THAI FOREST BULL., BOT. 44(2): 108–115. 2016.
DOI: 10.20531/TFB.2016.44.2.04

Genus *Calyptrochaeta* (Daltoniaceae, Bryophyta) in Thailand

WANWISA JUENGPRAYOON[1], BOON-CHUAN HO[2] & SAHUT CHANTANAORRAPINT[1,*]

ABSTRACT

A review of the genus *Calyptrochaeta* Desv. in Thailand is presented, based on herbarium specimens and field surveys. Two species are recognized, namely *C. remotifolia* (Müll. Hal.) Z. Iwats. *et al*. and *C. spinosa* (Nog.) Ninh. A key to species, descriptions, and illustrations for the species of *Calyptrochaeta* occurring in Thailand are provided. In addition, lectotype for the names *Eriopus spinosus* Nog. (= *C. spinosa*) are also designated in here.

KEYWORDS: Bryophyta, *Calyptrochaeta*, Daltoniaceae, lectotypification, moss, Thailand.

Published online: 8 December 2016

INTRODUCTION

The genus *Calyptrochaeta*, a member of the family Daltoniaceae, was first established by Desvaux in 1825 based on *Calyptrochaeta cristata* (Hedw.) Desv. It comprises approximately 30 species (Streimann, 2000; Frey & Stech, 2009), which are usually found growing on humus, decaying wood and tree bases in montane forest, and is distributed mainly in tropical regions of the world (Ho & Kruijer, 2007). *Calyptrochaeta* is easily recognized by 1) complanately foliated and often gemmiferous stems, 2) distinctly bordered leaves with a short, forked costa, 3) thick and spiny setae, and 4) fringed often-hairy calyptrae (Ho & Kruijer, 2007).

Thailand is well-known as one of the richest areas of bryophyte diversity (e.g. He *et al.*, 2012; Chantanaorrapint & Sridith, 2014; Inuthai *et al.*, 2014, 2015; Chantanaorrapint, 2015; Promma & Chantanaorrapint, 2015). Both the Indo-Burmese and Sundaland hotspots meet in this area (Myers *et al.*, 2000), which is considered as a centre of plant distribution in South-East Asia (Smitinand, 1989). Although several publications have contributed to the knowledge of the Asiatic species of *Calyptrochaeta* (e.g. Noguchi, 1937; Ninh, 1981; Tan & Robinson, 1990; Lin & Tan, 1995; Mohamed & Robinson, 1991; Ho & Kruijer, 2007), there are few reports of this genus from Thailand. The first report of *Calyptrochaeta* in Thailand was published by Touw (1968), who reported *C. remotifolia* (Müll.Hal.) Z.Iwats. *et al.* (as *Eriopus remotifolius* Müll.Hal.) from Nakhorn Si Thammarat Province. Later, Akiyama *et al.* (2011) reported *C. ramosa* (M.Fleisch.) B.C.Tan & H.Rob. subsp. *spinosa* (Nog.) P.J.Lin & B.C.Tan (= *C. spinosa* (Nog.) Ninh) from Doi Inthanon National Park, Chiang Mai Province. Sukkharak *et al.* (2014) also found *C. remotifolia* from Chanthaburi Province. The aim of the present study was to prepare a revision of *Calyptrochaeta* within the framework of the bryophyte Flora of Thailand.

MATERIALS AND METHODS

This study is based on recent collections from Thailand as well as herbarium specimens housed in BCU, BKF, CMU, HYO, L and PSU. Morphological and anatomical characters have been studied using stereoscopic and compound microscopes. The distinctive characters of the species have been illustrated with the aid of an Olympus drawing tube.

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

[2] Singapore Botanic Gardens, 1 Cluny Road, Singapore 259569, Republic of Singapore; e-mail: HO_Boon_Chuan@nparks.gov.sg

* Corresponding author: e-mail: sahut.c@psu.ac.th

In addition, an identification key to species and detailed descriptions of each species are provided along with their known distribution and ecological data.

