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Adiantum membranifolium (Pteridaceae), a new record of maidenhair fern from Laos

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ABSTRACT. *Adiantum membranifolium* S.Linds. & Suksathan is a species of maidenhair fern previously known only from a few shady limestone cliffs in Western, Northern, and North-Eastern Thailand. Recently, an exploratory survey in Khammouane Province, Laos led to the discovery of this species thriving on a limestone cliff with flowing water during the rainy season, a finding that extends its known geographical distribution. This species is characterised by having single or 1-pinnate fronds, pinnae that are deeply cleft up to or more than half of the length of pinnae, and terminal pinnae with basal angle usually ranging from 45–180° and larger than lateral pinnae. A key to *Adiantum* L. in Laos and a description with photographs and illustrations are also provided. Epidermal features of *A. membranifolium* are described here for the first time.

Keywords. Epidermal features, flora of Laos, polocytic stomata, pteridophyte

Introduction

The genus *Adiantum* L., with around 240 species and a cosmopolitan distribution (POWO, 2023), belongs to Pteridaceae subfam. Vittarioideae (PPG I, 2016). Members of this genus are characterised by simple to pinnately compound or pedate fronds, usually dimidiate or flabellate pinnae with free dichotomous venation, and sori along the veins on the inner face of false indusia (Tagawa & Iwatsuki, 1985).

During an expedition to the dense forest of Laos, a patch of maidenhair fern growing on a limestone cliff was discovered. Subsequent identification and comparative analysis of collected specimens revealed its identity as *Adiantum membranifolium* S.Linds. & Suksathan, a species previously known from Thailand. The discovery of *A. membranifolium* in the region is particularly intriguing, considering the shared climatic and habitat characteristics between Laos and its neighbouring countries, such as Cambodia (Lindsay & Middleton, 2012), Myanmar (Dickason, 1946) and Thailand (Lindsay & Middleton, 2012; Petchsri & Boonkerd, 2023). Until now, nine *Adiantum*

species have been documented in Laos: *A. capillus-veneris* L., *A. caudatum* L., *A. erylliae* Tardieu & C.Chr., *A. flabellulatum* L., *A. gingkoides* C.Chr., *A. philippense* L., *A. soboliferum* Wall. ex Hook., *A. stenochlamys* Baker, and *A. zollingeri* Mett. ex Kuhn (Lindsay & Middleton, 2012; Newman et al., 2023). The inclusion of *A. membranifolium* therefore increases the number of *Adiantum* species in the country.

In this manuscript, we present a detailed taxonomic account of *A. membranifolium* focusing on morphological and anatomical features, supplemented by ecological observations. Additionally, a key to the species of *Adiantum* found in Laos is also provided, contributing to enhanced accessibility and facilitating further botanical research in the region.

Materials and methods

The species description is based on examination of specimens collected from Laos (note that some of the variation found in Thai material has not been observed in material from Laos). Morphological and anatomical characters were observed with a stereomicroscope. Isotypes of *Adiantum membranifolium* kept at E (online images) and BKF were investigated for species confirmation. Anatomical features of epidermal cells were obtained by rehydrating dried terminal pinnae in boiled water. Discolouration was achieved by immersing the pinnae in 5% NaOH and bleaching the pinnae in 6% NaClO until cleared pinnae turned white (adapted from Vasco et al., 2014). Staining was done using fast green. Stomatal types were described following Sen & De (1992). Morphological characters were illustrated using the Sketchbook program on electronic devices.

