Podostemaceae (river-weeds) are aquatic haplophytes adapted to rapids and waterfalls in the tropics and subtropics. Members of the family grow submerged in violent current in the rainy season, then flower and fruit in the air in the dry season. The Podostemaceae comprise three subfamilies, of which Podostemoideae and Tristichoideae occur in Asia (Cook & Rutishauser 2007). In our studies using recent collections from Laos, we recorded 15 species in five genera of Podostemoideae (Koi & Kato 2012) and 15 species in three genera of Tristichoideae (Koi & Kato 2015). The numbers of species and genera in the family are about four times and two times as large as previously reported, respectively (Cusset 1973a, 1973b, 1992, Kato & Fukuoka 2002). Additional specimens were recently collected, mostly from northern Laos, which has been poorly explored, as well as from southern Laos. Those collections add five species in four genera, of which one genus is new to the Podostemoideae of Laos; two species are new to science. The specimens are deposited in the Herbarium (TNS), Department of Botany, National Museum of Nature and Science (Tsukuba) and the National Herbarium of Laos (HNL).

**Description of New Species and New Records**

**Thawatchaia laotica** Koi & M. Kato, sp. nov. — Fig. 1

_Typus._ Northern Laos. Luang Namtha Province: stream along Route 17B, between Ban Houay Mo and Ban Kang Kao, 657 m alt., 21°00′57.9″ N, 100°56′53.0″ E, 13 Jan. 2011, S. Koi, N. Katayama & T. Wongprasert LK-307 (holotype TNS!, isotype HNL!).

Root crustose, irregularly lobed, 0.3–0.4 mm thick (reproductive part). Flowering shoots bearing solitary terminal flowers, scattered on dorsal surface of root, appressed to root surface, 3–4 mm long (from base to tip of uppermost bract). Flowers strongly oblique; bracts thick, 2-ranked, (4–)6–10, markedly asymmetrically trilobed with...
middle and dorsal lobes, narrowly deltoid, apex bluntly acute, dorsal lobe subequal to middle lobe or slightly shorter, ventral lobe semicircular, much shorter than middle and dorsal lobes; lower bracts smaller than upper; spathella ellipsoid, 2–3.2 mm long, mucronate, mucrones ca. 0.3 mm long, ruptured irregularly near apex; pedicel ca. 0.2 mm long; tepals 2, one on each side of stamen, attached below middle of ovary stalk, 2–3.5 mm long, reaching above middle of ovary, linear; stamens 2, caducous, filaments forked 4/5–5/6 from base, 2.5–3 mm long; anthers ellipsoid, 0.5–0.8 mm long; stalk of ovary 0.5–0.8 mm long; ovary ellipsoid, 2–2.2 × 0.8–1 mm, 2-locular; stigmas 2, to 1.2–1.5 mm long, forked above base, equal, linear, entire, blunt or pointed; ovules 8–16 per locule, borne on whole septum surface except in lower central area; stalk of capsule 1.5–2 mm long; capsule ellipsoid, slightly flattened, 2–2.2 × 0.9–1 mm, ribs 7–8, dehiscing by 2 equal valves.


Notes. Thawatchaia laotica differs from T. trilobata M. Kato, Koi & Y. Kita in the remarkably asymmetrical lobed bracts with middle and dorsal lobes narrowly deltoid, and ventral lobe semicircular (trilobed with all lobes subdeltoid and apically blunt in T. trilobata), filaments forked 4/5–5/6 from base (forked above middle), and stigmas 1.2–1.5 mm long (0.6–1 mm).

Thawatchaia had been recognized as a monotypic genus endemic to Thailand. Thawatchaia laotica is the second species endemic to Laos and geographically distributed at higher latitudes than T. trilobata of northern (Chiang Mai) and northeastern (Loei) Thailand. In Koi et al. (2012),
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T. laotica was treated as conspecific with T. trilobata, but the two species are distinct morphologically and phylogenetically.

Specimens examined. Northern Laos. Luang Namtha Prov.: stream along Route 17B, Ban Kang Kao, 576 m alt., 20°59’49.9″ N, 100°55’09.7″ E, S. Koi, N. Katayama & T. Wongprasert LK-309 (TNS); Nam Tha river, Ban Sop-tout, 532 m alt., 20°54’30.6″ N, 101°25’56.8″ E, S. Koi, N. Katayama & T. Wongprasert LK-310 (TNS); Nam Tha river at bridge 24 km from Luang Namtha, near Ban Sop Shin, Nam Ha National Protected Area, 544 m alt., 20°53’03.4″ N, 101°28’19.0″ E, S. Koi, N. Katayama & T. Wongprasert LK-312 (TNS). —Bokeo Prov.: Houay Kalok stream, 474 m alt., 20°21’49.8″ N, 100°41’48.4″ E, S. Koi, N. Katayama & T. Wongprasert LK-319 (TNS).

