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Nicholas WILDING & Claudine AH-PENG

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# *Physcomitrium allardiae* N. Wilding & Ah-Peng, sp. nov. (Funariaceae), a new species with immersed, cleistocarpic capsules from Tanzania

**Nicholas WILDING**
Université de La Réunion, UMR PVBMT, 7 chemin de l'IRAT, 97410 Saint-Pierre, La Réunion (France)
and Missouri Botanical Garden, 4344 Shaw Blvd., St. Louis, Missouri 63110 (United States)
nicholaswilding@gmail.com (corresponding author)

**Claudine AH-PENG**
Université de La Réunion, UMR PVBMT, 7 chemin de l'IRAT, 97410 Saint-Pierre, La Réunion (France)
and Observatoire des Sciences de l'Univers de La Réunion (OSU-Réunion), UAR 3365, Université de La Réunion, CNRS, Météo France, IRD, Saint-Denis (France)
claudine.ahpeng@univ-reunion.fr

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## ABSTRACT
*Physcomitrium allardiae* N. Wilding & Ah-Peng, sp. nov. (Funariaceae) is described and illustrated based on a single collection from highlands in the Uluguru mountains of Tanzania. The new species was collected growing on soil, among a dense mat of liverworts, in high altitude *Podocarpus-Allanblackia* mist forest. *Physcomitrium allardiae* N. Wilding & Ah-Peng, sp. nov. can be distinguished from all other members of the genus by its strongly bordered leaves, sub-spherical, non-rostellate, capsules, and spores with baculate-insulate surface ornamentation.

KEY WORDS
Cleistocarpic, Funariaceae, moss, *Physcomitrium*, Tanzania, new species.

## RÉSUMÉ
Physcomitrium allardiae *N. Wilding & Ah-Peng, sp. nov. (Funariaceae), une nouvelle espèce à capsule immergée, cléistocarpique de Tanzanie.*
*Physcomitrium allardiae* N. Wilding & Ah-Peng, sp. nov. (Funariaceae) est décrite et illustrée à partir d'une seule collection provenant des hauts plateaux des montagnes d'Uluguru en Tanzanie. La nouvelle espèce a été collectée sur le sol, au sein d'un tapis dense d'hépatiques, dans la forêt de nuage de *Podocarpus-Allanblackia* de haute altitude. *Physcomitrium allardiae* N. Wilding & Ah-Peng, sp. nov. se distingue de tous les autres espèces du genre par ses capsules sous-sphériques, immergées, cléistocarpiques et ses spores étant baculate-isolées.

MOTS CLÉS
Cléistocarpique, Funariaceae, mousse, *Physcomitrium*, Tanzanie, espèce nouvelle.

## INTRODUCTION

The genus *Physcomitrium* (Brid.) Brid. (Funariaceae) comprises *c.* 62 species (Brinda & Atwood 2023) of small terricolous mosses with annual to ephemeral life cycles. The genus is widespread globally, and is most frequently encountered at lower elevations in temperate systems, and where levels of precipitation are moderate to high (Fife 1982, 1985). Their ability to rapidly complete their life cycle within as little as 12 weeks (Schaefer & Zrÿd 2001) has made them popular model organisms, e.g. *Physcomitrium patens* (Hedw.) Mitt., in studies of evolutionary development, hybridization (Wettstein 1932), physiology (Cove & Knight 1993; Cove 2005), and genetics (Rensing *et al.* 2008, 2020; Rensing 2014).

*Physcomitrium* is readily distinguished from other genera in the Funariaceae by its erect, radially symmetric, aperistomate capsules, often with characteristically thin-walled, isodiametric exothecial cells, and spinate to baculate spores. In contrast to its clear generic circumscription, the delimitation of species within *Physcomitrium* is difficult particularly because of a paucity of diagnostic characters. The lack of informative characters can largely be attributed to their relatively uniform gametophytes, which are typical of the Funariaceae, and also to their greatly simplified sporophytes. While the genus is characterized by a paucity of traits that offer phylogenetic information, taxonomic challenges are further emerging from evidence of interspecific hybridization and its role in the group's diversification (McDaniel *et al.* 2010; Beike *et al.* 2014; Ostendorf *et al.* 2021; Patel *et al.* 2023).

