KEW BULLETIN (2018) 73: 53
DOI 10.1007/S12225-018-9778-X

ISSN: 0075-5974 (print)
ISSN: 1874-933X (electronic)

Two new species of *Hydrobryum* (Podostemaceae) from Laos

Satoshi Koi[1] & Masahiro Kato[2]

Summary. Two new species of Podostemaceae are described from a single site in northern Central Laos. *Hydrobryum hapteron* is characterised by the many long holdfasts in the basal area of the crustose root and the long stalks of capsules. It shares the prominent holdfasts and stalks of capsules with *H. ramosum* (C. Cusset) Koi & M. Kato but is distinct from it in the crustose root. *Hydrobryum subcylindricoides* is similar to *H. subcylindricum* Koi & M. Kato in the ribbon-like root but differs from it in the wider root, Y-shaped stigmas and fewer ribs on the capsule.

Key Words. Holdfast, *Hydrobryum hapteron*, *Hydrobryum subcylindricoides*, Laos, Phou Khao Khouay, taxonomy.

Introduction

Podostemaceae, an aquatic haptophytic family, is classified into three subfamilies, of which Podostemoideae is the largest with c. 290 species (Koi & Kato 2012). The subfamily is distributed across tropical Africa (with Madagascar), America and Asia. Asian Podostemoideae comprises 13 genera including *Hanseniella* C. Cusset, *Hydrodiscus* Koi & M. Kato and *Thawatchaia* M. Kato, which are closely allied to *Hydrobryum* Endl. *Hydrobryum*, like the allied genera, occurs in East and South East Asia and comprises 27 species. Laos is the second most species-rich country for the genus (10 species; Koi & Kato 2012, 2015), following Thailand (15 spp.; Werukamkul *et al.* 2016). The genus is especially diverse (seven of 10 spp.) in the Phou Khao Khouay National Protection Area, which accounts for only 0.8% of the land area of Laos. The area is located in Bolikamxai Province, northern Central Laos. The species of *Hydrobryum* are also diverse morphologically. Among Asian Podostemoideae the genus was traditionally defined by the crustose root, as well as the flattened, ribbed capsules (Cusset 1992; Kato 2004; Cook & Rutishauser 2007). Recent explorations in Phou Khao Khouay have helped to discover or rediscover three species with ribbon-like roots, in addition to four species with crustose roots (Koi & Kato 2012). In this paper, we describe two more species of *Hydrobryum* from the area, using recent collections. One is characterised by crustose roots and elongate holdfasts; the other is characterised by ribbon-like roots and simplified flowers. As a result, the known morphological diversity of the genus has increased.

Taxonomic Treatment

Hydrobryum hapteron *Koi & M. Kato* **sp. nov.** Type: Laos, Bolikhamxay Province, rapids upstream of Tad Xai waterfall, Phou Khao Khouay National Protected Area, 18°28'15.5"N, 103°07'23.0"E, 400 m alt., 20 Nov. 2016 (fl. & fr.), *S. Koi, P. Werukamkul & M. Kato* LPK-06 (holotype TNS; isotype HNL).

http://www.ipni.org/urn:lsid:ipni.org:names:60476641-2

Annual. *Roots* crustose, fan- or irregular-shaped, irregularly lobed, corrugate, dull green, fleshy, up to 15 cm long, up to 5 cm wide, 0.6 – 0.9 mm thick, anastomose-veined (visible in fixed material), adhered to rock surface with prominent holdfasts. *Holdfasts* columnar, thickened to base, narrowed toward distal end, the end usually disk-like, fleshy, green when alive, 4 – 25 on ventral surface near base of root, absent from the other part, 2 – 9 mm long, 1.5 – 2 mm thick at proximal end, 1 – 1.5 mm thick at distal end. *Leaves* tufted, to 5 per tuft, linear, to 5 mm long, scattered on dorsal surface of root. *Flowers* scattered on dorsal surface of root, subtended by bracts; bracts 4, sometimes 6 in 2 rows, if 6, basal bracts reduced, elliptic-ovate, appressed to root; flower-buds appressed to root, flowers ascending or upright at maturity; spathella enclosing flower-bud, ruptured longitudinally, sometimes apically; tepals 2, borne near middle of ovary-stalk or below, filiform, on either side of filament (andropod), 1.5 – 2.5 mm long; stamens 2, 3 – 7 mm long, forked ¼ – ⅙ from top, anthers 2 on each filament, elliptic; ovary-stalk 2.5 – 4.5 mm long, 0.3 – 0.4 mm thick, slightly flattened; ovary 1, elliptic,