Hydrobryum luangnamtaense Koi & M. Kato, sp. nov. —Fig. 2


Root crustose, adhering to rock by thin pads of rhizoids, irregularly lobed, raised in annual rings around tufts of leaves; leaves 1–4 per tuft, erect, needle-like, terete, 2–3.5 mm long. Flowering shoots appressed, flower solitary at apex; bracts uniform, in two rows, 3–6, ovate, 1–1.5 mm long, papillate; spathella papillate, irregularly ruptured near apex at anthesis; pedicel ca. 0.4 mm long; tepals 2, 1 on each side of stamen, linear, ca. 1.5 mm long; stamens 2, branched slightly more than 1/2 from base, 2.5–3.5 mm long, longer than pistil; stalk of ovary ca. 1 mm long; ovary 2-locular, ellipsoid, flattened, ca. 2 × 1.3 × 1 mm; stigmas 2, narrowly deltoid, basal part flattened, facing each other, equal or subequal, 0.6–1 mm long, forked above base; ovules on whole septum except in lower central area, 20–43 per locule; stalk of capsule 0.5–1 mm long; capsule ellipsoid, flattened, ca. 2.5 × 1.2–1.5 × 0.9–1 mm, dehiscing by 2 equal valves; ribs 16–17.


Notes. Phylogenetically, Hydrobryum luangnamtaense is sister to the clade of H. loeicum M. Kato and H. vientianense (M. Kato & Fukuoka) Koi & M. Kato, and all three species are sister to H. phetchabunense M. Kato (Koi et al. 2012). In Koi et al.’s (2012) tree, specimens LK-313–LK-317 were named Hydrobryum sp. Hydrobryum luangnamtaense is similar to H. loeicum from northeastern Thailand and H. vientianense from north central Laos and northeastern Thailand, in the papillate bracts and spathellas, the stamens forked above middle and longer than the pistils, and the number of ribs on the capsule. It differs from the two species in the narrowly deltoid stigma (subulate in both species), the 20–43 ovules borne over the whole ovary septum except in the lower central part (4–8 in H. loeicum; 8–28 in H. vientianense) and the short stalk of the capsule (1–2 mm; 1–2.5 mm). Also it differs from H. phetchabunense, with a less close affinity, by the number of ovules (5–8 in H. phetchabunense) and the short stalk of capsule (1–1.5 mm).


Distribution. Northern Laos (Bokeo, Luang Namtha, Oudom Xai), new to Laos; southwestern Japan, South Central China (Yunnan), northern Vietnam, Thailand (Northern, Northeastern, Southwestern), and northern Myanmar.

Notes. The Lao specimens below have 2–5 smooth-surfaced ovate bracts, smooth-surfaced sathetla, two stamens with a common andropod, about 2 times as long (3–4 mm) as the ovary (1.3–2.5 mm), 2-locular, flattened ellipsoid or ovoid ovary with 10–21 ovules on the marginal surface.

*Hydrobryum japonicum* is the most widely distributed species of *Hydrobryum* in eastern and southeastern Asia (Kato 2013). All Lao specimens except *LK-301* have the same *matK* haplotype as one specimen from Japan and 15 specimens from northern and southwestern Thailand. This haplotype is most widely distributed among about 10 haplotypes of *Hydrobryum japonicum* (Koi et al. 2012, S. Koi, unpubl. data).

**Specimens examined.** Northern Laos. Luang Namtha Prov.: Nam Lueang stream, along Route 17A, 43 km from Muang Sing, 600 m alt., 21°05′09.4″ N, 101°22′26.8″ E, S. Koi, N. Katayama & T. Wongprasert LK-302 (TNS); Nam Lueang stream, along Route 17A, Ban Bone Xay, 644 m alt., 21°05′35.3″ N, 101°21′34.2″ E, S. Koi, N. Katayama & T. Wongprasert LK-303 (TNS); stream at entrance of Phagneung Phoukulom waterfall, along Route 17A, 17 km from Muang Sing, Nam Ha National Protected Area, 884 m alt., 21°07′12.0″ N, 101°14′37.9″ E, S. Koi, N. Katayama & T. Wongprasert LK-304 (TNS); stream under bridge on Route 17A, at the border of Nam Ha National Protected Area, 765 m alt., 21°08′09.7″ N, 101°12′00.2″ E, S. Koi, N. Katayama & T. Wongprasert LK-305 (TNS); stream along Route 17B, 17 km from Muang Sing, 723 m alt., 21°04′57.5″ N, 101°03′35.5″ E, S. Koi, N. Katayama & T. Wongprasert LK-306 (TNS); stream along Route 17B, Ban Kang Kao, 576 m alt., 20°59′49.9″ N, 100°55′09.7″ E, S. Koi, N. Katayama & T. Wongprasert LK-308 (TNS).—Bokeo Prov.: stream in Ban Ta Pha, 558 m alt., 20°25′47.5″ N, 100°53′06.1″ E, S. Koi, N. Katayama & T. Wongprasert LK-318 (TNS).—Oudom Xai Prov.: Nam Kad waterfall, Ban Faen, 713 m alt., 20°42′40.3″ N, 102°06′07.9″ E, S. Koi, N. Katayama & T. Wongprasert LK-301 (TNS).

