

A Taxonomic Study of Podostemaceae of Japan

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Abstract A taxonomic revision, including a key to the species, synonymy and taxonomic notes, of the two genera and six species Podostemaceae of Japan is presented. *Cladopus* is represented by *C. doianus* and *C. fukienensis*, and *Hydrobryum*, by *H. japonicum*, *H. floribundum*, *H. puncticulatum*, and *H. koribanum*. Of these, *H. floribundum*, *H. puncticulatum*, and *H. koribanum* are endemic to Japan, while the others are distributed in China (Fujian, Yunnan) and also northern Thailand.

Key words: *Cladopus*, *Hydrobryum*, Japan, Podostemaceae, taxonomy.

Introduction

Podostemaceae of Japan were discovered for the first time from Kubuki River, a tributary of Sendai River, at Yamazaki, Kagoshima prefecture, southern Kyushu by Imamura (1927). Imamura (1927, 1928a, 1928b) described a new species *Cladopus japonicus* Imamura and subsequently another new species assigned to *Hydrobryum*, *H. japonicum* (Imamura, 1929). Concomitantly, Koidzumi (1927, 1929, 1931, 1934) described four species, *Lawiella* (= *Cladopus*) *austrosatsumensis* Koidz. (1931), *L. doiana* Koidz. (1927), *Hydrobryum floribundum* Koidz. (1929), and *H. puncticulatum* Koidz. (1934), all from Kagoshima prefecture, southern Kyushu. As a consequence, Koidzumi (1935) recognized six species of two genera from Japan. Later, two other species were added: one is *Cladopus austro-osumiensis* Kadono et N. Usui from Kagoshima prefecture and the other is *Hydrobryum koribanum* Nakayama et Minamitani from Miyazaki prefecture northeast of Kagoshima prefecture. In total, two genera and eight species are known so far (Fig. 1).

In a comparative study of Japanese and Chinese species of Podostemaceae, Shin (1954a) synonymized *Lawiella chinensis* (H.C. Chao) Koidz. of Fujian province under *L. kiusiana* Koidz. (= *C. japonicus* Imamura) and suggested that *L. fukienensis* (H.C. Chao) Koidz. of Fujian

is probably conspecific with *L. doiana* Koidz. [= *C. doianus* (Koidz.) Ohwi]. In the Flora of China, Wu (1988) recognized three genera and three species, synonymizing *Cladopus chinensis* and *C. fukienensis* under *C. nymanii* H. Möller. Wu's treatment (Wu 1988) was based on van Royen's (1965) opinion that the Japanese *C. japonicus* and *C. doianus* are conspecific with *C. nymanii*, which has consequently been recognized as a remarkably widely distributed and polymorphic species. In her taxonomic treatment of Podostemoideae (Podostemaceae in her sense) in Asia, Cusset (1992) also reduced *C. chinensis* and *C. fukienensis* to *C. nymanii*.

Kato and Kita (2003) examined Chinese Podostemaceae, comparing them with species of the neighboring regions including Japan. *Cladopus japonicus* was regarded as conspecific with *C. austrosatsumensis* and *C. chinensis*. *Cladopus doianus* was also compared with *C. japonicus*. Kato and Kita (2003) compared *C. austro-osumiensis* and Chinese *C. fukienensis*.

My herbarium and field studies show that two of the four Japanese species of *Cladopus* are conspecific with Chinese species. Furthermore, *Hydrobryum japonicum* is not endemic to Japan and distributed much more widely than considered so far. In this paper I revise the taxonomy of Podostemaceae of Japan, based on morphology and molecular analysis (Kato and Kita, 2003; Kita and Kato, 2004; Kato, 2004). All species are re-

ferred to subfamily Podostemoideae.