Accepted for publication 12 September 2018. Published online 23 October 2018

[1] Botanical Gardens, Faculty of Science, Osaka City University, Katano, Osaka, 576-0004, Japan. e-mail: skoi@sci.osaka-cu.ac.jp
[2] Department of Botany, National Museum of Nature and Science, Tsukuba, 305-0005, Japan. e-mail: sorang@kahaku.go.jp

moderately flattened, 2.5 – 3 mm long, 1.2 – 1.5 mm wide, 2-locular; stigmas 2, forked at or above base, equal, subulate or linear, reflexed at maturity, 1.5 – 2 mm long; ovules 30 – 70 per locule, on surface of septum except in small lower sterile area. *Capsule* long-stalked (stalk 3 – 10 mm), elliptic, flattened, 2.5 – 3.2 mm long, 1.2 – 1.4 mm wide, ribbed, ribs 16, prominently raised, and also 2 less prominent dehiscing ribs, dehiscing by 2 valves, valves equal, persistent. Figs 1 and 2.

RECOGNITION. Distinct from all congeners in having many long holdfasts in the basal part of crustose roots.
DISTRIBUTION. Asia: Laos.
SPECIMENS EXAMINED. LAOS. Bolikhamxay Province: rapid on rock-bed upstream of Tad Xai waterfall, Phou Khao Khouay National Protected Area, 18°28'15.5"N, 103°07'23.0"E, 400 m alt., 20 Nov. 2016 (fl. & fr.), *S. Koi, P. Werukamkul & M. Kato* LPK-06 (holotype TNS; isotype HNL); loc. cit., 10 Dec. 2015 (fr.), *M. Kato* L-513 (TNS).
HABITAT. On rock surface in rapids submerged in the rainy season, and exposed, then dried in the dry season, densely covering flat and large rocks in open places (Fig. 2A and B).
CONSERVATION STATUS. Near Threatened (NT). Plants are abundant in one large population in a small area of about 100 m^2, which is far from a tourist spot. Further exploration in other areas is needed.
ETYMOLOGY. The species name is derived from the prominent holdfasts.
NOTES. The genus *Hydrobryum* was established based on *H. griffithii* (Wall. ex Griff.) Tul. with crustose roots. *Hydrobryum* sect. *Zeylanidium* Tul. was proposed based on the crustose *H. olivaceum* (Gardner) Tul., but later raised to a genus as *Zeylanidium* (Tul.) Engl. (Cusset 1992). Subsequently, the crustose genera *Synstylis* C. Cusset and *Diplobryum* C. Cusset were proposed as independent genera, but later merged with *Hydrobryum* (Cook & Rutishauser 2001; Kato 2004; Koi & Kato 2012).

Holdfasts, special organs with which to adhere to submerged rock surfaces in fast water currents (Rutishauser 1997; Cook & Rutishauser 2007), are present in some species with ribbon-like roots in different forms and degrees. However, holdfasts have not been recorded in crustose species until now. *Hydrobryum hapteron* is distinct in the genus in the crustose root and many elongate holdfasts on the ventral surface. The long-stalked capsules with 16 ribs and 2 less prominent dehiscing ribs and the thick, fleshy, corrugated, large root are also characteristic. The species is somewhat similar to *H. verrucosum* Koi & M. Kato with warty projections scattered on the ventral surface of the crustose root, the long stamens (3 – 7 mm vs 4 – 8 mm in *H. verrucosum*) and long stigmas (1.5 – 2 mm vs 0.5 – 2 mm), but distinct from it in the elongate and basal holdfasts and long stalk of the capsule (3 – 10 mm vs 1 – 4 mm). *Hydrobryum hapteron* also shares with *H. ramosum* prominent holdfasts (2 – 9 mm long, 1.5 – 2 mm thick vs 2 – 4 mm long, 0.5 mm thick in *H. ramosum*), longitudinally dehiscing spathella, equally long stigmas (1.5 – 2 mm vs 1.5 – 3 mm), long stalk of capsules (3 – 10 mm vs 2 – 10 mm), and 16 + 2 ribs on the capsule. However, its crustose root is markedly different from the subcylindrical, repeatedly branched root of *H. ramosum*. Moreover, the two species are distinct in the position of the tufted leaves and floriferous shoots on the root; they are scattered on the dorsal surface of the root in *H. hapteron*, whereas they are borne regularly at the sinuses of root branches in *H. ramosum*.

