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Research Article

Entosthodon dixonii Sim (Bryophyta) newly recorded in SW Asia and Saudi Arabia

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The aim of this study is to document the occurrence of *Entosthodon dixonii* Sim (Funariaceae) in the Asir Mountains of southwestern Saudi Arabia. Field surveys targeting bryophytes were conducted in montane wadis, and the collected material was identified using morphological characters. The species was found in shaded, subhumid microhabitats and represents the first record of *E. dixonii* for Saudi Arabia and Southwest Asia. Previously known only from southern Africa and Madagascar, this record extends the species' known distribution to its northernmost limit (17°N). The discovery also highlights floristic connections between the Afro-montane regions of Africa and the mountains of southern Arabia, which host several tropical bryophyte elements restricted to locally humid habitats.

Keywords: Afro–Arabian floristic connections, Asir mountains, *Entosthodon*, Funariaceae, monsoon-influenced mountains, Saudi Arabia, Southwest Asia

Introduction

The family Funariaceae is sparsely represented in the Arabian Peninsula, with only three genera documented to date, *Funaria*, *Physcomitrium* and *Entosthodon* (Kürschner and Frey 2020). The cosmopolitan ruderal *Funaria hygrometrica* Hedw. is frequently encountered in the Arabian Peninsula, with numerous records, especially from its western part (Hugonnot and Pépin unpubl.), and should therefore be considered a naturally established component of the regional flora. In contrast, *Physcomitrium pyri-forme* (Hedw.) Brid., reported together with *F. hygrometrica* from greenhouses of the Ministry of Agriculture in Kuwait (El-Saadawi 1976), may represent an introduction in Arabia, although its status requires further verification.

The genus *Entosthodon* accounts for the majority of the family Funariaceae's diversity in Arabia, with species concentrated along the Mediterranean and adjacent arid regions (often referred to as 'circum-Tethyan' in phytogeographical usage) (Kürschner and Frey 2020). Among these, *Entosthodon attenuatus* (Dicks.) Bryhn, *E. muhlenbergii* (Turner) Fife and *E. pulchellus* (H.Philib.) Brugués are widespread throughout



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the Peninsula, whereas *E. fascicularis* (Hedw.) Müll. Hal., *E. duriae* Mont. and *E. convexus* (Spruce) Brugués appear to have more localized distributions; the latter is confirmed from the United Arab Emirates and has been reported from the Taif region in Saudi Arabia (Abou-Salama et al. 2005).

The only taxon with nilotic–African affinities is *Physcomitrium niloticum* (Delile) Lindb. ex Müll. Hal. (often treated in *Micropoma niloticum* (Delile) Lindb.), which is restricted to the western part of the Peninsula. Previous assertions that Funariaceae are more diverse in the eastern sector of Arabia than in the western one (Abou-Salama et al. 2005) are not supported by recent observations (Hugonnot and Pépin unpubl.) and most likely reflect incomplete knowledge and misinterpretation of distributional data.

Taxonomic investigations in the family are further complicated by recurrent sterility and the rarity of sporophyte production, as well as by the frequent persistence of protonemal stages (El-Saadawi and Zanaty 1990, Hugonnot et al. unpubl.); these phenomena are likely linked to the prevailing arid conditions in much of the Arabian Peninsula, and together they often render species-level identification uncertain. In addition, the genus *Entosthodon* is now recognized as polyphyletic (Liu et al. 2012, Medina et al. 2018), thereby increasing the group's systematic and biogeographical complexity in the region. Within this framework, the occurrence of *Entosthodon dixonii* in Saudi Arabia provides new information on the composition of the Arabian bryophyte flora and its biogeographical affinities.

Molecular phylogenetic analyses indicate that *Entosthodon* is paraphyletic, with *E. dixonii* resolved within the 'Physcomitrellopsis clade' sensu Wilding (2016) and Medina et al. (2018), a lineage that excludes the type species of *Entosthodon*, *E. attenuatus*. This clade comprises species primarily distributed across the Afrotropical and Neotropical regions of the Southern Hemisphere, occurring mainly in tropical and Mediterranean climatic zones. Within this lineage, *E. dixonii* appears most closely related to the South American *E. balansae* Besch. and the Australian *E. smith-hurstii* (Broth. and Geh.) Paris (Wilding 2016). These three species share a distinctive combination of morphological characters, including leaves with irregular acute to obtuse marginal teeth in the upper third and exserted sporophytes with nearly symmetrical capsules.