Key to the Species

1. Stamen 1, simple; capsules globose, smooth, erect; bracts digitate, surface rough; roots compressed, subcylindrical or ribbon-like, with tufts of leaves at sinuses of root branches (genus *Cladopus*).
 2. Roots 2–4 mm or more wide, ribbon-like, branching monopodially; bract-bearing floral axes 3–10 mm long1. *Cladopus doianus*
 2. Roots to 1(–1.3) mm wide, compressed, subcylindrical, branching sympodially; bract-bearing floral axes 3–6 mm long2. *Cladopus fukienensis*
1. Stamens 2, forked from common andropod; capsules ellipsoid, compressed, ribbed, appressed to roots; bracts boat-shaped, entire; roots crustose, with tufts of linear leaves scattered on dorsal surface (genus *Hydrobryum*).
 2. Roots thin (0.1–0.2 mm)4. *Hydrobryum floribundum*
 2. Roots thick (0.2–0.5 mm).
 3. Roots 0.3–0.5 mm thick, ovary-septa longitudinally fissured in distal part3. *Hydrobryum japonicum*
 3. Roots 0.2–0.4 mm thick; ovary-septa not fissured.
 4. Roots soft-chartaceous, not coarse (but coarse in plants on vertical bank-wall of dam), green or light green; ovules 23–29 per ovary; capsule ca. 10-ribbed5. *Hydrobryum puncticulatum*
 4. Roots subcoriaceous, coarse, deep green or dull brownish green; ovules 27–36 per ovary; capsule ca. 12-ribbed6. *Hydrobryum koribanum*

Cladopus H. Möller

Ann. Jard. Bot. Buitenzorg, ser. 2, **16**: 115, 1899; Engl., Nat. Pflanzenfam. 2nd ed. **18a**: 50, 1930; Steenis, Fl. Males. Ser. 1, **4**: 65, 1949; Backer et Bakhuisen van den Brink, Bekn. Fl. Java **1**: 204, 1963; Ohwi, Fl. Jap. 394, 1965; C. Cusset, Fl. Cambodge, Laos et Viêt-nam **14**: 71, 1973; Bull. Mus. Natl. Hist. Nat., B, Adansonia **14**(1): 20, f. 1, 2, 1992; T.-L. Wu, Fl. Reipubl. Popularis Sin. **24**: 4, 1988; Kato et Kita, Acta Phytotax. Geobot. **54**: 90, 2003; Kato, Acta Phytotax. Geobot. **57**: 30, 2006. Type species—*Cladopus nymanii* H. Möller.

Lawiella Koidz. in Doi, Florula Satsum. **1**(2): 21, 1927; *emend.* Koidz. in Doi, Florula Satsum. **2**: 94, 1931; Acta Phytotax. Geobot. **4**: 23, 1935; H.-C. Chao, Contr. Inst. Bot. Natl. Acad. Peiping **6**(1): 5, 1948 (publ. 1949). Type—*Lawiella doiana* Koidz.

Hemidistichophyllum Koidz. in Doi, Florula Satsum. **1**(3): 24, 1928. Type—*Hemidistichophyllum japonicum* (Imamura) Koidz.

Lecomtea Koidz. in Doi, Florula Satsum. **1**(4): 52, 1929. Type—*Lecomtea pierrei* (Lecomte) Koidz.

Notes. In Cusset's (1992) classification, sect. *Cladopus* consists of two species, the widely distributed *C. nymanii* s. lat. and *C. taiensis* C. Cusset endemic to Thailand, while sect. *Griffithella* consists of *C. pierrei* (Lecomte) C. Cusset of Laos and Vietnam and *C. hookerianus* (Tul.) C. Cusset of southern India. Other authors (e.g., Ohwi, 1965; Chao, 1980; Kadono, 1994; Kadono and Usui, 1995; Kato and Kita, 2003) recognized two species (*C. chinensis*, *C. fukienensis*, *C. japonicus*, *C. fukienensis*) from China and four (*C. austro-osumiensis*, *C. austrosatsumensis*, *C. doianus*, *C. japonicus*) or three species excluding *C. austrosatsumensis* from Japan. Shin (1954a)

treated *C. chinensis* as conspecific with *C.* (as *Lawiella japonicus*). This treatment was followed by Kadono (1994) and Kato and Kita (2003). As a consequence, no species of *Cladopus* is endemic to Japan. Shin (1954a) also considered that *C. fukienensis* is probably conspecific with *C. doianus*.

The type and sole species of *Torrenticola*, *T. queenslandica*, from northeastern Queensland and southeastern New Guinea, was treated as *Cladopus queenslandicus* (Domin) C.D.K. Cook et Rutish. (Cook and Rutishauser, 2001), and Kita and Kato (2001) found it to be nested within the *Cladopus* clade in a molecular phylogenetic tree, although the two genera differ considerably in vegetative and reproductive characters (Aston, 1990). *Cladopus* may therefore consist of about 10 species. In molecular trees of section *Cladopus* (Kita and Kato, 2001, 2004; S. Koi, unpubl. data), there are two clades, one consisting of

Malesian and Thai species, and the other including the Chinese and Japanese species. The taxonomy of Malesian species will be published in a separate paper (Kato, in press).