TAXONOMIC TREATMENT

There are two species of *Calyptrochaeta* in Thailand: *C. remotifolia* and *C. spinosa* and a key for distinguishing them is given below:

1. Foliate stems up to 5.5 cm tall, with rounded apex when gemmiferous; stems in cross section with a central strand. Leaves strongly toothed along margin, bordered by 3–4 rows of linear cells **C. remotifolia**
1. Foliate stems up to 3 cm tall, with attenuated apex when gemmiferous; stems in cross section without a central strand. Leaves weakly toothed along margin, bordered by 1–2 rows of linear cells **C. spinosa**

1. Calyptrochaeta remotifolia (Müll.Hal.) Z.Iwats., B.C.Tan & Touw., J. Hattori Bot. Lab. 44: 150. 1978.— *Eriopus remotifolius* Müll.Hal., Bot. Zeitung (Berlin) 5: 828. 1847.— *Hookeria remotifolia* (Müll.Hal.) Müll.Hal., Syn. Musc. Frond. 2: 207. 1851. Type: Indonesia. Java, "monte Gédé supra terram humosam et lapides", *Reinwardt s.n.* (holotype **B**). Figs. 1 & 3A–D.

Plants light to dark green, glossy, turning to brownish yellow in herbarium specimens. *Rhizoids* dark reddish, dense on primary stem. *Primary stems* short tightly attached to substrata, bearing a number of aerial foliate stems. *Foliate stems* erect, medium to large in size, 2.5–5.5 cm long, 0.8–1.0 cm wide with leaves, usually unbranched, dark green to reddish brown, in cross section with a differentiated central strand, 24–28 cells across; cortical cells 4–5 layers, thick walled; medullary cells large in size and thin-walled. *Leaves* heteromorphic, complanate, widely spreading, somewhat rugose when dry, straight when moist; lateral leaves large, ovate to oblong, 4.2–5.0 mm long, 1.5–2.0 mm wide, apices broadly acute, margins coarsely dentate in upper half with strongly toothed, distinctly bordered all around with 3–4 rows of linear cells, costa short and forked, 0.5–1.0 mm long at leaf base; dorsal and ventral leaves smaller than lateral leaves, mostly broadly ovate to elliptic, 2.5–3.5 mm long, 1.3–1.7 mm wide; apices broadly acute, margins weakly dentate in upper half. Leaf cells large in size, thin walled, apical cells short hexagonal to rhomboidal, 80–125 × 20–35 µm; marginal and median cells oblong hexagonal to irregularly pentagonal, 100–150 × 25–45 µm; basal cells oblong hexagonal to irregularly pentagonal, 140–180 × 25–50 µm.

Dioicous. *Perigonial* leaves, yellowish green, narrowly ovate to elliptic, 0.8–1.2 mm long, 0.5–0.8 mm wide, acute, entire. *Antheridia* 600–650 µm long. *Perichaetial* leaves, yellowish green, narrowly ovate to elliptic, 0.7–1.0 mm long, 0.4–0.6 mm wide, round, entire. *Seta* slender, 4–7 mm long, reddish brown, papillose 5–10 µm long. *Capsule* ovoid-oblong, horizontal, 1.0–1.8 mm long, operculum long rostrate; outer peristome teeth orange to reddish, lanceolate, narrowly furrowed, transversely striolate; inner peristome teeth as long as outer peristome, with high basal membrane. *Calyptra* mitriform, slightly hairy above, strongly fringed hairs at the base. Asexual reproduction by gemmae, numerous cluster of reddish brown, filiform, present along distal part of foliate stem among leaves.