The aim of this study is to document the occurrence of *Entosthodon dixonii* in the Asir Mountains of southwestern Saudi Arabia and to discuss its taxonomic identity and biogeographical significance within the bryophyte flora of the Arabian Peninsula.

Material and methods

Field surveys were conducted in the Asir Mountains, southwestern Saudi Arabia, to document noteworthy or previously unrecorded bryophyte taxa for the Arabian Peninsula.

Bryophytes remain comparatively poorly known in Saudi Arabia. The currently documented flora comprises about

31 liverworts and 135 mosses (Hugonnot et al. 2025a), to which 12 additional species have recently been added (Hugonnot et al. 2025b), while hornworts have not yet been recorded (Kürschner 2000, Kürschner and Frey 2020). This relatively limited diversity reflects both the peninsula's predominantly arid climate and the still-incomplete bryological exploration of the region, particularly in montane areas such as the Asir Mountains, where locally humid microhabitats occur. This limited state of knowledge provides the rationale for targeted field surveys in potentially suitable habitats.

Site selection was based on the analysis of geological and topographical maps combined with the identification of potential moisture-retaining habitats such as wadis, springs, and wetlands. Accessibility was also taken into account, with priority given to sites within 5 km of existing trails and reachable on foot. All specimens collected during the surveys are preserved in the authors' bryological herbaria and in the herbarium REU. Detailed locality and collection data are provided in the results section.

Results

Entosthodon dixonii was collected in one locality in the Asir Mountains (Fig. 1). The details of the locality and collection are as follows:

Saudi Arabia, Asir Mountain, Fayfa, 996 m a.s.l., shaded, incised wadi at Jabal Fayfa on moist ledges and stream margins, Hugonnot 14725, 03 Feb. 2025; 17°15'40.28"N, 43°4'37.65"E (Private herbarium of VH; duplicate in REU [REU034062]).

Arabian specimens are characterized by sporophytes with a long, exserted seta and capsules lacking a peristome. The gametophytes bear leaves without a differentiated border, the costa being shortly excurrent (Fig. 1, 3). Leaf teeth are predominantly obtuse to rounded at the apex, although some may occasionally be acute. Additional illustrations are provided by Wilding (2016).

It was observed along a deeply incised wadi at about 1000 m a.s.l. The surrounding vegetation consists of open woodland dominated by *Acacia asak*, with scattered *Ficus cordata* and *F. ingens*, and locally *Ziziphus spina-christi*, while more humid sites near the streambed include *Maesa lanceolata* and *Myrica salicifolia*.

Entosthodon dixonii occurred on soil mixed with organic matter in shaded areas beneath trees, near the minor streambed, and near rocky ledges that provide additional humidity. No associated bryophytes were observed. Four small micro-populations were recorded along the wadi, each occupying only a few square decimetres.

Discussion

Our attribution to *Entosthodon dixonii* is based on morphological evidence, as no molecular data are currently available for the studied material. Given the transoceanic allopatric