The *Physcomitrium* sporophyte has lost most of the elaborate features presumably related with the release of spores, e.g. a long seta, peristome teeth and an inclined, zygomorphic capsule. Shifts towards simpler sporophytes are correlated with the groups recent and rapid diversification and have occurred multiple times in parallel (Liu *et al.* 2012; Medina *et al.* 2018). For example, the genus Physcomitrella Bruch & Schimp. *sensu* Tan (1979), now accommodated within *Physcomitrium*, was shown to be polyphyletic, meaning that its characteristic, highly reduced sporophytes evolved independently multiple times (Medina *et al.* 2019).

*Physcomitrium* has been treated in numerous regional floras (e.g. McIntosh 2007; Magill 1987; Smith 2004), however, the majority of the species in the genus remain poorly studied and under collected, particularly in parts of Africa, Asia and South America. O'Shea (2006) reported 11 species for sub-Saharan Africa, including *Physcomitrella magdalenae* De Sloover, now *Physcomitrium magdalenae* (De Sloover) R. Medina & Goffinet. In Africa, the genus has yet to be revised, and few species are known from more than a handful of collections. Only a single species, *Physcomitrium spathulatum* Müll.Hal., is known from more than five collections (GBIF) while most others, like *Physcomitrium subspathulatum* Thér. & Naveau, are known from the type and one or two additional localities. An initial review of African material in BOL, BR, PC & PRE suggests that the available names cannot adequately account for the apparent diversity present in the region and that much material is being lumped under one or two taxa. Increased collecting, and a taxonomic revision of the African species is needed to advance knowledge on the group.

Among the African species, *Physcomitrium magdalenae* is the only species described with an immersed, cleistocarpic capsule, hence its former placement in *Physcomitrella* Bruch. & Schimp. along with *Physcomitrium patens.* Apart from these, the only other species in the family with immersed, cleistocarpic capsules is the South African endemic, *Physcomitrellopsis africana* Wager & Broth. ex Dixon, which is member of a speciose clade sister to the *Entosthodon-Physcomitrium* crown group (Wilding 2015).

Here we describe an additional species of *Physcomitrium* with immersed, cleistocarpic capsules, which is morphologically distinct from all other species in the genus. The new species is known from a single collection, made in the Uluguru Mountains of Tanzania, and is the first new species to be described in the genus, from the African continent, in 97 years. We dedicate the new species to a dear colleague.

Family Funariaceae Schwägr.
Genus *Physcomitrium* (Brid.) Brid

***Physcomitrium allardiae*** N. Wilding & Ah-Peng, sp. nov
(Fig. 1)

Diagnosis. — *Physcomitrium allardiae* N. Wilding & Ah-Peng, sp. nov. differs from all congeners in the combination of strongly bordered leaves, sub-spherical, non rostellate capsules, and spores with baculate-insulate surface ornamentation.

Type material. — **Tanzania** • Uluguru Mts., North slopes of Bondwa, above Morogoro; high altitude *Podocarpus-Allanblackia* mist forest; 1800-2500 m alt.; 13.XII.1970; leg. *E.W. Jones & T. Pócs* 6308/S (holo-, PC[PC0723477]!).

Etymology. — The species is named in memory of Amandine Allard (1978-2023) a close friend and colleague of the authors. Amandine worked with enthusiasm as a technical officer at the Muséum national d'Histoire naturelle in Paris (PC) for 21 years, where she was responsible for assisting in the curation of the bryophyte collection and for welcoming visitors to the Paris herbarium. She contributed greatly in localizing and digitizing the bryophyte type specimens of the PC herbarium. Her hand written species names on the red type folders serve as a memory of her presence and her contribution at PC. During her time at the museum, Amandine developed the ability to recognize the hand writing of many historical bryophyte collectors and taxonomists, which was of immense help when curating historical material. Amandine was a kind and caring person, with a great sense of humour, she will be missed dearly by all who knew and worked closely with her.