Thailand.— NORTHERN: Chiang Mai [Doi Inthanon National Park, 15 ha Plot, near Check Point 2, 1600–1700 m, 31 Dec. 2008, *Akiyama et al. 239* (**HYO**); 6 Jan. 2009, *Akiyama et al. 407* (**HYO**); 10 Mar. 2011, *Printarakul 2673*, *3654* (**CMU**, **O**)]; Phitsanulok [Phu Hin Rong Kla National Park, 1624 m, 9 July 2015, *Juengprayoon 552*, *556*, *559*, *573* (**BKF**, **PSU**)]; NORTH-EASTERN: Loei [Man Dang Waterfall, 1615 m, 9 Dec. 2013, *Chantanaorrapint & Promma 3422* (**PSU**); Phu Luang Wildlife Sanctuary, 1151 m, 5 July 2015, *Juengprayoon 474* (**PSU**); 1517 m, 6 July 2015, *Poopath 1165*, *1166*, *1171*, *1173*, *1177*, *1192* (**BKF**, **PSU**)]; SOUTH-WESTERN: Prachuap Khiri Khan [Huai Yang Waterfall National Park, 1072 m, 3 Mar. 2016, *Chantanaorrapint et al.109* (**PSU**)]; PENINSULAR: Nakhorn Si Thammarat [Khao Nan National Park, Khao Nan Mt, 1000–1300 m, 21 Apr. 2007, *Chantanaorrapint 1622* (**PSU**); Khao Luang National Park, Khao Luang Mt, 4 Feb. 1966, *Touw 11612* (**L**), 1308 m, 21 Apr. 2014, *Juengprayoon 115*, *116A* (**PSU**); 1484 m, 22 Apr. 2014, *Juengprayoon 120*, *121B*, *122A*, *124* (**PSU**); 1537 m, 22 Apr. 2014, *Juengprayoon 126*, *127A*, *128*, *129B* (**PSU**); 1403 m, 23 Apr. 2014, *Juengprayoon 135A*, *137A* (**PSU**); 1264 m, 25 June 2015, *Juengprayoon 363*, *364*, *367* (**PSU**); 1326 m, 26 June 2015, *Juengprayoon 390*, *392*, *396*, *397*, *411*, *414*, *415*,