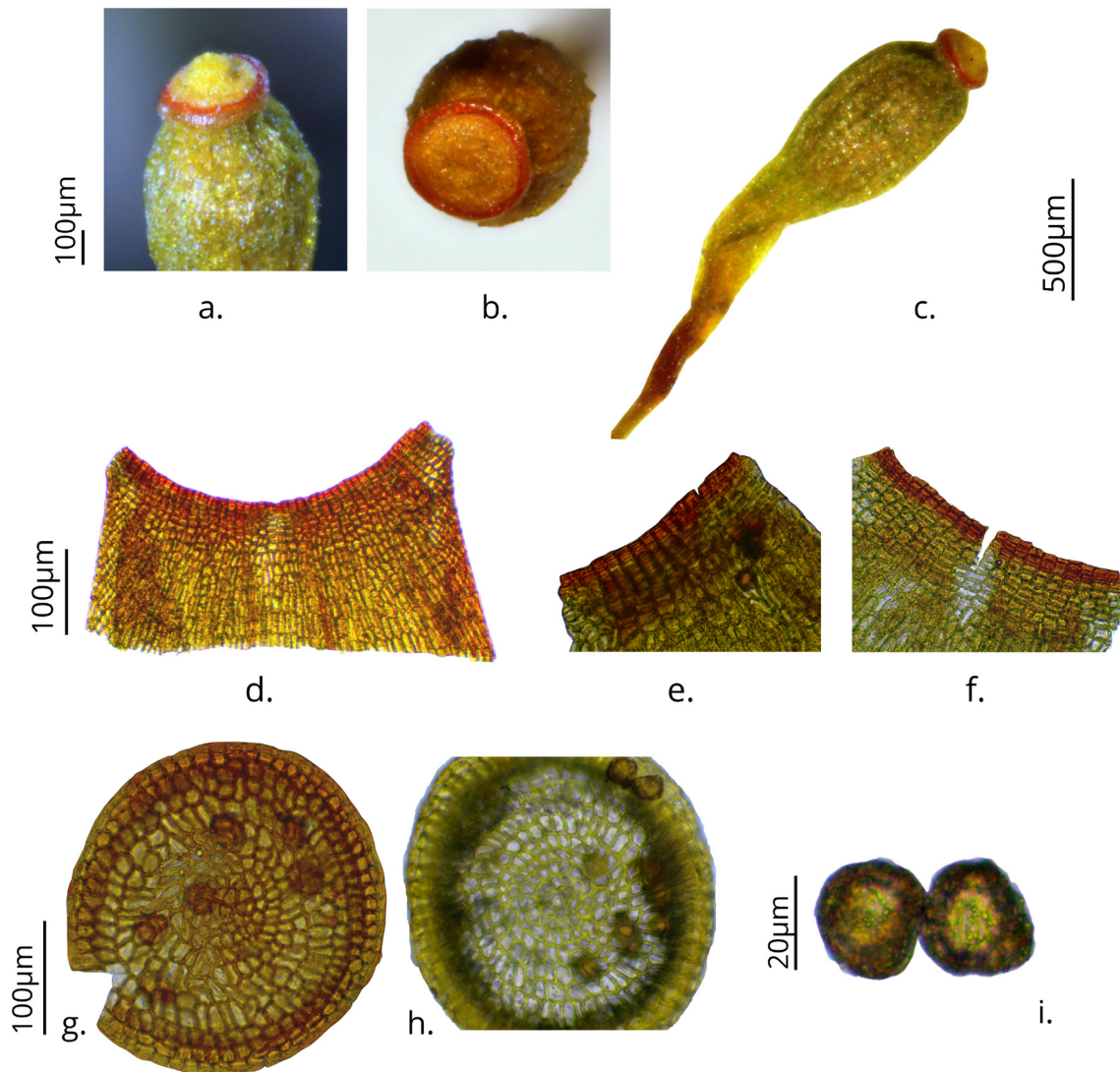


Figure 1. *Entosthodon dixonii* Sim from Jabal Fayfa. (a–b) apex of capsule, (c) capsule, lateral view, (d–f) exothecial areolation, (g–h) operculum, zenithal view, (i) two spores).

distribution of the species composing the *Physcomitrellopsis* clade, molecular analyses would be valuable in future studies to test the phylogenetic affinities of the Saudi Arabian population. All diagnostic characters are, however, consistent with this species. *Entosthodon dixonii* is relatively inconspicuous, and only a few sporophytes were observed in the Arabian wadi where it was collected. Nevertheless, sterile populations can be identified by gametophytic traits, notably spatulate leaves with strongly dentate margins and a cuspidate apex with a percurrent to shortly excurrent costa. The marginal teeth, clearly visible in the field, form swollen, very obtuse, and sometimes squarrose projections, but, on closer inspection, this character appears variable (i some teeth are also more acute). By contrast, *E. smithhurstii* (Broth. and Geh.) Paris and *E. balansae*, also produce similarly obtusely dentate margins, however, these species differ in the shape of the capsule, which is described by Fife and Seppelt (2001) as being 'distinctly pyriform' and with relatively short exothecial cells

and the costa that ends a few cells below the apex. Fife and Seppelt (2001) go on to say that they are unable to distinguish between the two and that they may represent a single species. In other *Entosthodon* species, as well as in *Physcomitrium pyriforme* and *E. mühlenbergii*, the marginal teeth are less prominent, generally more acute and are formed by the protruding distal ends of overlapping marginal cells, making the teeth in *E. dixonii* both distinctive and, to a certain extent, taxonomically informative.

