhl & Perry 1995, Soros & Bruhl 2000).

Pycreus divulsus (Ridl.) C.B.Clarke is an annual Madagascan endemic differing from the other *Pycreus* species by its reduced, simply spicate inflorescence comprising a few large spikelets, each sessile in the axil of a large bract and arranged in a single spike. In addition, the internodes of the main axis are elongated (Hooper 1972), (Fig. 1a, b). Inflorescence reductions are quite common in *Pycreus* and related genera, and can be found in either annual species from seasonal habitats (e.g., *P. melanacme* Nelmes, *P. pauper* (Hochst. ex A.Rich.) C.B.Clarke, *P. atrorubidus* Nees from the Soudano-Zambezian floristic region) or in perennial species with dense fibrous culm bases, living in extreme habitats such as at high altitudes on mountains (e.g. *P. gracillimus* Chiov.) or frequently burnt vegetation (*P. fibrillosus* (Kük.) Cherm., *P. diloloensis* Kük. ex Cherm.). However, the combination of reduction and elongation of the internodes is unique to *P. divulsus*.

It is not only the inflorescence that makes this plant peculiar among other *Pycreus* species. The fruits also show special characteristics, which has led to several controversial classifications. At the time of its publication (Ridley 1884), a subgeneric classification for *Pycreus* was not yet available. Ridley (1884) related the species to *C. intermedius* Steud. and *C. stramineus* Nees since, as he stated, both rarely show signs of an elongation of the main axis, however never as prominent as in *C. divulsus*. Clarke (1908) was the first to prepare a detailed infrageneric classification of *Pycreus*. *Pycreus divulsus* was put in *Pycreus* subgenus *Reticulati* C.B.Clarke, which is characterised by (nearly) isodiametric nutlet epidermal cells, in contrast to his second subgenus *Zonati*, which has strongly elongated nutlet epidermal cells. At the sectional level Clarke placed *P. divulsus* together with *P. sanguinolentus* (Vahl) Nees, *P. atronervatus* (Boeckeler) C.B.Clarke, *P. mundtii* Nees and *P. atropurpureus* C.B.Clarke in *Pycreus* sect. *Vestiti* C.B.Clarke, from which it differs in having a completely different habit, inflorescence, different nutlets and glumes. It was Chermezon (1919) who remarked on the difficulties of classifying *P. divulsus* among the other known species and, based on the unique tuberculated nutlets of the species, he established a new section *Tuberculati.* Chermezon treated Clarke's two subgenera at the sectional rank as well, resulting in a classification with three sections. Kükenthal (1936), who considered *Pycreus* to be a subgenus of *Cyperus* L., placed *Pycreus* sect. *Tuberculati* Cherm. in synonymy with his new *Cyperus* (*Pycreus*) sect. *Muricati* Kük. The latter section was treated by Kükenthal in a rankless group *Zonati* C.B.Clarke, which includes the taxa with elongated nutlet epidermal cells. *Cyperus* sect. *Muricati* contains, next to *C. divulsus*, three other species: *C. pauper* (Hochst. ex A.Rich.) C.B.Clarke, *C. zonatissimus* Kük. and *C. muricatus* Kük. All these species are characterised by turgid nutlets with a strongly wavy or muricate surface. In his key, Kükenthal places *C. divulsus* most closely to *C. pauper*, which is also an annual species with rather large glumes and nutlets and a reduced inflorescence.

More recently Hooper (1972) identified several African collections that approximated to *P. divulsus* based on the presence of a simply spicate inflorescence. At first they were thought to be introductions of the Madagascan species to the African mainland. Considering the scattered collections of this species from all over tropical Africa and the distinct nutlets (smooth vs tuberculate) and three vs two anthers, the African specimens were described as *P. divulsus* subsp. *africanus* S.S.Hooper. The distinction between the two taxa is, however, clear cut and easily observed, so the species level seems more appropriate for the African taxon. Both taxa are poorly known and often unidentified in herbaria. A key and illustrations are included to overcome this problem in the future. The nutlet epidermis of these taxa was studied with SEM to evaluate their position in the Kükenthal (1936) classification.

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MATERIALS AND METHODS

Mature nutlets of representative herbarium specimens (Table 1) were mounted on aluminium stubs using Leit-C. For SEM observation, the material was coated with gold with a SPI-ModuleTM Sputter Coater (SPI Supplies, West-Chester, Pennsylvania, USA). Scanning electron microscope (SEM) images were obtained with a JEOL JSM-5800 LV scanning electron microscope at the National Botanical Garden of Belgium in Meise.