*Distribution.* Southern Laos (Attapeu), new to Laos; Thailand (Eastern). The Lao plants occur sympatrically with *Dalzellia* sp. and *Cladopus pierrei*.

*Notes.* The plant of *Polypleurum longistylosum*, although fragmentary, has the diagnostic characters cited below of *Polypleurum longistylosum*, such as the flowering shoots borne on the flanks between successive root branches, the papillate spathella nearly completely enclosing the mature ovary and the lower part of filiment, the single stamen, the 1-locular ovary, the stigmas forked at or above middle, the ovules borne on the marginal surface of the septum, and ca. 12 ribs on the capsule. Molecular data support the identification (Koi et al. 2012, S. Koi, unpubl. data).

*Specimen examined.* Southern Laos. Attapeu Prov.: Tad Xay Pha waterfall, Se Pian National Park, 106°26'20.7" E, 14°46' 34.3" N, 137 m alt., M. Kato, S. Koi & T. Wongprasert LK-427 (TNS).


*Distribution.* Southern Laos (Attapeu), new to Laos; Thailand (Southeastern).

*Notes.* *Paracladopus* is a bispecific genus. Molecular data (S. Koi unpub. data) show that the specimen below is assigned to *Paracladopus chanthaburiensis*. The specimen is incomplete consisting of transitional plants between the sterile and fertile stages; the vegetative leaves are ensiform with rudimentary lobes at the base, and the bracts are digitate, often with elongate lobes similar to vegetative leaves. This species shares with *P. chiangmaiensis* M. Kato the tufts of leaves and flowering shoots borne on the flank of the root between root branches (the flower characters are unknown). *Paracladopus chanthaburiensis* differs from *P. chiangmaiensis* in the digitate bracts (vs. linear with basal lobes in *P. chiangmaiensis*).

*Specimen examined.* Southern Laos. Attapeu: Se Lamong stream, Dong Ampham National Protected Area, 107°16′6.3″ E, 14°44′ 40.9″ N, 178 m alt., M. Kato, S. Koi & T. Wongprasert LK-434 (TNS).

*Notes on Podostemaceae in Laos*

The present and previous papers show that Laos harbors 20 species and six genera of Podostemoideae, and 15 species and three genera of Tristichoideae (Koi & Kato 2012, 2015). Eight of the nine genera are shared with Thailand, and the monotypic genus *Hydrodiscus* (Podostemoideae) is endemic to Laos. Ten of the 20 species of Podostemoideae, including *Hydrobryum luangnamtaense* and *Thawatchaia laotica*, are endemic to Laos; seven species including *Polypleurum longistylosum* and *Paracladopus chanthaburiensis* are also in Thailand; one also in Vietnam (also Thailand; P. Werukamlul et al. unpubl. data); one also in Thailand, Cambodia and northern India; and one, *H. japonicum*, is widely distributed from northern Myanmar to Japan. In Tristichoideae, seven species are endemic to Laos, six species are

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**Key to the genera of Podostemoideae in Laos**

1a. Root absent; shoots elongate, floating, anchoring with disk-like base .................................. *Hydrodiscus*
1b. Roots present; shoots apparently absent or reduced, borne on root ........................................... 2
2a. Bracts simple .................................................................................................................................. 3
2b. Bracts lobed or digitate .................................................................................................................. 4
3a. Roots ribbon-like with tufts of leaves or flowering shoots on flanks or at sinuses of root branches; valves of capsule unequal or subequal ......................................................................... *Polypleurum*
3b. Roots subcylindrical or ribbon-like with tufts of leaves or flowering shoots at sinuses of root branches, or roots crustose; valves of capsule equal ...................................................... *Hydrobryum*
4a. Roots crustose; capsules ellipsoid, flattened ............................................................................. *Thawatchaia*
4b. Roots ribbon-like; capsules globose ........................................................................................... 5
5a. Tufts of leaves or flowering shoots on flanks of root; capsules ribbed ....................................... *Paracladopus*
5b. Tufts of leaves or flowering shoots at sinuses of root branches; capsules smooth .................. *Cladopus*
Key to the species of Podostemoideae in Laos

1a. Root absent; shoots to 1 m long, branched, floating, anchoring with disk-like base