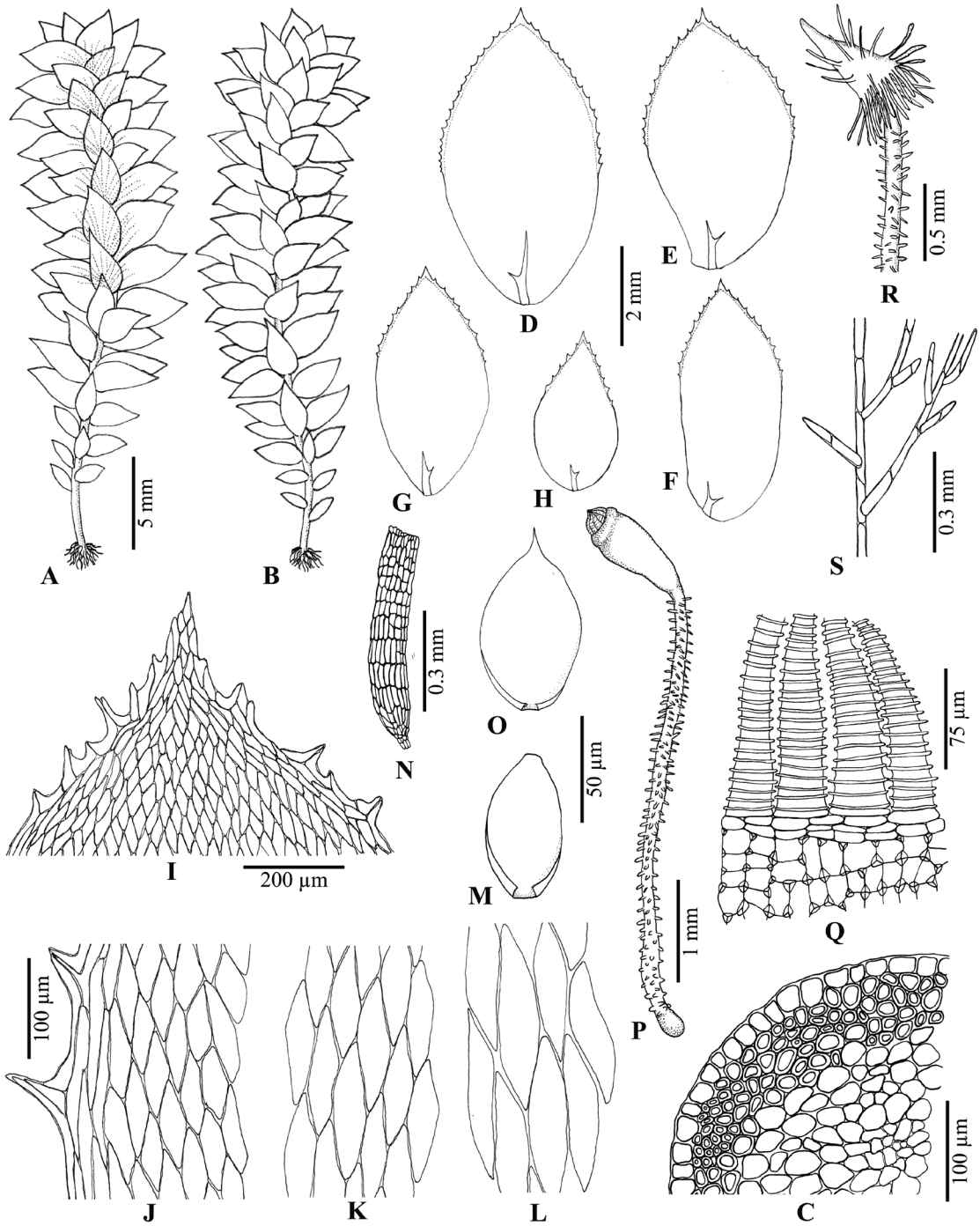

Figure 1. *Calyptrochaeta remotifolia* (Müll.Hal.) Z.Iwats., B.C.Tan & Touw. A–B. Sterile gametophytes; C. Cross section of stem; D–E. Lateral leaves; F–H. Dorsal leaves; I. Leaf apex; J. Cells at leaf margin; K. Cells at median part of leaf; L. Cells at leaf base; M. Perigonial leaf; N. Antheridium (old); O. Perichaetial leaf; P. Sporophyte; Q. Part of exostome; R. Calyptra on a developing capsule; S. Gemmaphore. All from *Juengprayoon 424* (PSU). Drawn by W. Juengprayoon.

422, *424*, *427*, *428A*, *434*, *442*, *443B*, *446* (**PSU**); Khao Ram Rom Mt, 945 m, 10 Feb. 2016, *Juengprayoon 722* (**PSU**), 10 Apr. 2016, *Juengprayoon 741* (**PSU**)]; Trang [Khao Chet Yot Mt, 1116 m, 21 May 2012, *Chantanaorrapint & Promma 1215A* (**BKF**, **PSU**); 1067 m, 2 May 2014, *Juengprayoon 152* (**PSU**)].

Distribution.— India, Indonesia (Bali, Flores, Java, Kalimantan, West Papua, Ceram and Sumatra), Malaysia (Malaya, Sabah, Sarawak), Papua New Guinea, Philippines and Thailand (Gangulee, 1977; Tan & Robinson, 1990; Mohamed & Robinson, 1991).

Habitat and ecology.— In Thailand, *Calyptrochaeta remotifolia* was found growing amongst other bryophytes such as *Distichophyllum cuspidatum* (Dozy & Molk.) Dozy & Molk., *Heteroscyphus coalitus* (Hook.) Schiffn., *Jubula* sp., *Pyrrhobryum spiniforme* (Hedw.) Mitt., and *Thuidium* sp., on wet rocks, tree trunks and rotten wood in montane forests, at altitudes between 1000 and 1630 m.

Notes.— The distinctive features of *C. remotifolia* are plant size medium to large, the presence of central strand in stem cross-section, leaf margins strongly toothed above, leaf border consisting of 3–4 rows of linear cells near the apex, and perichaetial leaves with blunt or round apex.

2. Calyptrochaeta spinosa (Nog.) Ninh, Acta Bot. Acad. Sci. Hung. 27: 159. 1981.— *Eriopus spinosus* Nog., J. Sci. Hiroshima Univ., Ser. B, Div. 2, Bot. 3: 51, f. 6. 1937.— *Calyptrochaeta ramosa* (M.Fleisch.) B.C.Tan & H.Rob. subsp. *spinosa* (Nog.) P.J.Lin & B.C.Tan, Harvard Pap. Bot. 7: 29. 1995. Type: Formosa (= Taiwan), prov. Taihoku (= Taipei), Mt Taihei, ca 2200 m, August 1932, *Noguchi 6601a* (holotype: **HIRO**, missing). Lectotype: Nog. J. Sci. Hiroshima Univ., Ser. B, Div. 2, Bot. 3: 51, f. 6. 1937 (here designated). Figs. 2 & 3E–H.