Entosthodon mouretii (Corb.) Jelenc is recorded from Turkey (Kürschner and Frey 2020) and Morocco (Brugués et al. 1999) and could co-occur with *E. dixonii* in the region. The species can, however, be easily distinguished by its leaves with differentiated marginal cells forming a toothed border in the upper half (versus marginal cells undifferentiated and not forming a border in *E. dixonii*), subpiliferous apex reaching up to 0.5 mm in length (versus costa shortly excurrent in *E. dixonii*), shortly oblong to almost isodiametric exothecial

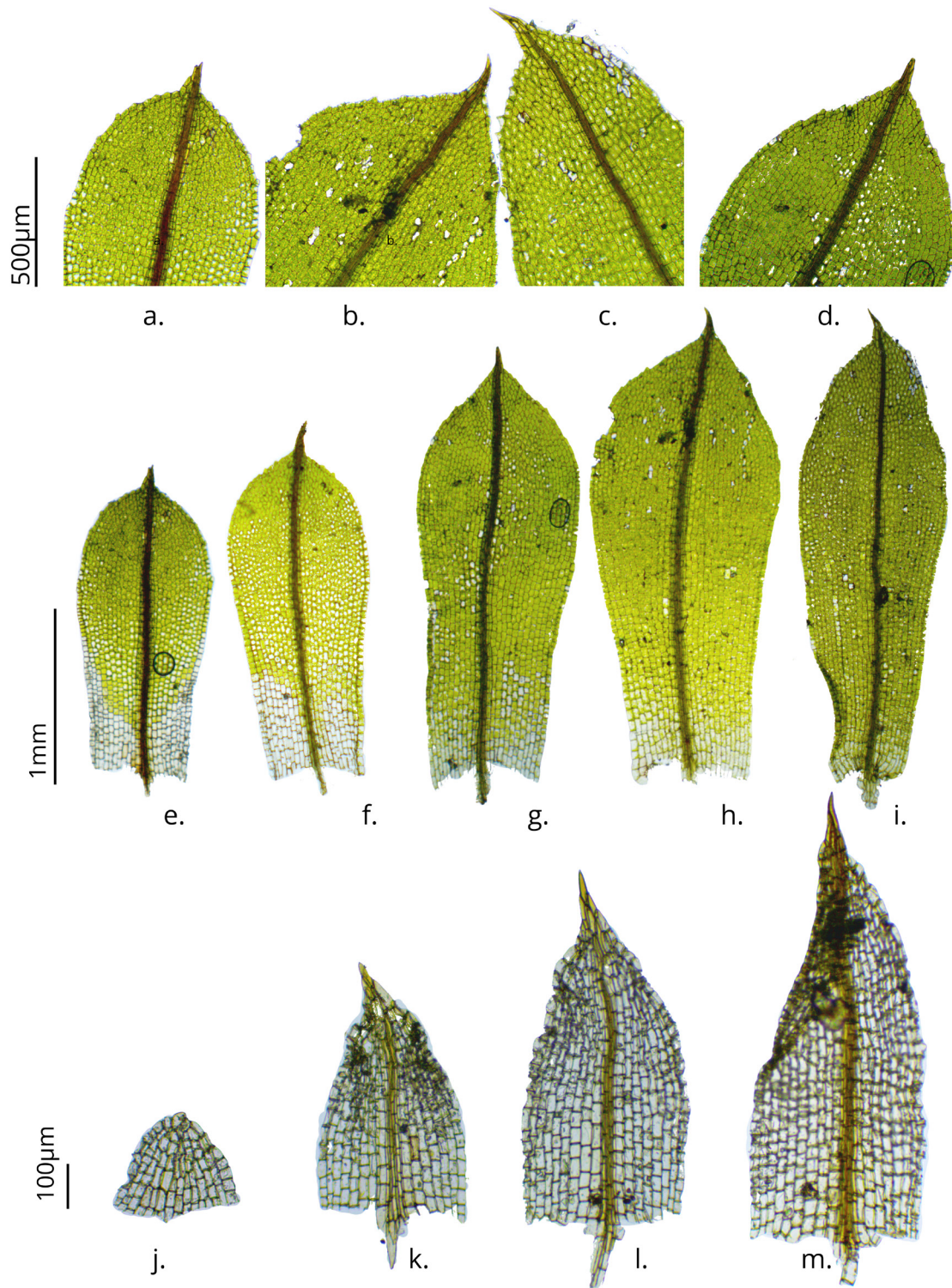


Figure 2. *Entosthodon dixonii* Sim from Jabal Fayfa. (a–d) leaf apices, (e–m) leaf sequence from the basal part of the stem upwards.

cells (versus narrow-oblong exothelial cells in *E. dixonii*), and reduced peristome (versus peristome absent in *E. dixonii*).

Ecologically, *E. dixonii* differs markedly from most Funariaceae in Arabia, which typically occur on unstable substrates such as mineral soils along wadi margins, scree slopes,

or ephemeral depressions prone to desiccation (Frey and Kürschner 1988, Hugonnot et al. 2025a, 2025b). Instead, it grows in shaded, subhumid to humid montane habitats where canopy cover and local hydrological conditions buffer moisture loss.