   ................................................................................................................................. **Hydrodiscus koyamae**

1b. Roots present; shoots apparently absent or reduced, rarely (in *H. takakiioides*) flowering shoots to
   1.5 cm long, borne on root ......................................................................................... 2

2a. Roots cylindrical to ribbon-like ............................................................................. 3

2b. Roots crustose .......................................................................................................... 12

3a. Roots floating at least distally ................................................................................ 4

3b. Roots adhering to rock along entire length ................................................................ 5

4a. Roots adhering by disk-like base; tufts of leaves (shoots) and flowers borne at sinuses of root branches ......................................................................................................................... **Hydrobryum ramosum**

4b. Roots adhering by proximal parts; tufts of leaves and flowers borne on flank of root between successive branches ................................................................................................................................. **Polypleurum wallichii**

5a. Tufts of leaves and flowers borne on flank of root between successive branches .......... 6

5b. Tufts of leaves and flowers borne only at sinuses of root branches .............................. 9

6a. Bracts trilobed or digitate, capsules globose ................................................................ 7

6b. Bracts simple; capsules ellipsoid ............................................................................... 8

7a. Bracts trilobed with reduced lateral lobes .................................................................... Paracladopus chiangmaiensis

7b. Bracts digitate ........................................................................................................... Paracladopus chanthaburiensis

8a. Stamens 2–3 mm long; ovary 2-locular, ca. 1 mm long; stigmas forked at base; ribs of capsules 8 or 9 .......................................................................................................................... **Polypleurum schmidtianum**

8b. Stamens up to 1.5 mm long; ovary 1-locular, 1.2–2 mm long; stigmas forked at or above middle; ribs of capsules ca. 12 ....................................................................................................................... **Polypleurum longistylosum**

9a. Bracts digitate; capsules globose or ellipsoid, smooth ................................................... **Cladopus pierrei**

9b. Bracts entire; capsules ellipsoid, ribbed ...................................................................... 10

10a. Flowering shoots erect; capsules not flattened ....................................................... **Polypleurum pluricostatum**

10b. Flowering shoots appressed; capsules flattened ...................................................... 11

11a. Roots to 1 mm wide; stamen 1 ................................................................................ **Hydrobryum subcylindricum**

11b. Roots 1–2 mm wide; stamens 2 ................................................................................ **Hydrobryum taeniatum**

12a. Bracts trilobed ........................................................................................................... Thawatchaia laotica

12b. Bracts simple ........................................................................................................... 13

13a. Flowering shoots erect, 7–14 mm long; bracts terete, subulate ................................ **Hydrobryum takakiioides**

13b. Flowering shoots appressed, less than 1.5 mm long; bracts flat, ovate at least at base ................................................................. **Hydrobryum austroalaticum**

14a. Stamens 1; ovary 1-locular ...................................................................................... 15

14b. Stamens 2; ovary 1 or 2-locular ............................................................................... 14

15a. Ovary 1-locular, subsessile, stalk 0.1–0.5 mm long, enclosed by spathella at maturity ........................................................................................................... **Hydrobryum subrustaceum**

15b. Ovary 2-locular, stalk 0.3–2 mm long, at least partly protruding from spathella .............. 16

16a. Bracts distally acute to linear; basal part of ovary enclosed by spathella................. **Hydrobryum tardhuangense**

16b. Bracts ovate, obtuse; ovary exposed ........................................................................ 17

17a. Bracts smooth .......................................................................................................... **Hydrobryum japonicum**

17b. Bracts papillate ...................................................................................................... 18

18a. Roots adhering to rock by prominent warty projections (holdfasts); stamens forked 1/4-1/8 from top ......................................................................................................................... **Hydrobryum verrucosum**

18b. Roots adhering by thin pads of rhizoids; stamens forked ca. 1/2–1/5 from apex ........ 19

19a. Stigma subulate; stalk of capsule 1–2.5 mm long; ovules 8–27 per locule ................. **Hydrobryum vientianense**

19b. Stigma narrowly deltoid; stalk of capsule 0.5–1 mm long; ovules 20–43 per locule ................................................................. **Hydrobryum luangnamtaense**
distributed also in Thailand, one is also in Cambodia (Koi & Kato 2015). Thus, Lao Podostemaceae are characterized by a number of endemic species (17 of 35 species, 49%) and most (13 species) of the rest common to only Thailand. Among the endemic species, *H. luangnamtaense*, *H. ramosum* (C. Cusset) Koi & M. Kato, and *H. takakioides* Koi & M. Kato are restricted to single rivers, while the others occur in multiple localities. Laos and Thailand together comprise a biodiversity hotspot for Podostemaceae, which is more diverse than southern Asia, the other hotspot in Asia (Willis 1902, Mathew & Satheesh 1997, Kato 2009).

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**References**


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