Calyptrochaeta pocsii Ninh, Acta Bot. Acad. Scientiarum Hung. 27: 157. 1981. Type: Vietnam. Tamdao, lower montane evergreen forest, 1350 m, on decaying wood, *Tr. Ninh 68–202a* (holotype **HNU**; isotype **SINU**).

Plants yellowish green to dark green, glossy, turning to greenish brown in herbarium specimens. *Rhizoids* dark reddish, dense on primary stems. *Primary stems* short, creeping and tightly adherent to substrate. *Foliate stems* erect, 1.5–3.0 cm long, 0.25–0.4 cm wide with leaves, simple or branched, dark green to reddish brown, in cross section without central strand, 17–20 cells across, cortical cells 2–3 layers, thick walled, medullary cells large in size and thin walled. *Leaves* heteromorphic, complanate, widely spreading, somewhat curved when dry, straight when moist; lateral leaves large, short ovate to oblong, 2.2–3.5 mm long, 1.3–1.8 mm wide, apices broadly acute, margins dentate, bordered all around with 1–2 rows of linear cells, costa short and forked, 0.3–0.5 mm long at leaf base; dorsal and ventral leaves smaller than lateral leaves, mostly broadly ovate, 1.3–1.5 mm long, 1.0–1.2 mm wide, apices broadly acute, margins slightly dentate in upper half. Leaf cells medium size, thin walled; apical cells short hexagonal, 30–45 ×15–20 µm; marginal and median cells oblong hexagonal to irregularly pentagonal, 50–90 × 25–40 µm; basal cells oblong hexagonal to irregularly pentagonal, 120–150 × 45–50 µm.

Dioicous. *Perigonial* leaves, yellowish green to light green, narrowly ovate to lanceolate, 0.5–0.7 mm long, 0.15–0.2 mm wide, acuminate, entire. *Antheridia* 300–450 µm long. *Perichaetial* leaves, yellowish green, broadly ovate, 0.7–1.0 mm long, 0.4–0.5 mm wide, acuminate, entire. Seta slender, 2.5–3.0 mm long, dark green to reddish brown, papillose 2–4 µm long. *Capsule* ovoid, erect or inclined, 0.5–0.8 mm long, operculum long rostrate; outer peristome teeth yellowish orange, lanceolate, narrowly furrowed, transversely striolate; inner peristome teeth as long as outer peristome, with high basal membrane. *Calyptra* mitriform, slightly hairy above, strongly fringed hairs at the base. Asexual reproduction by gemmae in numerous clusters, reddish brown, filiform or branched, present along distal part of foliate stem among leaves.

Thailand.— NORTHERN: Chiang Mai [Doi Inthanon National Park, 2300 m, 20 Dec. 1965, *Touw 10126* (**L**); 10 Dec.1969, *Beusekom B187* (**L**); Ang Ka, 2545 m, 23 July 2007, *Nathi 145* (**BCU**); 2580 m, 9 Feb. 2008, *Nathi 746* (**BCU**); 2214 m, 13 May 2008, *Nathi 1032* (**BCU**); 1900–2543 m, 31 Oct. 2015, *Juengprayoon 603*, *607*, *610A* (**BKF**, **PSU**); 15 ha Plot, near Check Point 2, 1600–1650 m, 28 Dec. 2008, *Akiyama et al. 132* (**HYO**); 31 Dec. 2008,