Kato (2006) proposed a new genus *Paracladopus*, sister to *Cladopus*, with a new species *P. chiangmaiensis* M. Kato from northern Thailand. Subsequently Koi *et al.* (2008) described a second species *P. chanthaburiensis* Koi et M. Kato. *Paracladopus chanthaburiensis* is similar to *Cladopus* in the digitate bracts, while similar to *Hydrobryum* and others in the ribbed capsule.

1. *Cladopus doianus* (Koidz.) Koriba (Figs. 2–4) *J. Jap. Bot.* **5**: 85, 1928; Ohwi, *Fl. Jap.* 394, 1965; Shin in Satake *et al.* (eds.), *Wild Fl. Jap. Herb. Pl.* **2**: 214, 1982.—*Lawiella doiana* Koidz. in Doi, *Florula Satsum.* **1**(2): 22, 1927. Type—Japan: Manose River, Kagoshima Pref. (Kyushu), *Y. Doi s.n.* Sept. 1927 (KYO?, not found).

Cladopus japonicus Imamura, *J. Jap. Bot.* **5**:

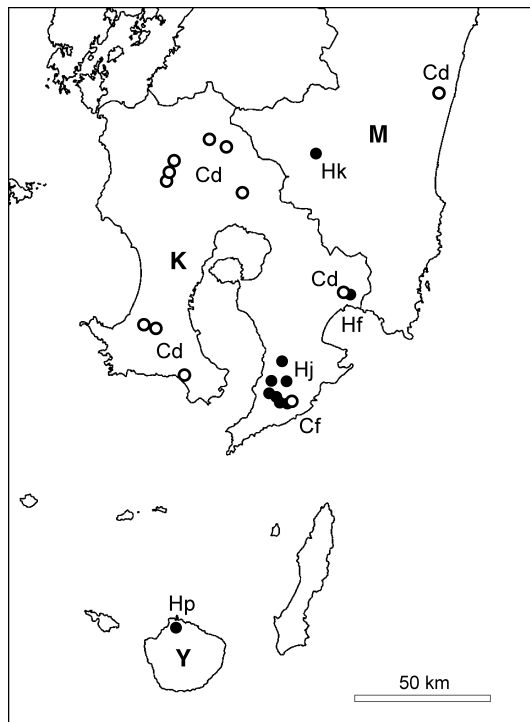


Fig. 1. Map of southern Kyushu showing distribution ranges of Japanese species of Podostemaceae. Open circles indicate *Cladopus*, and solid circles indicate *Hydrobryum*. Cd, *Cladopus doianus*; Cf, *Cladopus fukienensis*; Hf, *Hydrobryum floribundum*; Hj, *Hydrobryum japonicum*; Hk, *Hydrobryum koribanum*; Hp, *Hydrobryum punctulatum*. K, Kagoshima prefecture; M, Miyazaki prefecture; Y, Yakushima Island.

60, t. 1–3, f. 1–4, 1928; Bot. Mag. Tokyo **42**: 379, pl. 5, 6, 1928; Ohwi, Fl. Jap. 394, 1965; Shin in Satake *et al.* (eds.), Wild Fl. Jap. Herb. Pl. **2**: 214, 1982; Kato et Kita, Acta Phytotax. Geobot. **54**: 91, 2003.—*Hemidistichophyllum japonicum* (Imamura) Koidz. in Doi, Florula Satsum. **1**(3): 24, 1928.—*Lawiella kiusiana* Koidz., Fl. Symb. Orient. Asia. 96, 1930; in Doi, Florula Satsum. **2**: 97, 1931; Shin, J. Jap. Bot. **29**: 73, 1954; **syn. nov.** Type—Japan: Sendai River, Kagoshima Pref. (Kyushu), *Imamura, Koriba and Miki s.n.*, Aug. 1927 (TI?, not seen).