Hydrobryum subcylindricoides *Koi & M. Kato* **sp. nov.** Type: Laos, Bolikhamxay Province: Upstream of Tad Xai, Phou Khao Khouay National Protected Area, 18°28'15.5"N, 103°07'23.0"E, 400 m alt., 11 Nov. 2016 (fl. & fr.), *S. Koi, P. Werukamkul & M. Kato* LPK-07 (holotype TNS; isotypes NHL, BKF).

http://www.ipni.org/urn:lsid:ipni.org:names:60476642-2

Annual. *Root* ribbon-like, 0.9 – 1.2 mm wide, branched sympodially, attached to rock surface with pads of root hairs on ventral side at sinuses of root branches; tufts of leaves (= vegetative shoots) and floriferous shoots borne on dorsal side at sinuses of root branches, torn margins of root around tufts of leaves and floriferous shoots raised as prominent rings. *Leaves* 2 – 3 per tuft, subulate, to 3 mm long. *Floriferous shoots* appressed; bracts (2 –) 3 – 4 (– 5), in two rows, elliptic, sheath-like, apex acuminate (sometimes acute) or caudate with subulate tip, tip often caducous, 1 – 3 mm long, smooth-surfaced; spathella, ellipsoidal, 1.5 – 2 mm long, enclosing young flower, smooth-surfaced, ruptured near apex at anthesis, persistent, enclosing mature ovary or capsule, only distal part of stamen and stigma extruded; flowers subsessile (pedicel to 0.1 mm long); tepals 2, on both sides of stamen, linear, 0.7 – 1.5 mm long; stamen 1, (2 –) 2.3 – 2.5 (– 3) mm long, exposed part curved upward, longer or shorter than, or as long as, pistil; anthers elliptic; ovary 1, ellipsoidal, flattened, 1 – 1.2 (– 2) mm long, 0.6 – 1 mm wide, 0.5 mm thick, subsessile (ovary stalk to 0.3 mm long), 1-locular with partial septum attached to ovary wall by apical and basal ends, marginally free; stigmas forked ⅓ – ½ from base, equal or subequal, subulate, 0.8 – 1.5 mm long, curved upward; ovules 24 – 39 per ovary, borne on marginal surface of free septum except sterile central part. *Capsule* ellipsoidal, flattened, 1 – 1.5 mm long, c. 1 mm wide, c. 0.5 mm thick, subsessile or

