THAI FOREST BULL., BOT. 46(2): 155–161. 2018.
DOI https://doi.org/10.20531/tfb.2018.46.2.07

A revision of the genus *Tapeinidium* (Lindsaeaceae) in Thailand

NUTDANAI PUTTHISAWONG[1] & SAHUT CHANTANAORRAPINT[1,*]

ABSTRACT

A revision of the genus *Tapeinidium* (C.Presl) C.Chr. in Thailand is presented based on herbarium specimens and field surveys. Two species are recognized, namely *Tapeinidium luzonicum* (Hook.) K.U.Kramer and *T. pinnatum* (Cav.) C.Chr. A key to species, descriptions, photographs and conservation assessments are provided. In addition, issues with the previous lectotypifications of *Davallia luzonicum* Hook. and *D. pinnata* Cav. are resolved.

KEYWORDS: conservation assessment, *Davallia*, fern, lectotypification, pteridophyte.

Published online: 22 December 2018

INTRODUCTION

With about 18 currently accepted species, *Tapeinidium* (C.Presl) C.Chr. is the third largest genus of the family Lindsaeaceae (Lehtonen *et al.*, 2010; PPG I, 2016). Although it is primarily a Malesian genus its members occur from southern India to Samoa and as far north as the Ryukyu Islands of Japan but are absent from northern India, the northern parts of mainland South-East Asia (including northern Thailand), China and Australia (Holttum 1955 [‘1954’]; Kramer, 1967, 1971). The genus was first described as a subgenus of *Microlepia* C.Presl (Presl, 1851 [‘1849’]) and was subsequently raised to the generic rank by Christensen (1906), based on *Tapeinidium pinnatum* (Cav.) C.Chr.

The earliest report of *Tapeinidium* in Thailand was by Holttum (1955 [‘1954’]) who reported that *T. pinnatum* “occurs...throughout Malaysia [but] northwards of Malaya it extends only into Lower Siam”. More than a decade later, Tagawa & Iwatsuki (1967) reported *Tapeinidium biserratum* (Blume) Alderw. from Khao Luang, Nakhon Si Thammarat province but this was quickly redetermined as *T. luzonicum* (Hook.) K.U.Kramer by Kramer (1968 [‘1967’]). Tagawa & Iwatsuki (1985) subsequently produced an account of *Tapeinidium* for the Flora of Thailand that recognized two species based on a handful of specimens from only three localities: *T. luzonicum* from Khao Luang (Nakhon Si Thammarat) and *T. pinnatum* from Khao Luang (Nakhon Si Thammarat), Ban Mae Lao (Yala) and Ko Chang (Trat). Although the genus concept remains unchanged from that of Tagawa & Iwatsuki (1985), the realization that many more specimens have been collected since the publication of the Flora of Thailand account (now also from Chanthaburi, Krabi, Phatthalung, Phangnga and Trang) prompted us to reassess whether the earlier species concepts also hold. Our study confirmed that there are only two *Tapeinidium* species in Thailand, *T. luzonicum* and *T. pinnatum*. But, more importantly, it resulted in an improved key to these species, more detailed descriptions, conservation assessments and the resolution of some typification issues.

MATERIALS AND METHODS

This study was largely based on fresh specimens from field surveys and herbarium specimens housed in BCU, BK, BKF, PSU and QBG. Most morphological and anatomical characters were examined using stereo and light microscopes. Mature spores were also examined with an electron microscope. Ecological and geographical data were compiled from field observations, specimen labels and publications.

[1] Department of Biology, Faculty of Science, Prince of Songkla University, Hat Yai, Songkhla 90112, Thailand.

* Corresponding author: sahut.c@psu.ac.th

TAXONOMIC TREATMENT

Tapeinidium (C.Presl) C.Chr., Index Filic. 631. 1906; Holttum, Rev. Fl. Malaya ed. 1, 2: 338. 1955 [‘1954’]; Kramer, Blumea 15(2): 545. 1968 [‘1967’]; Kramer in Van Steenis & Holttum (eds), Fl. Males., Ser. 2, Pterid. 1(3): 184. 1971; Tagawa & Iwatsuki in Smitinand & Larsen (eds), Fl. Thailand 3(2): 145. 1985; Kramer in Kramer & Green (eds), Fam. & Gen. Vasc. Pl. 1: 91. 1990; Lethonen *et al.*, Bot. J. Linn. Soc. 163: 337. 2010; Shiyong in Zhengyi & Raven, Fl. China. 2−3: 141. 2013.— *Microlepia* subg. *Tapeinidium* C.Presl, Epimel. Bot.: 968. 1851 [‘1849’].— *Protolindsaya* Copel., Philipp. J. Sci., C. 5: 283. 1910. Type species: *Tapeinidium pinnatum* (Cav.) C.Chr.