Taxonomic treatment

Adiantum membranifolium S.Linds. & Suksathan, Thai Forest Bull., Bot. 38: 67 (2010). – TYPE: Thailand, Chiang Mai Province, Fang District, Doi Ang Khang, limestone cliffs not far from Royal Project, 1 October 2009, *Middleton, Lindsay & Suksathan 5031* (holotype QBG; isotypes BCU, BKF, E). (Figs 1–3)

Plant lithophytic. ***Rhizome*** dark brown to black, long-creeping, frequently branched, 0.7–1.3 mm diam., densely covered with scales. ***Scales*** dark brown, narrowly triangular to almost linear, 0.8–1.3 × c. 0.2 mm at base, 3-cell wide at base tapering to a single cell at apex, linear and sharply pointed, sometimes missing in older scales leaving a blunt apex, margin entire, stiff, shiny; cell walls darker in colour than the surrounding areas, clathrate. ***Fronds*** 2.3–6 (including stipe) × 1.1–3.7 cm, simple or 1-pinnate (≥ 3 pinnae per frond, possibly up to 8 as seen in Thai material, sometimes 2 pinnae). ***Stipes*** dark brown to black, 14–30 × c. 0.1 mm, shiny, glabrous, flexible. ***Laminae*** flabellate (when simple) or somewhat oblong in outline, 1.5–3 × 1.2–3 cm. ***Rachis*** dark brown to black, c. 1 cm long, usually zig-zagging between pinnae, shiny, glabrous. ***Fertile***

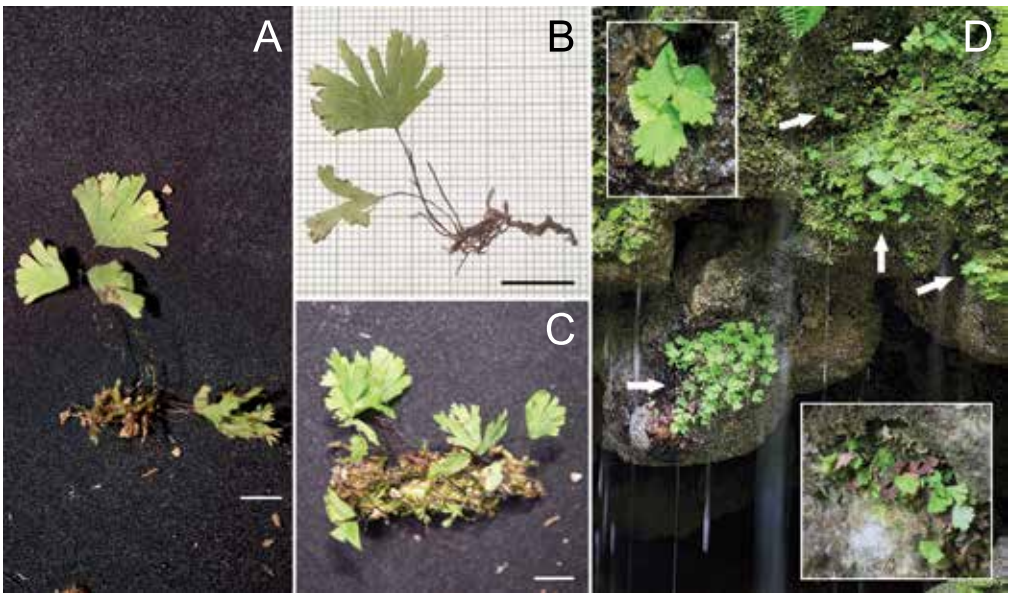

Fig. 1. *Adiantum membranifolium* S.Linds. & Suksathan from Laos. **A**, **B.** Specimens exhibiting leaf polymorphism. **C.** Colony on a mossy surface. **D.** Plant growing in natural habitat shown with arrows and insets. Scale bars: 1 cm. A–C from *C. Limtaropas 01/23*. (Photos: A–C, T. Sripeng; D, C. Limtaropas)