Lawiella austrosatsumensis Koidz. in Doi, Florula Satsum. **2**: 101, 1931; Acta Phytotax. Geobot. **4**: 26, 1935.—*Cladopus austrosatsumensis* (Koidz.) Ohwi, Fl. Jap. 394, 1965; Shin in Satake *et al.* (eds.), Wild Fl. Jap. Herb. Pl. **2**: 214, 1982; **syn. nov.** Syntypes—Japan: Mawatari River, Kagoshima pref. (Kyushu), *Doi s.n.*, June 1929, *Doi s.n.*, Oct. 1929 (KYO?, not seen).

Lawiella chinensis H.C. Chao, Contr. Inst. Bot. Natl. Acad. Peiping **6**: 4, pl. 3, f. 1–19, 1948 (publ. 1949).—*Cladopus chinensis* (H.C. Chao) H. C. Chao, Fl. Fukien **1**: 481, pl. 437, f. 1–13, 1982; **syn. nov.** Syntypes—Fujian Province, China: Ting River, Hukou, Changting Hsien, *H.-C. Chao 2289* (AU?), Jan. 21, 1945, *H.-C. Chao 2294* (AU?, IBSC!, KUN!, PE!), Nov. 15, 1945; Ting River, Lipifeng, *H.-C. Chao 2295* (AU?, PE! as 2290), Nov. 15, 1945; Ting River, Shihlipu, *H.-C. Chao 2284* (AU?), Oct. 25, 1944, *H.-C. Chao 2287* (AU?), Nov. 20, 1944, *H.-C. Chao 2301* (AU?), Jan. 27, 1946; Changantein, Ting River, *H.-C. Chao 2286* (AU?), Nov. 1944; Choshui, Chotien, *H.-C. Chao 2297* (AU?), Dec. 13, 1945 (specimens not found at AU; see Kato and Kita [2003]).

Cladopus nymanii auct. non H.Möller: T.-L. Wu in Fl. Reipubl. Popularis Sin. **24**: 5, 1988; C. Cusset, Bull. Mus. Natl. Hist., B, Adansonia **14**(1): 22, 1992, *p. p.*

Distribution. Japan (Kagoshima Pref., Miyazaki Pref., southern Kyushu), southeastern China (Fujian prov.: Changting, Nan'an).

Habitat. On submerged rocks in rapids in open places. Roots green.

Notes. Molecular data indicate that there is no difference in the *matK* sequence between *Cladopus doianus* and *C. japonicus* (Kita and Kato, 2004). Morphologically, plants in Manose River, or *C. doianus s.s.*, may differ from *C. japonicus* only in the narrower (to 2.5 mm) roots and the longer [4–8(–10) mm long] floral axes with the upper bracts larger than the lower. *Cladopus doianus s.s.* shows a remarkable teratological variation in the flowers (Doi, 1929; Shin, 1950, 1954b, 1964). Here I treat the two as conspecific. I am disappointed to synonymize *C. japonicus* described by Imamura (1928) who discovered podostemads from Japan for the first time and unraveled the curious morphology and ecology of this rare species in his detailed observations.

Cladopus austrosatsumensis, which was considered to be endemic to southern Kyushu, is also conspecific with *C. doianus*, as noted by Kato and Kita (2003). The two species do not obviously differ in vegetative or floral characters. Although the leaves of *C. austrosatsumensis* are not deciduous and those of *C. doianus* are deciduous (Koidzumi, 1935), this inconspicuous difference may be ecological or local.

Although *Cladopus japonicus* (= *C. doianus*), like *C. fukienensis*, has been regarded as conspecific with *C. nymanii* (Cusset 1992), it is distinct from *C. nymanii* with its bract-bearing floral axes up to 10 mm long, stamens to 2.5 mm long and longer than the ovaries (*vs.* to 1.3 mm long and equaling or shorter than the ovaries in *C. doianus*). *Cladopus doianus* also differs from *C. fukienensis* by the features used in Key.

In a detailed comparison of the Chinese and Japanese species, Shin (1954a, 1954b) found considerable variation in the stigma, the number of lobes of the digitate bracts, and the length of the floral axis, and consequently no significant difference between *C. chinensis* and *C. japonicus* (as *Lawiella kiusiana*). He concluded that the two species are conspecific. His treatment is supported by morphological and molecular data. The *matK* sequences are identical in *C. doianus* and *C. austrosatsumensis* (Kita and Kato, 2004). *Cladopus doianus* thus defined is not endemic to

Japan, but disjunct between Fujian (China) and Kyushu (Japan).