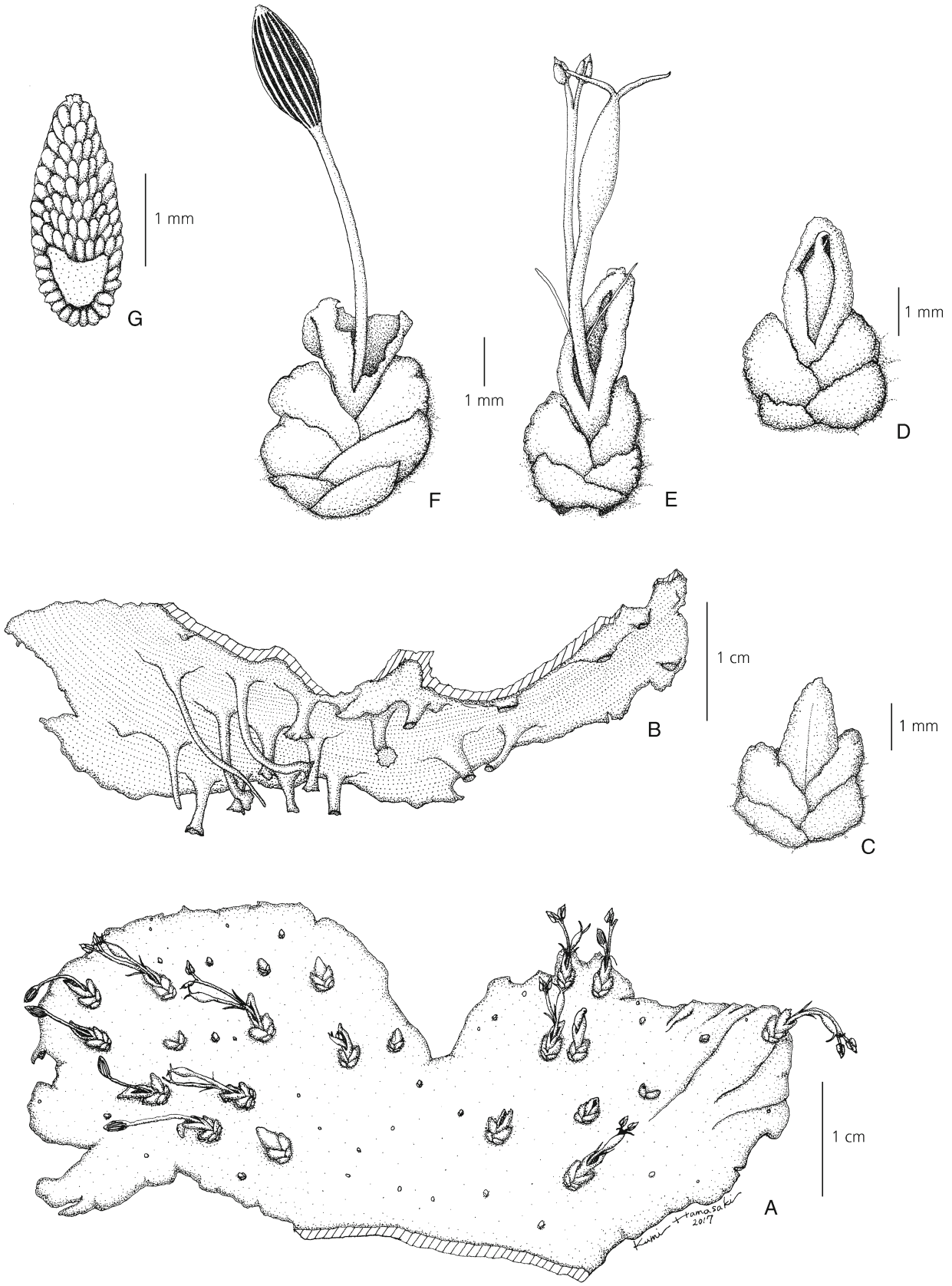

Fig. 1. *Hydrobryum hapteron*. **A** root with flowers, flower buds and fruits scattered on dorsal surface; **B** root holdfasts on ventral side; **C** flower bud enclosed by spathella subtended by bracts; **D** flower extruding from ruptured spathella subtended by bracts; **E** floriferous shoot at anthesis; **F** fructiferous shoot; **G** ovules on septum surface except in lower sterile area. All from *Koi et al.* LPK-06. DRAWN BY KUMI HAMASAKI.

Fig. 2. *Hydrobryum hapteron*. A Population in natural habitat; B dense mats of dried plants in natural habitat; C floriferous shoots; D fructiferous shoots on root.

short-stalked (stalk to 0.7 mm long), often enclosed by spathella, ribs 10 – 12. Fig 3.

RECOGNITION. Similar to *Hydrobryum subcylindricum* in the ribbon-like root, persistent spathella subtending mature flowers except the stigmas and distal part of stamen, single stamens, 1-locular ovary, and subsessile or short-stalked capsule. However, it differs in the wider root (0.9 – 1.2 mm vs 0.5 – 0.8 mm in *H. subcylindricum*), Y-shaped stigmas (vs V-shaped), and fewer ribs on the capsule (10 – 12 vs 16 – 20).