A distribution map of *P. divulsus* and *P. africanus* was created with Arcview GIS 3.2.

Table 1 Specimens used in the SEM study of nutlet epidermal cells.

Taxon	Collector and nr.	Herbarium	Country
P. africanus	*Léonard 4156*	BR	D.R. Congo
P. divulsus	*Perrier de la Bâthie 13052*	BR	Madagascar
P. muricatus	*Browning 633*	GENT	South Africa
P. pauper	*Taylor 9184*	BR	Tanzania
P. zonatus	*Robinson 5102*	GENT	Zambia

PYCREUS SECTION *TUBERCULATI*

Cyperus (*Pycreus*) sect. *Muricati* Kük. was established to unite the *Pycreus* species with turgid and muricate nutlets (Kükenthal 1936). It can be automatically typified under Art. 22.6 (McNeill et al. 2006) by the type of the name of the species from which the subdivisional epithet was derived, i.e. *C. muricatus* Kük. Although this section contains *C. divulsus*, which is the type of *Pycreus* sect. *Tuberculati* Cherm., established in 1919, he placed the latter in synonymy. Kükenthal's name, in its original circumscription, should therefore be considered as a superfluous later homonym for sect. *Tuberculati* (Art. 11.4 and 52.1 McNeill et al. 2006).

As Kükenthal (1936) noticed, the nutlets of *P. divulsus* resemble those of the other members of the section in their wavy aspect. However, SEM pictures from the nutlets of *P. divulsus*, *P. muricatus*, *P. pauper* and *P. zonatus* clearly show a difference in the shape of the nutlet epidermal cells. *Pycreus muricatus*, *P. pauper* and *P. zonatus* all have strongly elongated epidermal cells and due to this elongation, the tangential walls of the epidermal cells are lifted, resulting in the strongly wavy appearance of the nutlets (Fig. 1a–c). In other *Pycreus* species, for example *P. flavescens*, this elongation is less pronounced, which results in narrow transverse frills on the nutlet surface. In contrast, the nutlet epidermal cells of *P. divulsus* are isodiametric or only slightly elongated, as already correctly observed by Clarke (1908) (see Fig. 1d, e). Therefore we conclude that the classification of *P. divulsus* in the 'Zonati' and relationships with the other members of *Cyperus* (*Pycreus*) sect. *Muricati* by Kükenthal (1936) was based on superficial similarities and the name *Pycreus* sect. *Tuberculati* should be reserved for *P. divulsus* and its relatives. Only with exclusion of *P. divulsus*, *Cyperus* sect. *Muricati* becomes available for further use (Art. 52.3 McNeill et al. 2006).

TAXONOMY

Pycreus sect. ***Tuberculati*** Cherm.

Pycreus sect. *Tuberculati* Cherm. (1919) 65. — Type: *Pycreus divulsus* (Ridl.) C.B.Clarke.

Note — The section comprises *Pycreus* species characterised by a simply spicate inflorescence and large, asymmetrically turgid nutlets (abaxial side most swollen) with a smooth to tuberculate surface. The section is automatically typified by *P. divulsus*, the only species in the section at the time of its description.

KEY TO THE SPECIES

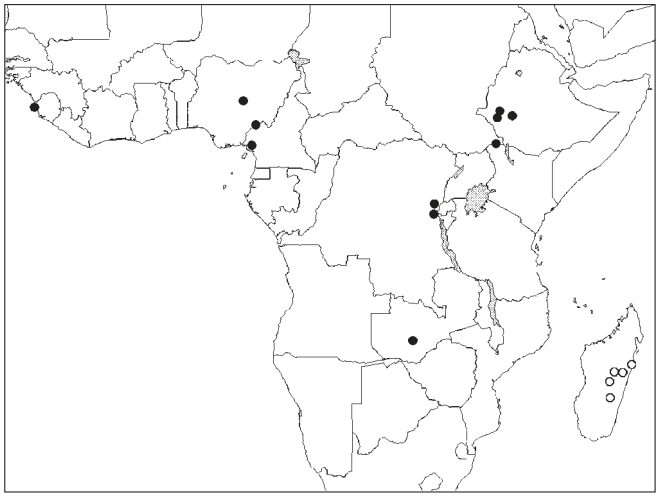
1. Nutlets smooth, 1.5–1.9 mm long. — Tropical Africa . . . . . 1. *P. africanus*
1. Nutlets strongly tuberculate, 1.2–1.5 mm long. — Madagascar . . . . . 2. *P. divulsus*