Recently this species was discovered in Miyazaki prefecture as the northernmost population in the distribution range. It grows on a flat concrete bottom in a channel for agricultural water running in villages. Our field survey could not find natural populations in nearby rivers. The growth in this artificial environment provides a clue for protection of endangered Podostemaceae (see also Notes under *Hydrobryum puncticulatum*).

2. *Cladopus fukienensis* (H. C. Chao) H. C. Chao (Figs. 5–6)

Fl. Fukien 1: 480, pl. 436, f. 1–13, 1982; Kato et Kita, Acta Phytotax. Geobot. **54**: 92, 2003.—*Lawiella fukienensis* H. C. Chao, Contr. Inst. Bot. Natl. Acad. Peiping **6**: 4, pl. 2, f. 1–21, 1948 (publ. 1949). Syntypes—Fujian Province, China: Ting River, Lungmen, Chanting, *H.-C. Chao 2281* (AU?), Feb. 6, 1944, *H.-C. Chao 2282* (AU?, PE!), July 18, 1944, *H.-C. Chao 2283* (AU?, IBSC!, KUN!, PE!), Sept. 25, 1944 (fr.), *H.-C. Chao 2292* (AU?, FNU!, PE!), Oct. 30, 1945 (fl., fr.); Ting River, Shijenshia, *H.-C. Chao 2293* (AU?), Oct. 30, 1945 (specimens at AU not found; see Kato and Kita [2003]).

Cladopus austro-osumiensis Kadono et N. Usui, Acta Phytotax. Geobot. **46**: 133, f. 1, 2, 1995; **syn. nov.** Type—Japan: Okawa River, Tashiro-cho, Kagoshima Pref., Kyushu, *N. Usui and M. Mukoyama s.n.*, Dec. 27, 1990 (OSA).

Cladopus nymanii auct. non H. Möller: T.-L. Wu in Fl. Reipubl. Popularis Sin. **24**: 5, 1988; C. Cusset, Bull. Mus. Natl. Hist. Nat., B, Adansonia **14**(1): 22, 1992, *p. p.*

Distribution. Japan (Kagoshima Pref., southern Kyushu), southeast China (probably central Guangdong and Fujian: N of Fuzhou, Changting).

Habitat. On seasonally submerged rocks in streams and rivers.

Notes. Chinese plants of *Cladopus fukienensis* share with *C. austro-osumiensis* of Japan in the narrow (usually 0.5–1 mm wide), subcylindrical