DISTRIBUTION. Asia: Laos.

SPECIMEN EXAMINED. LAOS. Bolikhamxay Province: Upstream of Tad Xai, Phou Khao Khouay National Protected Area, 18°28'15.5"N, 103°07'23.0"E, 400 m alt., 11 Nov. 2016 (fl. & fr.), *S. Koi, P. Werukamkul & M. Kato* LPK-07 (holotype TNS; isotypes NHL, BKF).

HABITAT. Rock surface in rapids submerged in rainy season, and exposed, then dried in dry season.

CONSERVATION STATUS. Vulnerable (VU). Plants occur in a patch of less than 4 m^2, which is far from a tourist spot. Further exploration in other areas is needed.

ETYMOLOGY. The species name is derived from *Hydrobryum subcylindricum* with similar roots.

NOTES. Koi & Kato (2012) added to *Hydrobryum* species with ribbon-like roots, *H. ramosum*,

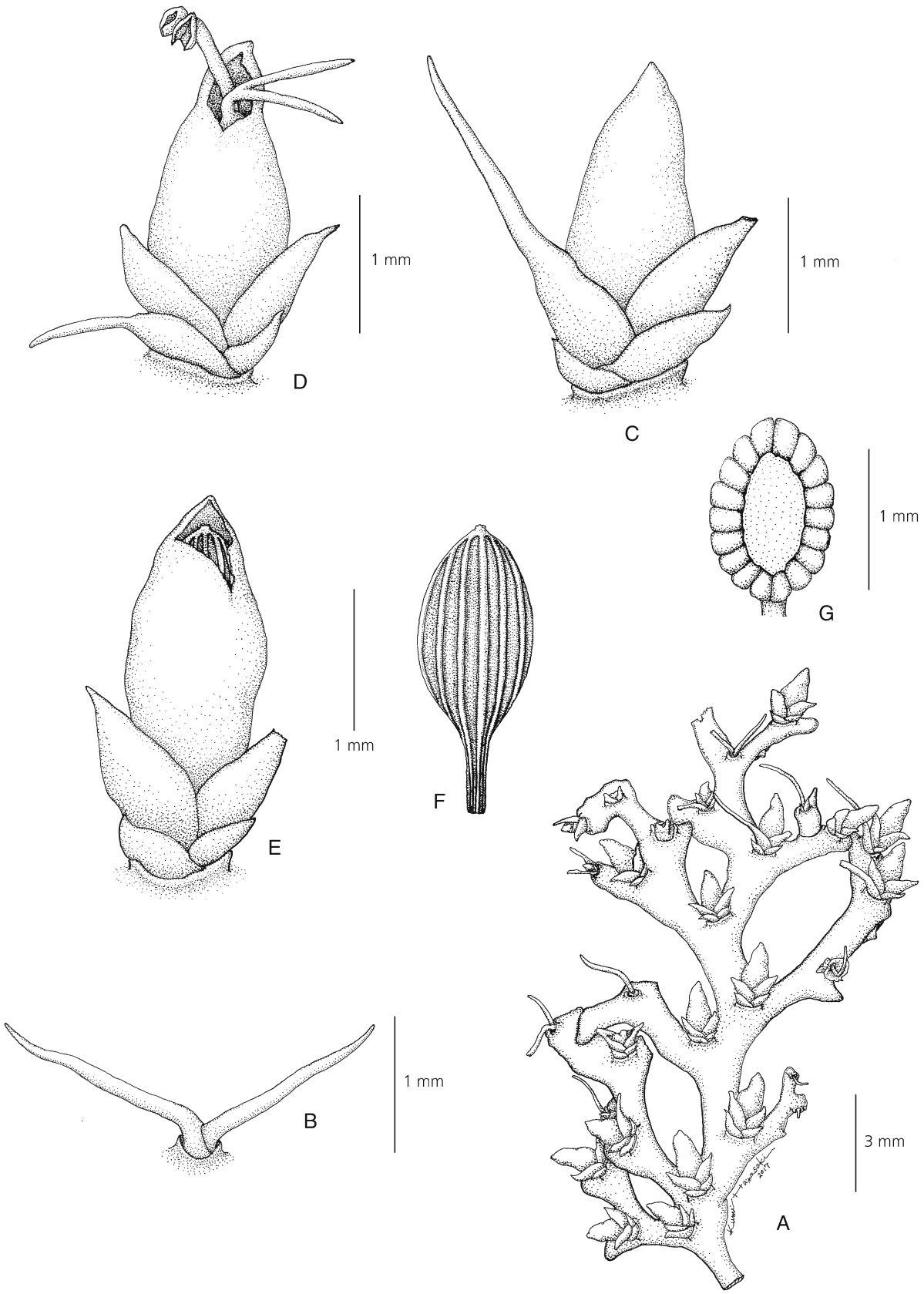

Fig. 3. *Hydrobryum subcylindricoides*. **A** root with young floriferous shoots and tufts of leaves at sinuses of root branches; **B** leaves; **C** flower bud enclosed by spathella subtended by bracts; **D** flower with stigmas and stamen extruded from ruptured spathella; **E** young fruit enclosed by spathella; **F** fruit; **G** ovules borne along margin of septum. All from *Koi et al.* LPK-07. DRAWN BY KUMI HAMASAKI.

H. subcylindricum and *H. taeniatum* Koi & M. Kato, on the basis of molecular phylogenetic relationships and comparative morphology. In these species, as in *H. subcylindricoides*, the tufts of leaves and floriferous shoots are borne regularly at sinuses of root branches, whereas they are scattered irregularly on the surface in crustose species. *Hydrobryum subcylindricoides* is a fourth ribbon-like species. It differs from *H. ramosum* and *H. taeniatum* in the single stamen and the Y-shaped stigmas forked far above the base (vs two stamens and stigmas forked immediately above base), and