Plants usually terrestrial, sometimes lithophytic. *Rhizome* very short to moderately long creeping, solenostelic with an internal sclerified pith, scaly. *Scales* non-clathrate, basally attached, narrowly triangular, apex long attenuate, margin minutely to coarsely toothed. *Fronds* monomorphic. *Stipes* pale to dark brown. *Laminae* pinnately compound, simply pinnate to tripinnate, coriaceous (or subcoriaceous), bearing sparse hairs on lower surface; hairs transparent, uniseriate, 2–3 cells long. *Rachises* with U or V shape vascular bundle in cross section. *Veins* free, pinnately or dichotomously branched, not reaching the margin of the lamina. *Sori* submarginal, terminal on veins, uninerval or very rarely binerval (exceptionally trinerval, but not in Thai species), paraphyses present, uniseriate, 5–11 cells long. *Indusia* firm, pouch-shaped, attached at the base and at least the greater part of the sides, opening towards the margin of the lamina but not reaching it. *Spores* bilateral, monolete.

A tropical Asian and Pacific genus of ca 18 species distributed from southern India to Samoa and as far north as the Ryukyu Islands of Japan but absent from northern India, the northern parts of mainland SE Asia (including northern Thailand), China and Australia (Holttum 1955 [‘1954’]; Kramer, 1967, 1971); Two species in Thailand, mostly in Peninsular Thailand.

KEY TO THE SPECIES OF *TAPEINIDIUM* IN THAILAND

1. Lamina simply pinnate; pinnae linear-lanceolate, up to 0.7 cm wide; margins crenate, serrate or bi-serrate; basal pinnae smaller than or as large as middle pinnae **1. T. pinnatum**
1. Lamina bipinnatisect to tripinnatifid; pinnae not linear-lanceolate; largest pinnae 1.5–8(–13.5) cm wide; basal pinnae larger than other pinnae **2. T. luzonicum**

1. Tapeinidium pinnatum (Cav.) C.Chr., Index Filic.: 631. 1906; Christensen, Bot. Tidsskr. 32: 345. 1916; Holttum, Rev. Fl. Malaya ed. 1, 2: 339, f. 196. 1955 [‘1954’]; Ching, Fl. Reipubl. Popularis Sin. 2: 8. 1959; Kramer, Blumea 15(2): 553. 1968 [‘1967’]; Kramer in Van Steenis & Holttum (eds), Fl. Males., Ser. 2, Pterid. 1(3): 193. 1971; Kramer, Gard. Bull. Singapore 26: 8. 1972; Tagawa & Iwatsuki in Smitinand & Larsen (eds), Fl. Thailand 3(2): 146. 1985; Boonkerd & Pollawatn, Pterid. Thailand: 96. 2000.— *Davallia pinnata* Cav., Descr. Pl. (Cavanilles): 277. 1802.— *Microlepia pinnata* (Cav.) Bedd., Handb. Ferns Brit. India: 64. 1883; Christ, Bot. Tidsskr. 24: 111. 1901.— Type: Philippines [but incorrectly labelled as being from “Chile & the Philippines”], *Née s.n.* (lectotype **MA** [MA475617], first step designated by Kramer (1968 [‘1967’]), second step designated here; isolectotype **MPU** [MPU017606] photo seen). For further synonymy see Kramer (1971). Fig. 1.