1. *Pycreus africanus* (S.S.Hooper) Reynders, *comb. nov.* — Fig. 1e, 2; Map 1

Pycreus divulsus subsp. *africanus* S.S.Hooper, Kew Bull. 27 (1972) 579. — Type: *J.Br. Hall 1381* (holo K; iso P), Cameroon, Gaudua, eastern foothills of the Gotel Mountains, march, 17 July 1969.

Pycreus africanus is a rare species known from several remote locations in tropical Africa (Map 1). Most collections are from moist grassland occurring at medium altitudes except the collection in Sierra Leone which is from near the coast. In Ethiopia the species could be confused with *P. pauper* which can be found in the same habitats (e.g. *Robertson in Mooney 7548a & b* (K), mixed collection). The latter is also an annual species with a reduced inflorescence and large spikelets and nutlets. However, it differs from *P. africanus* in having a rather capitate inflorescence, black-tipped glumes and nutlets with elongated epidermal cells as shown in Fig. 1c.

Annual herbs 6.5–38 cm high, with triangular and glabrous culms 0.7–1.1 mm wide. Leaves basal, 0.8–2 mm wide, scabrid near the tip; sheaths pale with many small red dots. *Anthela* simple and reduced to a terminal spike with 2–4 sessile and suberect spikelets, the lower spikelets often 5–7 mm lower than the others. Bracts 3 or 4, leafy, 1.4–9.8 cm long, erect. Spikelets narrowly elliptic, suberect, 4–15 mm long, 2.5–4.4 mm wide with 4–18 flowers; rachilla straight, pale. Glumes oblong elliptic, with a narrow acute tip, 3.1–4.2 mm long, 1.1–1.5 mm wide, golden, brownish tinged and with many small red dots, hyaline border wider towards the tip, keel green with 5 nerves; slightly imbricate. *Stamens* 3, anthers oblong, 0.5 mm long. Nutlets broadly elliptic, 1.5–1.9 mm long, 1–1.2 mm wide, strongly swollen (nearly round in cross section), black and shiny, the surface smooth; epidermal cells irregular.



Map 1 Distribution of *Pycreus* sect. *Tuberculati* Cherm. based on the specimens cited in the text. *Pycreus africanus* (●), *P. divulsus* (O).

Reference specimens. Cameroon, Gaudua, eastern foothills of the Gotel Mountains, march, 17 July 1969, *Hall J. Br. 1381* (K, P); Manengouba mts. Base, Nkongsamba, 900 m, 30 Sept. 1971, *A.J.M. Leeuwenberg 8527* (K). — Congo, Kivu region, zone de Mwenga, Collectivité Luindi, Localité Kilimbwe, house yard in grass, 1300 m, 13 Nov. 1977, *Takako Yamada 134* (K); Walungu, Kabare territory, Savanne á *Eragrostis* Wolf, May 1959, *Léonard 4156* (BR). — Ethiopia, Midwest Ethiopia, Mattu near Gore, open grassland,