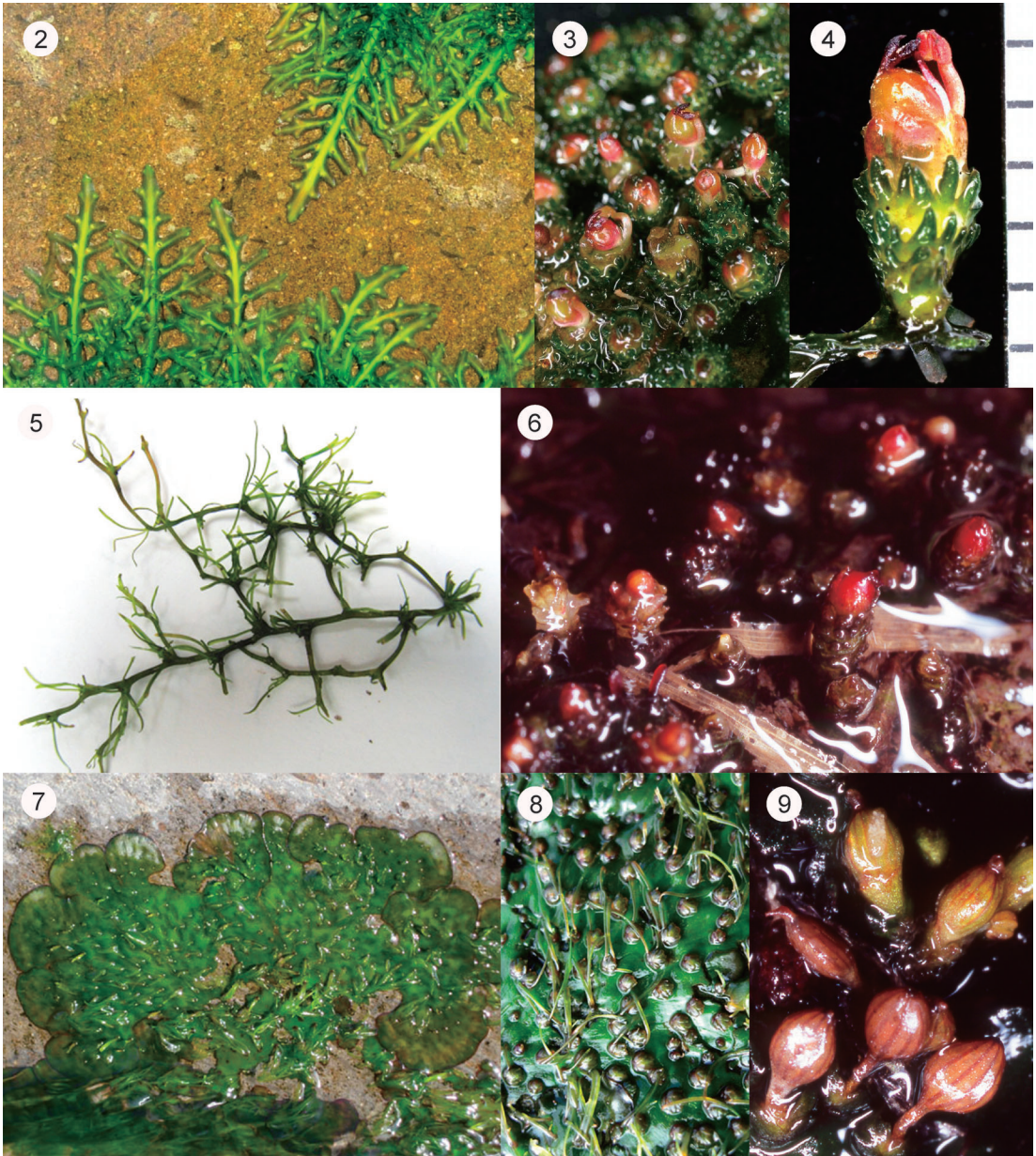
roots and rather long (up to 6 mm; to 8 mm in *C. austro-osumiensis*) bract-bearing floral axes. As noted in Kato and Kita (2003), here I have the two conspecific. This treatment is in accordance with molecular evidence (Kita and Kato, 2004; S. Koi, unpubl. data). There are differences in only a few characters, however. In *C. fukienensis* the stalk of the capsule is 1.3–3 mm long and extrudes from the spathe, while in *C. austro-osumiensis* the stalk of the capsule is 0.5–2 mm long and is often surrounded by the spathe in the lower half.

Hydrobryum Endl.

Gen. Pl. 1375, 1841, *p. p.*; Tul., Ann. Sci. Nat. ser. 3, **11**: 103, 1849; Arch. Mus. Paris **6**: 137, 1852; Hook. f., Fl. Brit. Ind. **5**: 63, 1886; Willis, Ann. Roy. Bot. Gard. (Peradeniya) **1**(3): 225, 1902; Engl., Nat. Pflanzenfam., 2nd ed. **18a**: 52, 1930; Ohwi, Fl. Jap. 393, 1965; C. Cusset, Fl. Cambodge, Laos et Viêt-nam **14**: 66, 1973; Bull. Mus. Natl. Hist. Nat., B, Adansonia **14**(1): 44, 1992; D.-D. Tao, Acta Bot. Yunnan. **5**: 175, 1983; T.-L. Wu, Fl. Reipubl. Popularis Sin. **24**: 4, 1988; Kato et Kita, Acta Phytotax. Geobot. **54**: 94, 2003; Kato, Acta Phytotax. Geobot. **57**: 143, 2004. Type species—*Hydrobryum griffithii* (Wall. ex Griff.) Tul.

Hydroanzia Koidz., Acta Phytotax. Geobot. **4**: 26, 1935. Lectotype species—*Hydroanzia floribunda* (Koidz.) Koidz.