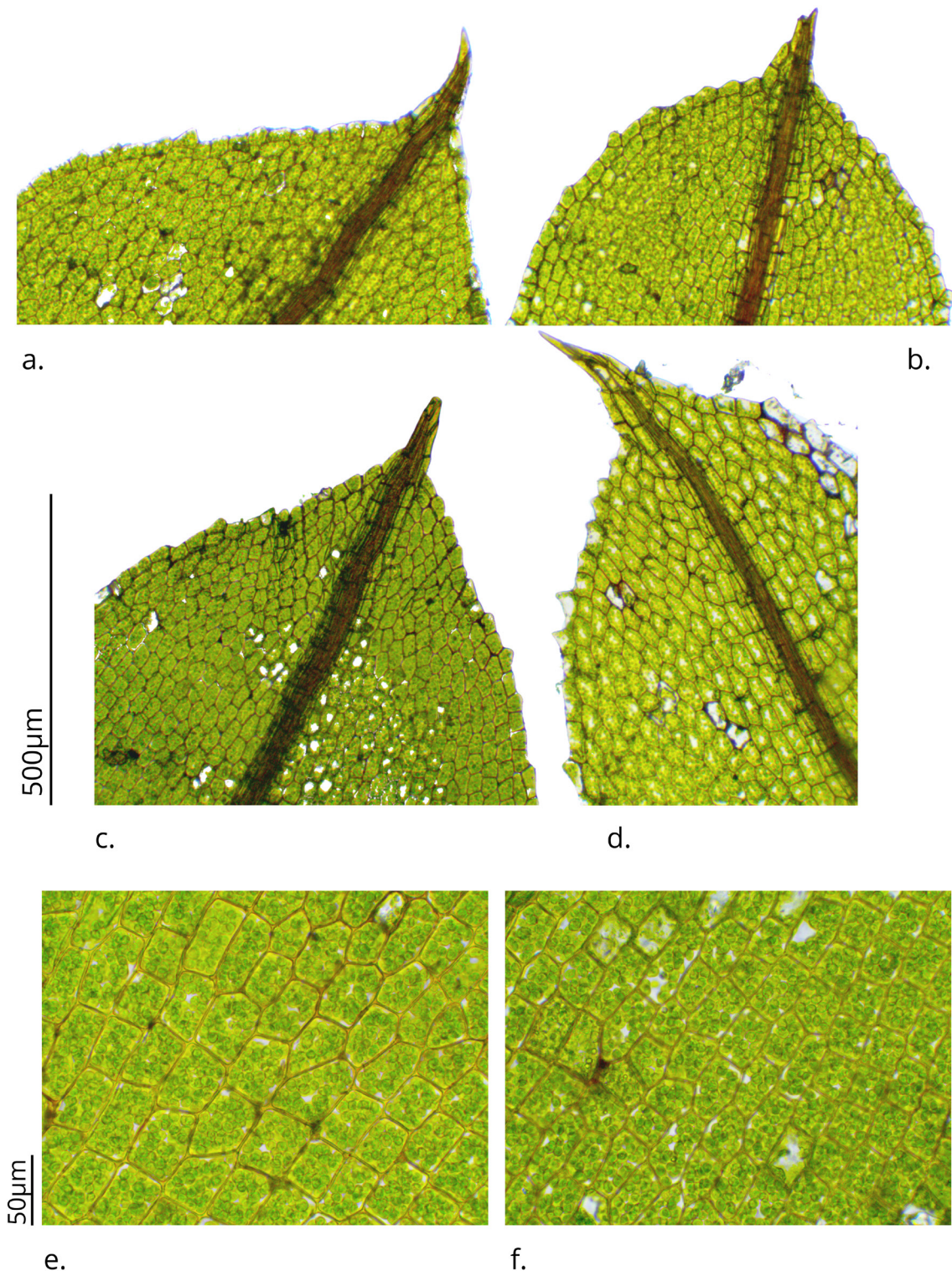


Figure 3 . *Entosthodon dixonii* Sim from Jabal Fayfa. (a–d) leaf apex showing strong serration, (e–f) areolation at mid-leaf).

Previously known from southern Africa (northern South Africa, southern Botswana, Zimbabwe) and Madagascar (Magill 1987, Wilding 2016), its occurrence in the Asir Mountains of Saudi Arabia represents the first record for Southwest Asia and a major phytogeographical disjunction,

with the Arabian population more than 4500 km from the nearest African occurrences. It also marks the northernmost limit of the species' global range (ca 17°N latitude). With its main distribution in subtropical and tropical southern and eastern Africa, including Madagascar, where it inhabits humid

environments below 1500 m, *E. dixonii* can be regarded as a predominantly tropical element of the family. Its Arabian occurrence exemplifies an Afro–Arabian disjunction and constitutes the first truly tropical representative of Funariaceae documented in the Peninsula. A closer examination of its range, however, indicates that the species is not restricted to humid lowlands: many African records fall within temperate and arid steppe climates (Köppen–Geiger system) or transitional tropical–arid zones, suggesting a broader ecological amplitude (Wilding 2016).

The presence of pantropical, paleotropical, and even neotropical bryophyte elements in South Arabia and Socotra is well established, reflecting the Arabian Peninsula's role as a floristic bridge between Africa and Asia during the Tertiary (Kürschner and Ochya 2003). Subsequent aridification confined many tropical lineages to orographically humid mountain ranges influenced by the Indian Ocean monsoon (Kürschner et al. 2001), where they persist today as isolated populations. *Entosthodon dixonii* fits into this framework, occupying shaded, subhumid to humid montane microhabitats in the Asir region, in clear ecological continuity with afromontane floras. It should be noted, however, that recent molecular dating analyses (Medina et al. 2018, Bechteler et al. 2023) place the diversification of the Physcomitrellopsis clade and even the subfamily within the last 10–30 million years. This suggests that the extant lineages, including *E. dixonii*, are evolutionarily younger than the Tertiary bridge concept might imply, though their current distributions nonetheless mirror historical biogeographical connections across the Afro–Arabian realm. More broadly, such isolated populations are of great value for phylogeographical research, potentially revealing hidden genetic diversity and shedding light on the historical assembly of the Arabian bryophyte flora. The species requires further status assessment, but current evidence indicates that it is infrequent, as comparable habitats in the Asir range have yielded no additional records.

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Conflict of interest – The authors declare no conflict of interest.

Author contributions

VH and **FP** collected the field data, carried out the surveys, organised the dataset and wrote the manuscript. **NW** contributed to the writing and to the identification of the specimens. All authors read and approved the final version of the manuscript.

Data availability statement

There are no additional data for this paper.

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