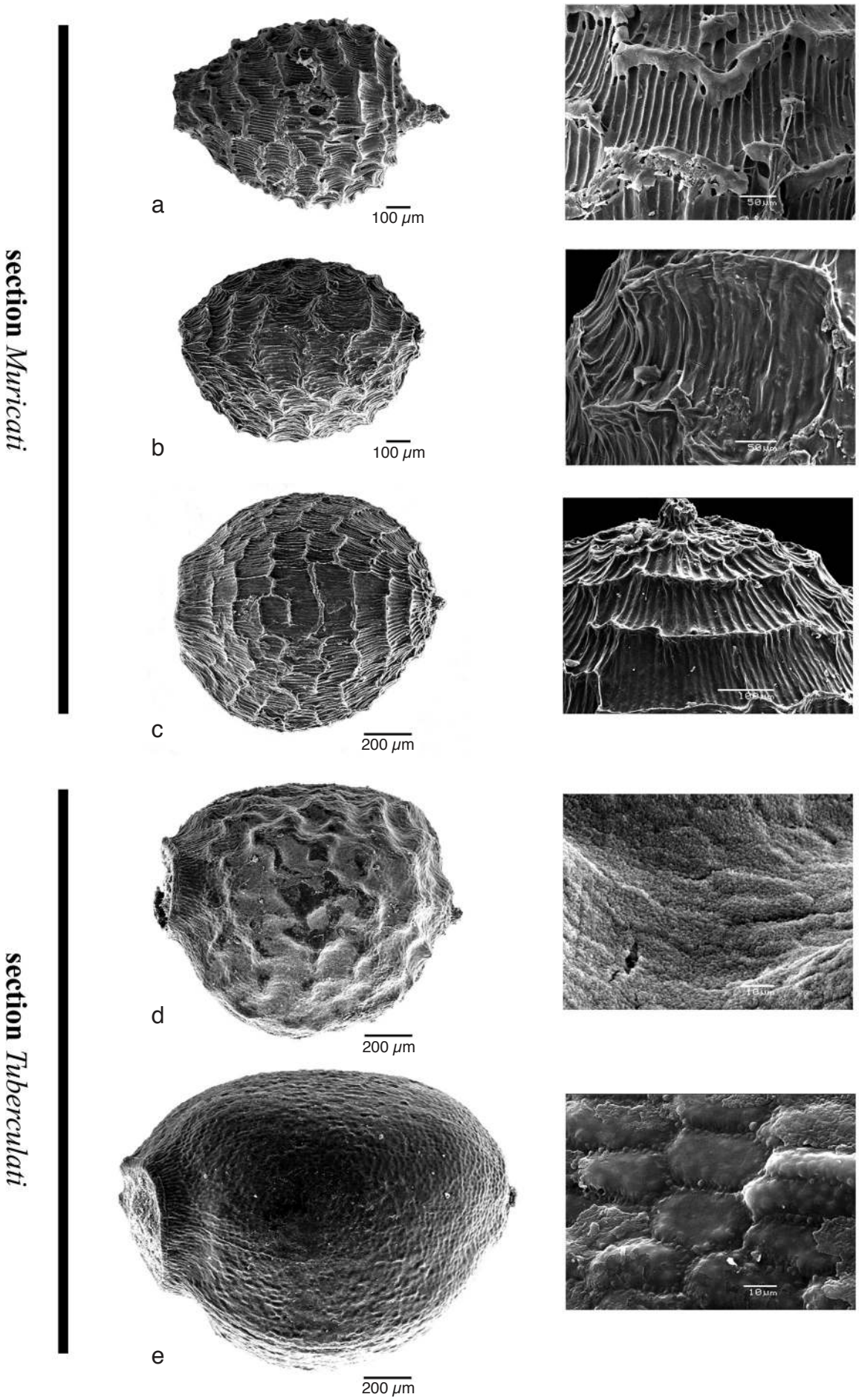


Fig. 1 SEM pictures of the nutlets in the section *Muricati* Kük. and the section *Tuberculati* Cherm., on the left lateral views of mature nutlets, on the right details of the nutlet epidermis of: a. *P. muricatus*; b. *P. zonatus*; c. *P. pauper*; d. *P. divulsus*; e. *P. africanus* (a: *Browning 633*, GENT; b: *Robinson 5102*, GENT; c: *Taylor 9184*, BR; d: *Perrier de la Bâthie 13052*, BR; e: *Léonard 4156*, BR).