pinnae pale to mid-green, papyraceous, glabrous on both sides, distichous, widely spaced on the rachis; veins conspicuous, free dichotomous; stalks dark brown to black, 2–2.5 mm long. ***Terminal pinnae*** symmetrically flabellate in outline, 23–26 × 14–19 mm (distinctly larger than lateral pinnae), base cuneate, obtuse to truncate forming an angle of 45–180°, deeply cleft forming several long narrow lobes with the medial cleft up to or more than half-length of pinnae, apex and margins irregularly dentate. ***Lateral pinnae*** usually asymmetrically flabellate in outline but sometimes nearly symmetrical, 7–27 × 12–16 mm (more or less equal in size to each other), base rounded to cuneate forming an angle of 45–80°, deeply cleft forming several long narrow lobes with the medial cleft up to or more than half-length of pinnae, apex and margins irregularly dentate, deeply cleft forming several long narrow lobes. ***Sterile pinnae*** pale to mid-green, flabellate or lanceolate to irregular in shape with heavily dentate to serrate margins and lobes, 1.1–1.4 × 0.4–1.8 cm, papyraceous, glabrous on both sides, distichous; veins conspicuous, free dichotomous; stalks dark brown to black, 2–2.5 mm long. ***Sori*** at apices of lobes, on the inner surface of reflexed marginal flaps (false indusia), 4–7 per pinna; indusia sub-quadrangular, c. 1.3 × 1.3–2.1 mm, glabrous. ***Sporangia*** globose, 0.1–0.12 mm diam., glabrous. ***Spores*** dark brown, trilete, tetrahedral-subglobose.