Ecology. — The type specimen is described as having been collected on soil in "*Podocarpus-Allanblackia* mist forest", at an elevation of 1800-2500 m. The type collection is almost entirely comprised of a dense humusy mat of small liverworts, *c.* 2.5 × 2.5 cm, among which a small number of plants of *Physcomitrium allardiae* N. Wilding & Ah-Peng, sp. nov. are present. The liverwort mat appears to


Fig. 1. — *Physcomitrium allardiae* N. Wilding & Ah-Peng, sp. nov. **A**, habit humid; **B**, habit dry (same plant as in **A**); **C**, habit dry; **D**, perichaetial leaf; **E**, leaf apex, showing the limbate, serulate margin; **F**, spores. All from the holotype. Scale bars: A-C, 1 mm; D, 500 µm; E, 100 µm; F, 30 µm.

comprise primarily *Riccardia* sp., *Lejeunea* sp. and an unidentified Geocalycaceae.

Distribution. — The species is known only from the type locality in the Uluguru Mountains of Tanzania.

## Description

Plants small to medium, light-green. Stem reddish, to *c.* 1.8 mm high, branching multiple times by sub-perigonial innovation; rhizoids cerise. Leaves erect-spreading, slightly contorted when

dry, oblong-obovate to spathulate, *c.* (1-)1.4-2.1(-3.5) × 0.4-0.8(-1.4) mm, plane to weakly concave, margin limbate, entire below, serrulate above, apex short-acuminate to attenuate, decreasing in size basally, perichaetial leaves bigger than perigonial leaves; cells of upper lamina isodiametric to oblong, pentagonal or hexagonal, 35-60(-70) × 25-35 µm; basal cells lax, oblong, more or less quadrate, 62-150(-188) × (15-)20-35(-43) µm; marginal cells narrower, thicker-walled, forming a border 1-3 cells wide; costa ending below apex.

Autoicous? Seta *c.* 0.2 mm long, straight, smooth, pale-yellow. Capsule erect, sub-spherical, inoperculate, *c.* 0.6-0.7 × 0.5-0.7 mm, slightly wrinkled when dry, orange-yellow at maturity, lacking a well-defined neck; exothecial cells isodiametric 30-60 µm in diameter, in cross-section with non-thickened anticlinal walls; operculum absent, cleistocarpic; peristome absent; spores 25-30 µm, sub-spherical, baculate-insulate. Calyptra not seen.

### Remarks

*Physcomitrium allardiae* N. Wilding & Ah-Peng, sp. nov. is characterized by its sub-spherical, non-rostellate, cleistocarpic capsules, which are unique within the family. Other species of *Physcomitrium* with comparatively reduced sporophytes, i.e. *Physcomitrium patens*, *Physcomitrium magdalenae*, and *Physcomitrium readeri* Müll. Hal. all have capsules that are distinctly rostellate at the apex and not rounded as in *P. allardiae*. In East Africa, *P. allardiae* may co-occur with *P. magdalenae,* however, in addition to the difference in capsule shape, the two can easily be distinguished by their leaves (strongly bordered by longer, narrower, thicker-walled cells in *P. allardiae* vs weakly bordered by longer cells with unthickened walls in *P. magdalenae*), and spore ornamentation (baculate-insulate in *P. allardiae* vs. densely spinulose in *P. magdalenae*).

In the absence of genetic data, it is impossible to infer a close relationship with any of the afore mentioned species, i.e. those members composing a polyphyletic Physcomitrella, since they each appear to have independently evolved the same reduced phenotype (Medina *et al.* 2019). Physcomitrium allardiae may yet prove to be another example of an independent reduction in sporophyte morphology.

The single known specimen of *Physcomitrium allardiae* was originally identified as *Physcomitrellopsis africana* by an unknown individual, and consists of fewer than ten plants of which only two of these have mature sporophytes. No duplicate specimens of the type collection could be located at EGR or in any of the other herbaria where Jones and Pócs would have distributed their *exsiccatae*.

Observations based on a single plant suggest that maturation of the perichaetia and perigonia may occur simultaneously. The sexuality of the species could not be definitively confirmed due to the extremely limited number of fertile plants, but observations suggest it to be autoicous. Its sexuality could, however, be more complex, as has been observed in some species of *Entosthodon* and *Physcomitrium,* where the terminal innovation that overtops the perigonium is synoicous and possibly protogynous, however, this state is difficult to confirm because archegonia tend to be fertilized early-on, inhibiting the development of antheridia (Wilding 2015, 2017).

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