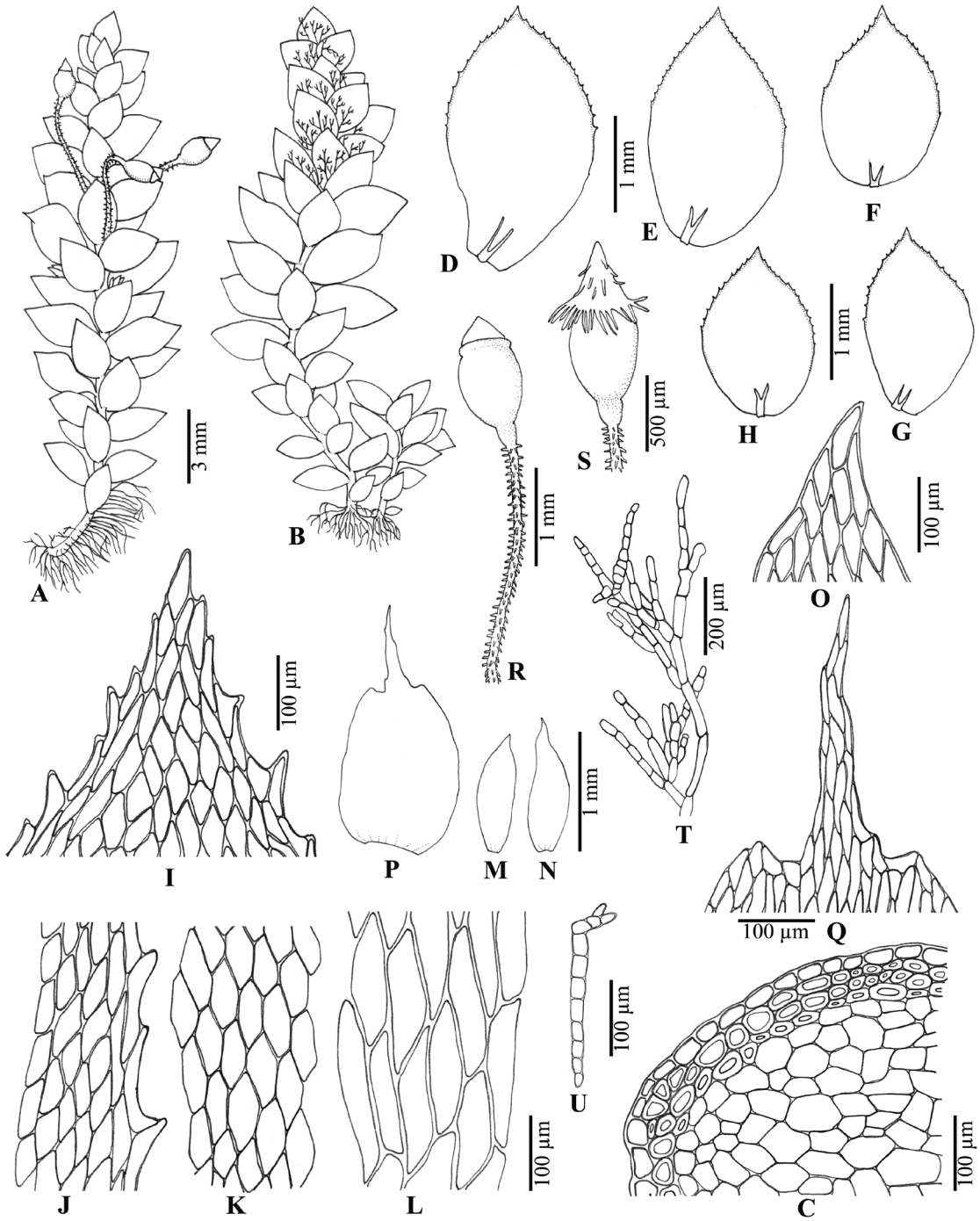

Figure 2. *Calyptrochaeta spinosa* (Nog.) Ninh. A. Gametophyte with sporophytes; B. Gametophyte with gemmae; C. Cross section of stem; D–E. Lateral leaves; F–H. Dorsal leaves; I. Cells at leaf apex; J. Cells at leaf margin; K. Cells at median part of leaf; L. Cells at leaf base; M–N. Perigonial leaves; O. Cells at the apex of perigonial leaf; P. Perichaetial leaf; Q. Cells at the apex of perichaetial leaf; R. Upper part of sporophyte; S. Capsule with calyptra; T. Gemmaphore with gemmae; U. Gemma. All from *Juengprayoon 603* (PSU). Drawn by W. Juengprayoon.

Figure 3 A–D. *Calyptrochaeta remotifolia* (Müll.Hal.) Z.Iwats., B.C.Tan & Touw.: A–B. Plants in natural habitat, C. Gametophytes producing the reddish gemmae; D. Gametophyte with sporophytes; E–H. *Calyptrochaeta spinosa* (Nog.) Ninh.: E. Plants in natural habitat (dry condition), F. Plants in wet condition, G–H. Gametophytes with mature sporophytes. Photographed by S. Chantanaorrapint.