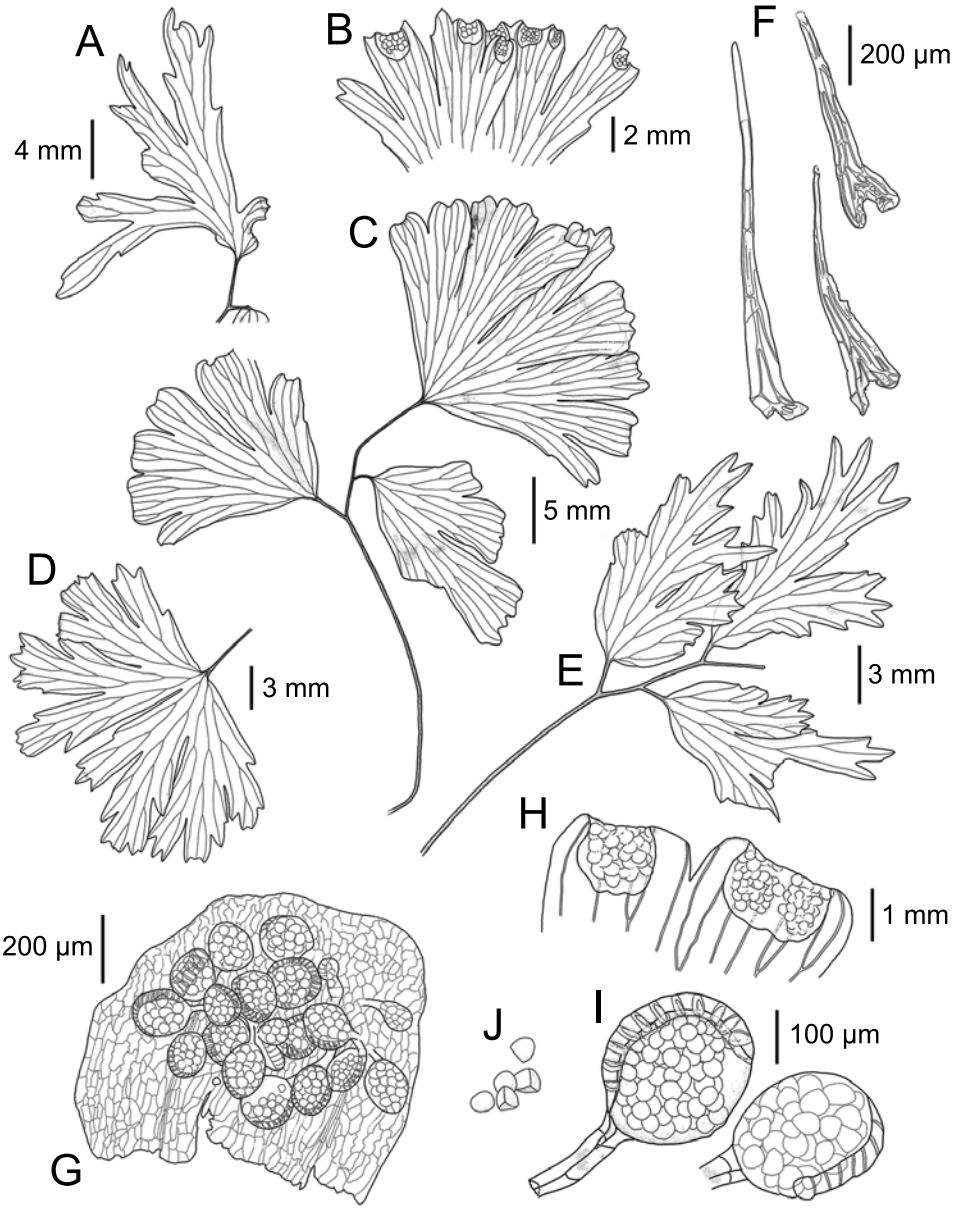

Fig. 2. *Adiantum membranifolium* S.Linds. & Suksathan. **A.** Terminal irregular sterile pinna showing the deeply cleft morphology, similar to the isotype at BKF. **B.** Upper part of fertile pinna showing the deeply cleft margin and lobe apices with sori. **C.** 1-pinnate frond with deeply cleft margins similar to the type. **D.** Single frond with truncate base. **E.** Sterile fronds with lanceolate to irregular pinnae. **F.** Scales from the stipe base. **G.** Sporangia on false indusium. **H.** Sorus on each lobe. **I.** Sporangia with vertical annulus. **J.** Trilete, tetrahedral-subglobose spores. Drawn by T. Sripeng based on *C. Limtaropas 01/23*.

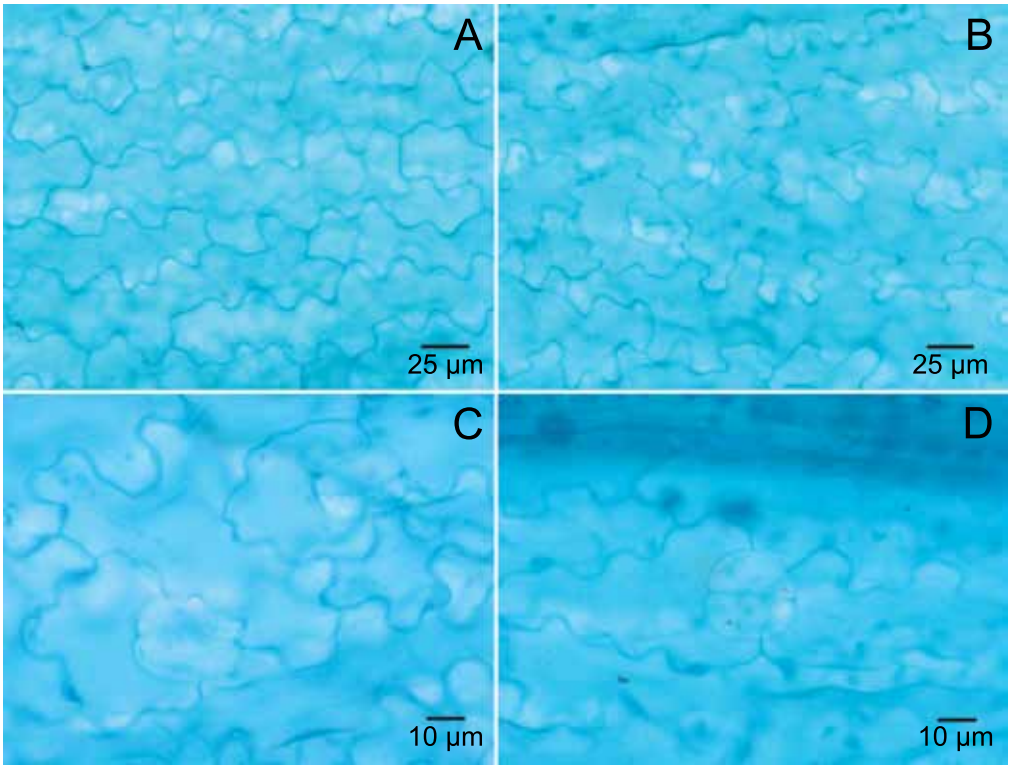

Fig. 3. Epidermal features of *Adiantum membranifolium* S.Linds. & Suksathan. **A.** Upper epidermis showing elongated rectangular epidermal cells with sinuated wall. **B.** Lower epidermis showing two polocytic stomata amongst elongated rectangular epidermal cells. **C.** Lower epidermis showing two polocytic stomata at high magnification. **D.** Lower epidermis showing anomocytic stoma. All micrographs based on *C. Limtaropas 01/23*. (Photos: J. Sangrattanaprasert)