Rhizome short creeping, 2–3.5 mm diam., internodes less than 8 mm long, densely scaly throughout. *Scales* light brown to brown, narrowly triangular, 2–4 mm long, up to 12 cells wide at base, apex long attenuate ending with 3–8 uniseriate cells, base obtuse, margin minutely toothed. *Stipes* stramineous or pale brown to dark brown, up to 20 cm long, up to 2.5 mm diam., scaly at base, grooved on adaxial side. *Laminae* simply pinnate, oblong or oblong-lanceolate in outline, 20–46 × 14–23 cm, coriaceous, terminal part pinnatisect and acute to attenuate. *Rachises* green or pale brown, 0.5–1.5 mm diam. at base of lamina, grooved on adaxial side, sharply keeled (carinate) on abaxial side. *Pinnae* up to 27 pairs, consisting (from the base upwards) of 1–3 pairs of lower pinnae and 5–24 pairs of upper pinnae. *Lower pinnae* slightly stalked (petiolules less than 1 mm long), opposite or sub-opposite, linear-lanceolate, 3–14 × 0.2–0.6 cm, apex acute or acuminate, base cuneate, margin crenate, serrate or

bi-serrate; basal pinnae smaller than or as large as other ones. *Upper pinnae* sessile, alternate, linear-lanceolate, 4–15 × 0.3–0.7 cm, apex acute or acuminate, base cuneate, margin crenate, serrate or bi-serrate; the main pinnae all more-or-less the same size, the upper ones gradually becoming smaller towards the frond apex. *Costae* distinct, sharply keeled below, slightly grooved above. *Veins* distinct below, once-forked. *Sori* submarginal, terminal on 1(–2) veins, 0.5–0.75 × 0.5–1.5 mm; 1–3 in each lobe, paraphyses 7-11 cells long. Indusia brown, pouch-shaped, free margin subentire. *Sporangia* spheroidal, 0.2–0.25 × 0.15–0.2 mm; annulus with 15–16 cells; sporangial stalk triseriate, 4–5 cells long. *Spores* light brown, ellipsoid, 35–45 × 20–30 µm, psilate.

Thailand.— SOUTH-EASTERN: Chanthaburi [Khitchakut district, Khao Khitchakut National Park, Krating waterfall area, 425 m, 10 Jan. 2009, *Middleton 4671* (**BKF**, **E** [E00727425], **P** [P02433068])]; Trat [Ko Chang, Khlong Mayom, 100 m, 2 June 1923, *Kerr 6503* (**BK**); 16 Feb. 1955, *Smitinand 2164* (**BKF**); Ko Chang, Lem Dan Kao, 1150 m, 3 Oct. 1924, *Kerr 9244* (**BK**); Ko Chang district, Khlong Phlu Ranger station, 80 m, 6 Jan. 2009, *Middleton et al. 4622* (**BKF**, **E** [E00736559])]; PENINSULAR: Krabi [Khao Phanom Bencha National Park, Khao Penom, 1000 m, 18 June 2006, *Williams et al. 1910* (**BKF**); Pha Nam Yot, Khao Ngon Nak, Noppharatthara Beach-Phi Phi Islands National Park, 480 m, 12 Nov. 2018, *Putthisawong 853* (**PSU**)]; Nakhon Si Thammarat [Khao Luang area, near Khiri Wong village, 16 May 1968, *van Beusekom & Phengkhlai 808* (**BKF**); Khao Nan National Park, Khao Khom, 10 May 2006, *Boonkerd et al. 177* (**BCU**)]; Phatthalung [Pa Bon district, Khao Sam Phu, 200 m, 29 June 2016, *Putthisawong 175* (**PSU**)]; Phangnga [Klong Hin Poeng to Toong Rha, 700 m, 27 Mar. 2000, *Suksathan 2516*, *3666* (**QBG**)]; Yala [Betong district, Ban Malao, 700 m, 25 Aug. 1923, *Smith 1913* (**BKF**); Betong district, Hala-Bala Wildlife Sanctuary, trial up unnamed '1490' mountain reached from shores of Bang Lang Reservoir, 1050 m, 23 May 2005, *Middleton et al. 3581* (**BKF**, **E** [E00246597])].

Distribution.— Southern India, Peninsular Malaysia, Singapore, Indonesia (Sumatra to Sulawesi), Sabah, Sarawak, Philippines, Taiwan and Japan (Ryukyu Islands).

Ecology.— In Thailand, *Tapeinidium pinnatum* grows on soil or rocks near streams in shady areas in lowland evergreen, dry evergreen, and lower montane forests, 80–1150 m altitude. Kramer (1971) suggests that it is a facultative rheophyte.