Akiyama et al. 249 (**HYO**); 2 Jan. 2009, *Akiyama et al. 306* (**HYO**); 10 Mar. 2011, *Printarakul 3669*, *3670* (**CMU**, **O**); near Plot E-07, 2300 m, 11 Mar. 2011, *Akiyama* & *Printarakul 1531* (**HYO**); Kieo Mae Pan, 2167 m, 28 June 2007, *Nathi 1182* (**BCU**); 2214 m, 13 May 2008, *Nathi 1032* (**BCU**); 2167 m, 1 Nov. 2015, *Juengprayoon 617*, *618A*, *619A*, *622B*, *623*, *624A*, *625*, *627*, *628A* (**BKF**, **PSU**); Doi Pha Hom Pok National Park, 1922 m, 2 Nov. 2015, *Juengprayoon 641*, *643*, *644* (**BKF**, **PSU**)].

Distribution.— China (Guangxi, Guangdong, Guizhou, Hainan, Sichuan, Yunnan), Nepal, Taiwan, Thailand and Vietnam (Gangulee, 1977; Nihn, 1981 as *C. pocsii*; Lin & Tan, 1995 as *C. ramosa* subsp. *spinosa*; Redfearn *et al.*, 1996; Akiyama *et al.*, 2011 as *C. ramosa* subsp. *spinosa*).

Habitat and ecology.— The species were found growing amongst other bryophytes, such as *Bazzania* sp., *Calycularia crispula* Mitt., *Plagiochila* sp. and *Thamniopsis utacamundiana* (Mont.) W.R.Buck, on tree trunks in montane forest, between 1900 and 2543 m altitude.

Notes.— The main diagnostic characters for *C. spinosa* are plant size small to medium, the absence of central strand in stem cross-section, leaf margins weakly toothed above, leaf border consisting of 1–2 rows of linear cells, and perichaetial leaves with acuminate apex. Tan and Robison (1990) suggested that *C. spinosa* might be a juvenile form of *C. ramosa* (M.Fleisch.) B.C.Tan & H.Rob. Later, Lin and Tan (1995) reduced *C. spinosa* as a subspecies of *C. ramosa*. However, our examination of the various specimens of both species reveals that *C. spinosa* is quite different from *C. ramosa* and thus cannot be a juvenile form of *C. ramosa*. Therefore, we agree with Redfearn *et al.* (1996) in reinstating *C. spinosa* as a distinct species.

Typification.— *Calyptrochaeta spinosa* was originally described by Noguchi (1937) as *Eriopus spinosus* Nog., based on his collection from Taiwan. Unfortunately, the type specimen can not be located in HIRO (see Lin & Tan, 1995: 29) and could have been destroyed during WWII (T. Yamaguchi, pers. comm. 21 December 2015). It became necessary to lectotypify this name. Noguchi's (1937) illustrations in the original protologue is designated here as the lectotype of *Eriopus spinosus*.

ACKNOWLEDGEMENTS

We would like to thank the curators and staffs of BCU, BKF, CMU, HYO, L and PSU for making specimens available for study through loans or visits. Sincere thanks to Dr Hiroyuki Akiyama for providing the specimens and the anonymous readers who reviewed this manuscript. The help of Prof Tomio Yamaguchi for looking for the type of *Eriopus spinosus* in HIRO and his suggestion of what could have happened to it is much appreciated. This work was supported by the Faculty of Science Research Fund, and the Graduate School, Prince of Songkla University. The first author would like to express her sincere appreciation for a research assistantship from the Faculty of Science, Prince of Songkla University.

REFERENCES

Akiyama, H., Furuki, T., Sri-Ngernyuang, K. & Kanzaki, M. (2011). Alphabetical list of bryophytes occurring in a 15 ha long-term monitoring plot at Doi Inthanon, Northern Thailand. Bryological Research 10: 153–164.

Chantanaorrapint, S. (2015). Taxonomic studies on Thai Anthocerotophyta II. The genus *Notothylas* (Notothyladaceae). Cryptogamie, Bryologie 36: 251–266.

Chantanaorrapint, S & Sridith, K. (2014). The genus *Plagiochasma* (Aytoniaceae, Marchantiopsida) in Thailand. Cryptogamie, Bryologie 35: 127–132.