furthermore from *H. ramosum* in the 1-locular ovary (vs 2-locular) (for the differences from *H. subcylindricum*, see above). Molecular data indicate that it is not close to any of the ribbon-like species (S. Koi unpubl.). *Hydrobryum subcylindricoides* is allopatric with the ribbon-like *H. ramosum*, *H. subcylindricum* and *H. taeniatum* (Koi & Kato 2012), and sympatric with *H. hapteron* described above.

Acknowledgements

We thank P. Werukamkul for her collaboration with field work and two reviewers for the useful comments. This study was supported by a JSPS KAKENHI Grant (No. 26870502 to SK).

References

Cook, C. D. K. & Rutishauser, R. (2001). Name changes in Podostemaceae. *Taxon* 50: 1163 – 1167.

—— & ——(2007). Podostemaceae. In: K. Kubitzki (ed.), *The Families and Genera of Vascular Plants* 9: 304 – 344. Springer, Berlin.

Cusset, C. (1992). Contribution a l'etude des Podostemaceae: 12. Les genres asiatiques. *Bull. Mus. Natl. Hist. Nat. Paris, B. Adansonia* 14: 13 – 54.

Kato, M. (2004). Taxonomic study of Podostemaceae of Thailand 1. *Hydrobryum* and related genera with crustaceous roots (subfamily Podostemoideae). *Acta Phytotax. Geobot.* 55: 133 – 165.

Koi, S. & Kato, M. (2012). A taxonomic study of Podostemaceae subfamily Podostemoideae of Laos with phylogenetic analyses of *Cladopus*, *Paracladopus* and *Polypleurum*. *Kew Bull.* 67: 331 – 365.

—— & ——(2015). Additions to Podostemaceae subfamily Podostemoideae of Laos. *Acta Phytotax. Geobot.* 66: 181 – 187.

Rutishauser, R. (1997). Structural and developmental diversity in Podostemaceae (river-weeds). *Aquat. Bot.* 57: 29 – 70.

Werukamkul, P., Ampornpan, L., Kato, M. & Koi, S. (2016). New species and new records of Podostemaceae from Phitsanulok, northern Thailand. *Acta Phytotax. Geobot.* 67: 97 – 114.