Proposed IUCN Conservation Assessment.— Least Concern (LC). *Tapeinidium pinnatum* is the most common and widespread species of *Tapeinidium* (Kramer, 1968 ['1967']) and several of the Thai localities are in protected areas.

The original description of *Davallia pinnata* Cav. (Cavanilles, 1802) was based on specimens collected "in Chile and the Philippines" by the French-born Spanish botanist and explorer, Luis Née, during his 5-year expedition (1789–1794) to nearly all the Spanish possessions in the Americas and Asia. While he is known to have collected large numbers of specimens in both Chile and the Philippines there seems to be some confusion over what was collected where as *Davallia pinnata*, like all members of the genus *Tapeinidium*, only occurs naturally in the Old World. Aware that Chile was an incorrect locality, Kramer (1968 ['1967']) chose a Née specimen (*Née s.n.*) from the Philippines at **MA** to serve as the "Type" (i.e. lectotype). Kramer cited this "Type" again in his Flora Malesiana revision (Kramer, 1971) but we cannot locate any Née specimen at **MA** that is solely labelled as being from the Philippines. Instead, there are two specimens of *Davallia pinnata* collected by Née at **MA** that, due to the confusion over the collecting locality, are each still labelled as being from "Chile and the Philippines". Although these labels are misleading it is reasonable to assume that both specimens were collected by Née in the Philippines and, therefore, that either can serve as the lectotype of *Davallia pinnata*. We have chosen *Née s.n.* with barcode MA475617 for the second-step lectotypification (see Art. 9.17 of the Shenzhen Code (Turland *et al.*, 2017)).

2. Tapeinidium luzonicum (Hook.) K.U.Kramer, Blumea 15(2): 552. 1968 ['1967']; Kramer in Van Steenis & Holttum (eds), Fl. Males., Ser. 2, Pterid. 1(3): 191, f. 11. 1971; Kramer, Gard. Bull. Singapore 26: 8. 1972; Tagawa & Iwatsuki in Smitinand & Larsen (eds), Fl. Thailand 3(2): 146, f. 10.5. 1985.— *Davallia luzonica* Hook., Sp. Fil. 1: 174, t. 60B, f. 2, 3 & 5. 1846.— Type: Philippines, Luzon, *Cuming 139*, p.p. (lectotype **E** [E00782194], designated

here; isolectotypes **B**?, not seen but reported by Kramer (1971), **GH** [GH00020954] photo seen (mixed with *T. pinnatum*), **GOET** [GOET009148] photo seen, **L** [L0052135] photo seen).

— *Tapeinidium biserratum* auct. non (Blume) Alderw.: Holttum, Rev. Fl. Malaya ed. 1, 2: 339, f. 197. 1955 ['1954']; Tagawa & Iwatsuki, S.E. Asian Studies [Jap. J. S.E. Asian Studies] 5: 75. 1967. For further synonymy see Kramer (1971). Fig. 2