Upper epidermal cells rectangular in outline, elongated, parallel to the veins, 87.5–275 × 17.5–37.5 µm; anticlinal walls sinuous and minutely lobate in some areas. ***Lower epidermal cells*** rectangular in outline, elongated, parallel to the veins, 67.5–195 × 20–45 µm; anticlinal walls irregularly sinuous. ***Epidermal cells adjacent to veins*** mostly longer than neighbouring epidermal cells, 1/7 the width of neighbouring epidermal cells; outer walls smooth, but inner wall minutely regularly sinuous. ***Stomata*** confined to the lower epidermis, surrounded by 2–3 epidermal cells, guard cells 25–30 × 10–12 µm, mostly polocytic with 1 U-shaped subsidiary cell encircling part of guard cells or anomocytic, stomatal density 40 per mm^2.

Distribution. Thailand (Chiang Mai, Chiang Rai, Loei, Kanchanaburi) (Lindsay et al., 2010; Petchsri & Boonkerd, 2023) and Laos (Khammouane).

Habitat and ecology. In shade on moist limestone cliffs, at 480–1360 m in Thailand and 150–200 m in Laos.

Provisional IUCN conservation assessment. Based on the IUCN Red List Criteria

(IUCN Standards and Petitions Committee, 2024), *Adiantum membranifolium* was proposed as a Near Threatened (NT) species owing to the frequent exploitation of limestone regions by extractive industries.

Additional specimen examined. LAOS: **Khammouane Province:** Thakhek, 29 Jul. 2023, *C. Limtaropas 01/23* (BCU).

Key to the species of *Adiantum* in Laos

1a. Pinnae or pinnules sessile, up to 45 pairs per frond 2
1b. Pinnae or pinnules ± stalked, various number of pinna pairs but not reaching 45 pairs 3

2a. Pinnae and rachis densely hairy; lamina veins very prominent ..... *A. caudatum*
2b. Pinnae glabrous, rachis hairy only on the upper surface; lamina veins obscure ..... *A. zollingeri*

3a. Rhizomes creeping 4
3b. Rhizomes erect or suberect 5

4a. Lateral pinnae flabellate and deeply cleft forming several long narrow lobes ..... *A. membranifolium*
4b. Lateral pinnae obliquely rhomboid to subtriangular, margin slightly entire not forming a cleft ..... *A. capillus-veneris*

5a. Pinnae opposite ..... *A. erylliae*
5b. Pinnae alternate 6

6a. Fronds pedate or 2- or 3-pinnate 7
6b. Fronds 1-pinnate 8

7a. Stipes grooved; pinnae 8–15 pairs per frond ..... *A. flabellulatum*
7b. Stipes not grooved; pinnae 3–5 pairs per frond ..... *A. stenochlamys*

8a. Pinnae flabellate, 2–4 pairs per frond, uniform in size throughout the frond ..... *A. gingkoides*
8b. Pinnae oblong to linear-lanceolate, 10–20 pairs per frond, terminal pinnae smaller or reduced 9

9a. Stipes and rachises with a narrow membranous wing; basal pinnae reflexed; sori 4–9 per pinnae, false indusia dark brown, oblong or reniform, 4–8 mm long ..... *A. soboliferum*

9b. Stipes and rachises without a narrow membranous wing; basal pinnae not reflexed; sori 2–6 per pinnae, false indusia dark brown or brownish-green, linear-oblong, 1–1.8 mm long ..... *A. philippense*

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