Frey, W. & Stech, M. (2009). Bryophyta. In: Frey, W. (ed), Syllabus of Plant Families – A. Engler's Syllabus der Pflanzenfamilien, 13th Edition. Part 3: Bryophytes and seedless Vascular Plants. Borntraeger, Berlin, pp. 116–257.

Gangulee, H.C. (1977). Mosses of Eastern India and adjacent regions. Fascicle 6 (Hookeriales). Calcutta, India.

He, Q., Zhu, R.-L., Chantanaorrapint, S., Kornochalert, S. & Printarakul, N. (2012). *Drepanolejeunea laciniata* (Lejeuneaceae), a new species from northern Thailand. Cryptogamie, Bryologie 33: 291–298.

Ho, B.-C. & Kruijer, H. (J.D.). (2007). Growth Patterns in *Calyptrochaeta* Desv. (Daltoniaceae). In: A.E. Newton, & R. Tangney (eds), Pleurocarpous mosses: Systematics and Evolution. Systematics Association Special Volume Series 71, Chapter 5: 111–115. CRC Press, Boca Raton.

Inuthai, J., Zhu, R.-L. & Chantanaorrapint, S. (2014). *Drepanolejeunea actinogyna* (Lejeuneaceae), a new species from southern Thailand. Bryologist 117: 165–169.

_____. (2015). Taxonomic notes on *Drepanolejeunea pleiodictya* (Marchantiophyta, Lejeuneaceae), a little-known Asiatic species. Polish Botanical Journal 60: 13–17.

Lin, P.-J. & Tan, B.C. (1995). Contribution to the Bryoflora of China (12): A taxonomic revision of Chinese Hookeriaceae (Musci). Harvard Papers in Botany 1: 25–68.

Mohamed, H. & Robinson, H. (1991). A taxonomic revision of the moss families Hookeriaceae and Hypopterygiaceae in Malaya. Smithsonian Contributions to Botany 80: 1–44.

Müller, C. (1847). De muscis nonnullis novis vel minus cognitis exoticis. Botanische Zeitung (Berlin) 5: 825–840.

_____. (1851). Synopsis Muscorum Frondosorum Omnium Husque Cognitorum. Pars 2. A. Foerstner, Berlin.

Myers, N., Mittermeier, R.A., Mittermeier, C.G., Da Fonseca, G.A.B. & Kent, J. (2000). Biodiversity hotspots for conservation priorities. Nature 403: 853–858.

Ninh, T. (1981). Mosses of Vietnam, II. Acta Botanica Academiae Scientiarum Hungaricae 27: 151–160.

Noguchi, A. (1937). Studies on the Japanese Mosses of the Orders Isobryales and Hookeriales II: Journal of Science of the Hiroshima University: Series B, division 2 (botany) 3: 37–56.

Promma, C. & Chantanaorrapint, S. (2015). The epiphyllous *Radula* (Radulaceae, Marchantiophyta) in Thailand, with the description of *Radula grandilobula* sp. nov. Cryptogamie, Bryologie 36: 217–234.

Redfearn, P.L., Tan, B.C. & He, S. (1996). A newly updated and annotated checklist of Chinese mosses. Journal of the Hattori Botanical Laboratory 79: 163–357.

Smitinand, T. (1989). Thailand. In: Cambell D.C. & Hammond H.D. (eds), Floristic Inventory of Tropical Countries. New York, New York Botanical Garden, Bronx, pp. 65–82.

Streimann, H. (2000). Taxonomic studies on Australian Hookeriaceae (Musci). 3. The genera *Calyptrochaeta*, *Daltonia*, *Hookeriopsis* and Sauloma. Journal of the Hattori Botanical Laboratory 88: 101–138.

Sukkharak, P., Kitlap, P., Likananonn, A. & He, S., (2014). A preliminary study of bryophytes in the Khao Soi Dao wildlife sanctuary, Chanthaburi Province, Thailand. Songklanakarin Journal of Science and Technology 36: 527–534.

Tan, B.C. & Robinson, H. (1990). A review of Philippine Hookeriaceous taxa (Musci). Smithsonian Contributions to Botany 75: 1–41.

Touw, A. (1968). Miscellaneous notes on Thai Mosses. Natural History Bulletin of the Siam Society 22: 217–244.