Rhizome moderately long creeping, 3–5 mm diam., internodes up to 12 mm long, densely scaly throughout. *Scales* light brown to brown, narrowly triangular, 2–5 mm long, 6–15 cells wide at base, apex long attenuate ending with 2–6 uniseriate cells, base obtuse, margin irregularly toothed. *Stipe* dull brownish yellow or brown to dark brown, up to 40 cm long, up to 2.5 mm diam., scaly at base, grooved on adaxial side. *Laminae* bipinnatisect to tripinnatifid, deltoid or oblong-ovate in outline, 16.5–40 × 7.5–30 cm, coriaceous, terminal part pinnatisect and acute to attenuate. *Rachises* dull brownish yellow, 0.5–1.5 mm diam. at base of lamina, grooved on adaxial side, sharply keeled (carinate) on abaxial side. *Pinnae* up to 24 pairs; consisting (from the base upwards) of 1–3 pairs of lower pinnae, 3–6 pairs of middle pinnae, and up to 15 pairs of upper pinnae. *Lower pinnae* slightly stalked (petiolules less than 3 mm long), opposite or subopposite, pinnatisect to bipinnatifid (see Fig 2B), lanceolate-deltoid in outline, 4–22 × 1.5–8(–13.5) cm, the basal pinnae the largest; pinnules (if present) subsessile, 1–3 pairs, subopposite to alternate, shallowly lobed to pinnatifid (see Fig 2B), ovate-lanceolate to linear-lanceolate in outline, 0.5–3.7 × 0.2–0.7 cm, apex obtuse to acuminate, base cuneate, basal basiscopic pinnules often the largest. *Middle pinnae* sessile, alternate, pinnatisect, oblong-lanceolate in outline, 4–14 × 1.2–3 cm. *Upper pinnae* sessile, alternate, shallowly lobed to pinnatifid, oblong-lanceolate in outline, 0.9–3.8 × 0.4–1.1 cm, base cuneate. *Costae* distinct, sharply keeled below, flattened or slightly grooved above. *Veins* in pinnules and ultimate lobes pinnate, veinlets simple or once-forked. *Sori* submarginal, terminal on 1(–2) veins, 0.25–0.5 × 0.5–1.5 mm, paraphyses 5-7 cells long. *Indusia* brown, pouch-shaped, free margin subentire. Sporangia spheroidal, 0.2–0.25 × 0.15–0.2 mm; annulus with 11–16 cells; sporangial stalk triseriate, 4–5 cells long. *Spores* light brown, ellipsoid, (30–)35–47.5 × (20–)22.5–32.5 µm, psilate.

Thailand.— PENINSULAR: Nakhon Si Thammarat [Khao Nan National Park, Khao Khom, 10 May 2006, *Boonkerd et al. 173*, *176* (**BCU**); Khao Luang, 1100–1768 m, 21 Jan. 1966, *Tagawa et al. T4830* (**BKF**, **L**); 1400 m, 23 Aug. 1967, *Iwatsuki et al. s.n.* (**BKF**); 1100 m, 23 May 1968, *van Beusekom & Phengkhlai 941* (**BKF**); 1400 m, 4 July 2017, *Putthisawong 613* (**PSU**); 1400 m, 1 Jan. 2018, *Putthisawong 710* (**PSU**)]; Phatthalung [Pa Bon district, Khao Sam Phu, near summit, ca 950 m, 1 July 2016, *Putthisawong 214* (**PSU**)]; Kongra district, Khao Lon Nom Sao, 900 m, 27 May 2017, *Putthisawong 455* (**PSU**); 1100 m, 28 May 2017, *Putthisawong 467* (**PSU**)]; Trang [Yan Ta Khao district, Khao Banthat mountains, near summit of Phu Pha Mek, 1200 m, 7 Apr. 2003, *Middleton et al. 1993* (**A**, **BKF**, **E** [E00736795], **L**, **MICH**)].

Distribution.— Peninsular Malaysia, Indonesia (Sumatra to Sulawesi), Sabah, Sarawak, Brunei and the Philippines.

Ecology.— In Thailand, *Tapeinidium luzonicum* grows on soil on slopes and stream banks in evergreen and lower montane forests, 900–1770 m altitude.

Proposed IUCN Conservation Assessment.— Least Concern (LC). This species is not under any immediate threat and several of the Thai localities are in protected areas.

The original description of *Davallia luzonica* Hook. (Hooker, 1846) was based on elements of *Cuming 139*, a mixed collection of at least three *Tapeinidium* species and, reputedly, one Athyriaceae species (K000398343, not seen) collected in Luzon, the Philippines. As was common practice at this time Hooker did not designate a holotype nor did he cite any specimen that could serve as the type of *Davallia luzonica*. Kramer (1968 ['1967']) suggested, with some reservation ["Type: *Cuming 139* (**K** ?; isotypes **B**, **L**)."], that *Cuming 139* at **K** could be the "holotype" but for reasons that were not explained he did not cite any **K** specimen or propose an alternative "holotype" (strictly speaking, a lectotype) in his Flora Malesian revision (Kramer, 1971). We think it's possible that by 1971 he had concluded, as we have done, that the only specimen of *Cuming 139* at **K** that is *Tapeinidium* (K000360561) is not *T. luzonicum* (so is not *Davallia luzonica*). Kramer's earlier attempt to lectotypify the name *Davallia luzonica* Hook. with the only *Tapeinidium* specimen

Figure 1. *Tapeinidium pinnatum* (Cav.) C.Chr.: A–B. plants in natural habitats (A on soil, B on rock); C. section of fertile pinna showing serrate margins and submarginal sori terminal on veins; D–E. SEM micrographs of spores, D. equatorial view, E. close-up of surface showing lack of spore ornamentation. D & E. from *Putthisawong 175* (PSU).