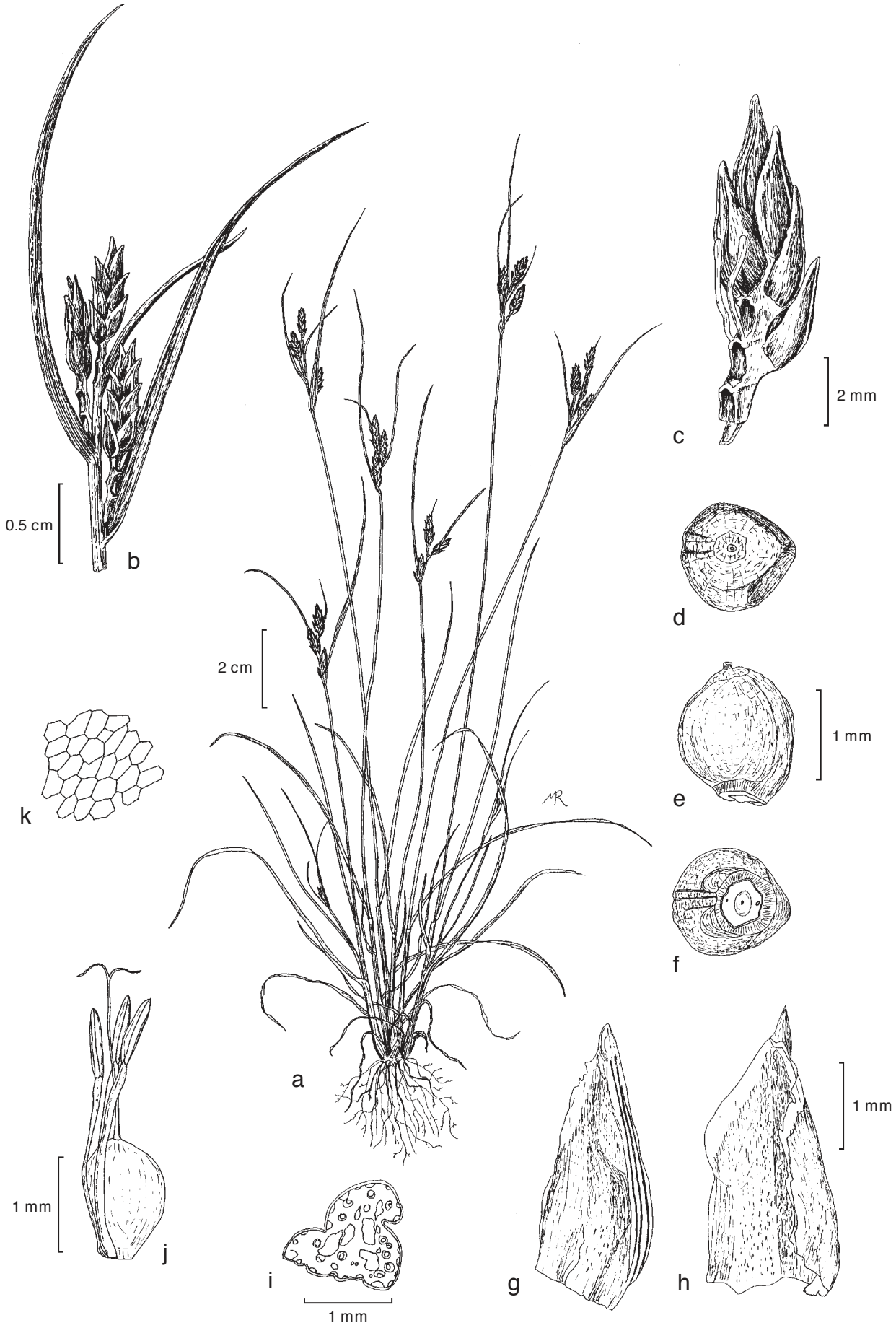


Fig. 2 *Pycreus africanus* (S.S.Hooper) Reynders. a. Habit; b. inflorescence; c. spikelet; d. nutlet upper view; e. nutlet lateral view; f. nutlet basal view; g, h. glumes; i. transverse section culm; j. flower; k. detail nutlet epidermal cells (all: *Leonard 4156*, BR).

1500 m, 23 Oct. 1958, *Robertson in Mooney 7548a* (K); Wollega region, 138 km on Ghimbi-Asosa road, sloping short grassland, 16 Sept. 1975, *M.G. Gilbert & M. Thulin 796* (K, P); Hippo pool on Jimma river, c. 5 km north-west of Jimma on Addia Abala road, Kaffa province, 22 Oct. 1973, *Ash 2225 (K)*; Illubabor region, 38 km north of Tepi, along the new road to Gore, 1900 m, meadow in moist *Pouteria adolfifriderici* (Engl.) A.Meeuse – *Schefflera abyssinica* (Hochst. ex A.Rich.) Harms forest, 16 Nov. 1995, *I. Friis*, *S. Bidgood*, *P. Host*, *Dessalegn Desissa & Shigulte Kebede 7164* (K). — Nigeria, Plateau province, near Farin Rua between William kamp and Marbai, short grass on bank of river in open situation, 24 Aug. 1968, *Hall J. Br. 652* (K). — Sierra Leone, Freetown, Tower hill, in grass on dry gravel hillside, 2 Nov. 1930, *F.C. Deighton 1868* (K, P). — Zambia, Namwala, heavily grazed mixed grassland, light sandy soil in a mixed woodland area, 17 Apr. 1963, *H.J. van Rensburg 2014* (K).