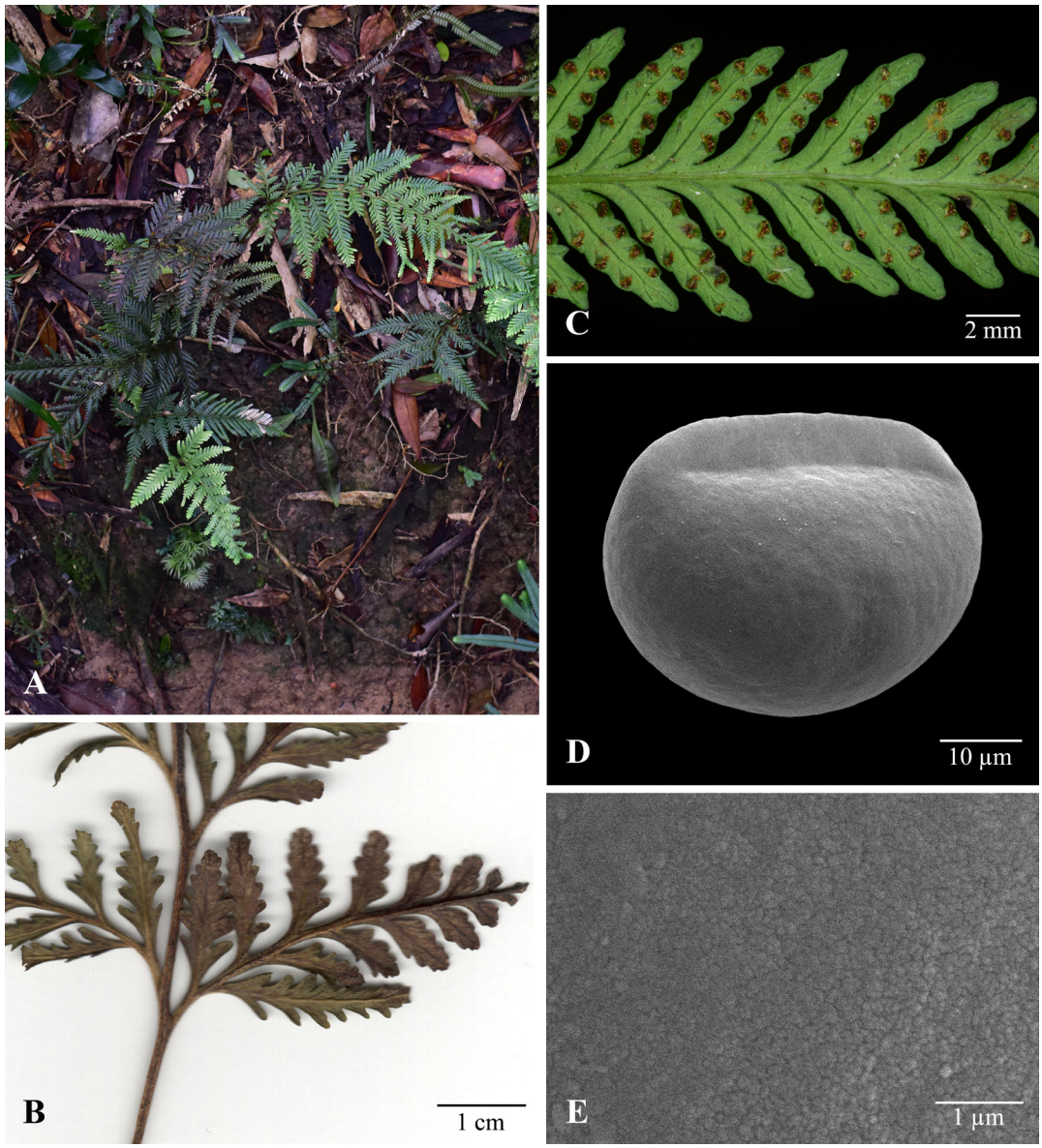

Figure 2. *Tapeinidium luzonicum* (Hook.) K.U.Kramer: A. plant in natural habitat (on soil slope); B. basal pinnae of a tripinnatifid frond (but note that the division of basal pinnae can vary from pinnatisect (resulting in a bipinnatisect frond) to bipinnatifid (resulting in a tripinnatifid frond); C. section of fertile middle pinna showing typical pinnatisect division and submarginal sori terminal on veins; D–E. SEM micrographs of spores, D. equatorial view, E. close-up of surface showing lack of spore ornamentation. B. from *Putthisawong 467* (PSU) and D & E. from *Putthisawong 455* (PSU).

of *Cuming 139* at **K** must be disregarded since that specimen is in serious conflict with the protologue (see Art. 9.19 of the Shenzhen Code (Turland *et al*., 2017)). Since there are no appropriate specimens of *Cuming 139* at **K** we have chosen a specimen at **E** to serve as the lectotype of *Davallia luzonica*. This specimen of *Cuming 139* (E00782194) was previously housed in Glasgow University herbarium where Hooker once worked.

ACKNOWLEDGMENTS

We would like to thank the curators of BCU, BK, BKF, E, GH, GOET, K, L, MA, MPU, P, PSU, QBG and JSTOR Global Plants for access to specimens and/or specimen images. We also thank S. Lindsay (National Parks Board, Singapore) and an anonymous reviewer for useful suggestions. This work was supported by Prince of Songkla University Research Fund (SCI610429S). The first author would like to express his sincere appreciation to the Science Achievement Scholarship of Thailand (SAST) for financial support.

REFERENCES

Cavanilles, A.J. (1802). Descripción de las Plantas. Imprenta Real, Madrid. 625 pp.

Christensen, C.F.A. (1906). Index Filicum: sive enumeratio omnium generum specierumque filicum et hydropteridum ab anno 1753 ad finem anni 1905 descriptorum adjectis synonymis principalibus, area geographica etc. Hafniae [Copenhagen] H. Hagerup. 744 pp.

Holttum (1955 [‘1954’]). A revised Flora of Malaya, an illustrated systematic account of the Malayan flora, including commonly cultivated plants. Vol. 2. Ferns of Malaya. Edition 1. Government Printing Office, Singapore. 643 pp.

Hooker, W.J. (1846). Species Filicum 1. W. Pamplin, London. 245 pp.

Kramer, K.U. (1968 [‘1967’]). The Lindsaeoid ferns of the Old World II. A revision of *Tapeinidium*. Blumea 15(2): 545–556.

_____. (1971). *Lindsaea* Group. Flora Malesiana, Series 2, Pteridophyta 1(3): 177–254.

Lehtonen, S., Tuomisto, H., Rouhan, G. & Christenhusz, M.J.M. (2010). Phylogenetics and classification of the pantropical fern family Lindsaeaceae. Botanical Journal of the Linnean Society 163: 305–359.

PPG I. (2016). A community-derived classification for extant lycopods and ferns. Journal of Systematics and Evolution 54: 563–603.

Presl, C.B. (1851 [‘1849’]). Epimeliae Botanicae. A. Haase, Prague. 264 pp.

Tagawa, M. & Iwatsuki, K. (1967). Enumeration of Thai pteridophytes collected during 1965–66. [Japanese Journal of] Southeast Asian Studies. 5: 23–120.

_____. (1985). Lindsaeaceae. In: T. Smitinand & K. Larsen (eds), Flora of Thailand. 3(2): 129–149. Royal Forest Department, Bangkok.

Turland, N.J., Wiersema, J.H., Barrie, F.R., Greuter, W., Hawksworth, D.L., Herendeen, P.S., Knapp, S., Kusber, W.-H., Li, D.-Z., Marhold, K., May, T.W., McNeill, J., Monro, A.M., Prado, J., Price, M.J. & Smith, G.F. (eds) 2018: International Code of Nomenclature for algae, fungi, and plants (Shenzhen Code) adopted by the Nineteenth International Botanical Congress Shenzhen, China, July 2017. Regnum Vegetabile 159. Glashütten: Koeltz Botanical Books. 254 pp. DOI https://doi.org/10.12705/Code.2018