2. *Pycreus divulsus* (Ridl.) C.B.Clarke — Fig. 1d; Map 1

Pycreus divulsus (Ridl.) C.B.Clarke in Durand & Schinz (1894) 536. — *Cyperus divulsus* Ridl. (1884) 128. — Type: *Hildebrandt 4020* (holo K: K000363055; iso M: M0106884, M0106885, P: P00459905, P00459906, P00459907), Madagascar, Centre, Betsiléo, in Sümpfen, Feb. 1881.

= *Cyperus paucispiculatus* Boeckeler (1884) 497. — Type: see *C. divulsus* and discussion below.

In January 1884, Ridley published *Cyperus divulsus* based on *Hildebrandt 4020* from central Madagascar. However, in September that year, Böckeler described, independently from Ridley, *Cyperus paucispiculatus* Boeck., based on the same collection. Clarke (in Durand & Schinz 1894) synonymized *C. paucispiculatus* with *C. divulsus* and in later studies only the latter name has been used. Unfortunately Chermezon (1919) was unaware of Böckeler's earlier name when he used *C. paucispiculatus* Cherm. nom. illeg. for a new Madagascan taxon and placed it in its own section *Paucispiculati* Cherm. nom. nud. The latter species clearly does not belong to *Pycreus* and is not related to *P. divulsus*, although both share a reduction in the number of spikelets. *Cyperus paucispiculatus* Cherm. is a later homonym of *C. paucispiculatus* Boeck. and thus illegitimate. A new name for this taxon, *Cyperus limiticola* Larridon & Reynders, has been given elsewhere (Larridon et al. 2008).

Pycreus divulsus is a rare species found scattered, from central to eastern Madagascar (Map 1). Although it occurs near sea level it is mainly a medium altitude species. Its habitat is quite variable, from moist grassland to weedy gardens.

Annual herbs 7–25 cm high, with triangular and glabrous culms 0.4–0.8 mm wide, often curved. Leaves basal, 0.6–1.2 mm wide, canaliculate to flat, scabrid near the tip; sheaths pale. *Anthela* simple and reduced to a terminal spike with 2–4 sessile and suberect spikelets, the spikelets widely spaced from each other. Bracts 3 or 4, leafy, at the base of each single spikelet, 1.5–7 cm long, erect. Spikelets narrowly elliptic, suberect, 6–15 mm long (at c. 7–10 mm from the top the fruits are ripe and the glumes are falling off), 3–4 mm wide with 6–20 flowers; rachilla straight, pale. Glumes ovate, with a narrow acute tip, 2.3–3.9 mm long, 1.2–1.5 mm wide, shiny castaneous, with a narrow, hyaline, undulating border, keel green with 3 nerves; imbricate. *Stamens* 2, anthers linear, with a short reddish connective. Nutlets broadly elliptic to almost globose, 1.2–1.5 mm long, 1–1.1 mm wide, strongly swollen, black and shiny, apiculate, the surface strongly tuberculate; epidermal cells irregular.

Reference specimens. Madagascar, Central, Betsileo, in Sümpfen, 1156 m, Feb. 1881, *Hildebrandt 4020* (K, M, P); Tananarive, marécage, *Perrier de la Bâthie 2677b* (P), jardins, *Perrier de la Bâthie 13052* (BR, P), bord de route, *Perrier de la Bâthie 17606* (P), Apr. 1922, *Waterlot 495* (P); c. 5 km S of Tananarive centrum, in grassland in edge of pool, 31 Mar. 1971, *K.A. Lye 5932* (K, P); Antsirabe, *Perrier de la Bâthie 2730* (P), *1926* (P); Forêt d'Analamazaotra: fonds humides vers 900 m, 1 Oct. 1912, *Viguier et Humbert 949* (P); Region de l'est, Tamatave, Nov. 1906, *d'Alleizette 1380* (P); Tamatave province, E of Moramanga, Andasibe, Perinet reserve, open area on trail trough forest, 5 Mar.1988, *D.A. Simpson 88/109a* (K); s.l., *Baron 5641*; s.l. donné par l'Academie Malgache (R. Lambinon) 910 (P).

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