Notes. In Asia, all species of *Hydrobryum*, *Hanseniella* (2 species), *Thawatchaia* (1 species), *Zeylanidium olivaceum* (Gardner) Engl., and *Z. maheshwarii* C. J. Mathew et Satheesh, have crustose roots with tufts of leaves scattered over the dorsal surface of the root. The foliose roots are the most specialized transformation from the typical cylindrical root, and tufts of leaves on reduced, inconspicuous shoot are also extremely reduced shoots (Ota *et al.*, 2001). Our recent field and molecular phylogenetic studies have shown that *Hydrobryum* of Laos includes species devoid of crustose roots (S. Koi and M. Kato, unpubl. data). The definition of the genus



Figs. 2–9. *Cladopus* and *Hydrobryum* of Japan. Figs. 2–4. *Cladopus doianus*. Fig. 2. Ramified roots 2–4 mm wide, creeping on rock surface. Shoot buds are borne at sinuses of root branches. Photo by S. Koi. Figs. 3, 4. Flowers with single stamen above digitate bracts. Scale unit on right side of Fig. 4 is 1 mm. Photos by T. Minamitani. Figs. 5–6. *Cladopus fukienensis*. Fig. 5. Root up to 1 mm wide ramified and meandering. Tufts of linear leaves are borne at sinuses of root branches. Photo by N. Katayama. Fig. 6. Flowers (with ovaries ca. 1.5 mm long) above digitate bracts. Photo by M. Kato. Figs. 7–9. *Hydrobryum japonicum*. Fig. 7. Crustose root, 5–15 cm wide, adhering to rock surface. Linear leaves are borne on dorsal surface. Photo by N. Katayama. Fig. 8. Flower buds above linear leaves and ovate bracts. Photo by N. Katayama. Fig. 9. Young capsules (ca. 2 mm long) with vertical stripes, which become ribs as fruits ripen. Photo by M. Kato.

requires substantial amendment.

Koidzumi (1935) distinguished *Hydroanzia* from *Hydrobryum* by its perennial habit. However, plants of *Hydrobryum* and other genera may be annual or perennial according to where they grow. Plants exposed to air may become desiccated and die in dry seasons if they occur on upper rocks, but submerged plants may remain alive even in the dry season.

In his taxonomic treatment of Podostemaceae of Thailand, Kato (2004) described 10 species of *Hydrobryum* from Thailand. *Hydrobryum japonicum*, one of them, occurs in northern Thailand, whereas most others are endemic to Thailand.

3. *Hydrobryum japonicum* Imamura (Figs. 7–9) Bot. Mag. Tokyo **42**: 376, 1928; Bot. Mag. Tokyo **43**: 332, 1929; Ohwi, Fl. Jap. 394, 1965; Shin in Satake *et al.* (eds.), Wild Fl. Jap. Herb. Pl. **2**: 214, 1982; C. Cusset, Bull. Mus. Natl. Hist. Nat., B, Adansonia **14**(1): 46, 1992, *p. p.*; Kato *et al.*, Acta Phytotax. Geobot. **54**: 95, 2003; Kato, Acta Phytotax. Geobot. **55**: 167, 2006—*Hydroanzia japonica* (Imamura) Koidz., Acta Phytotax. Geobot. **4**: 28, 1935. Type—Japan: Ohnejime, Kagoshima Pref. (Kyushu), *Senokuchi s.n.* (TI?).

Distribution. South-central China (southern Yunnan), southern Japan (southern Kyushu), northern and central (Cusset 1992) Thailand.

Habitat. On rocks in streams at forest edges.

Notes. This species has been considered to be an endemic to Japan until recently (Kadono 1994). However, Kato and Kita (2003) and Kato (2004) revealed that it is distributed in Yunnan, China, and northern Thailand. Kita and Kato (2004) argued that “Taking this relationship (i.e., *H. japonicum* is close to Japanese *H. floribundum*, *H. koribanum* and *H. puncticulatum*) into account, the distribution pattern is unusual in that *H. japonicum* is disjunct between Thailand (Figs. 16–17), south-central China and Japan.” Kita and Kato (2004) also argued that the disjunct distribution is due to three dispersal events. The earliest dispersal occurred northward to give rise to a distribution pattern similar to the present one, fol-

lowed by two events, one dispersal from Japan to Yunnan and the other most recent dispersal from Japan to northern Thailand.

A northern Vietnamese plant (*Pételot 3370* [P] from Sapa [Chapa], Laocai) with cristate stigmas is *H. griffithii* (Cusset, 1973). But Cusset (1992) misidentified it as *H. japonicum*. Therefore, there is no evidence that *H. japonicum* occurs in Vietnam.

4. *Hydrobryum floribundum* Koidz.

(Figs. 10–11)

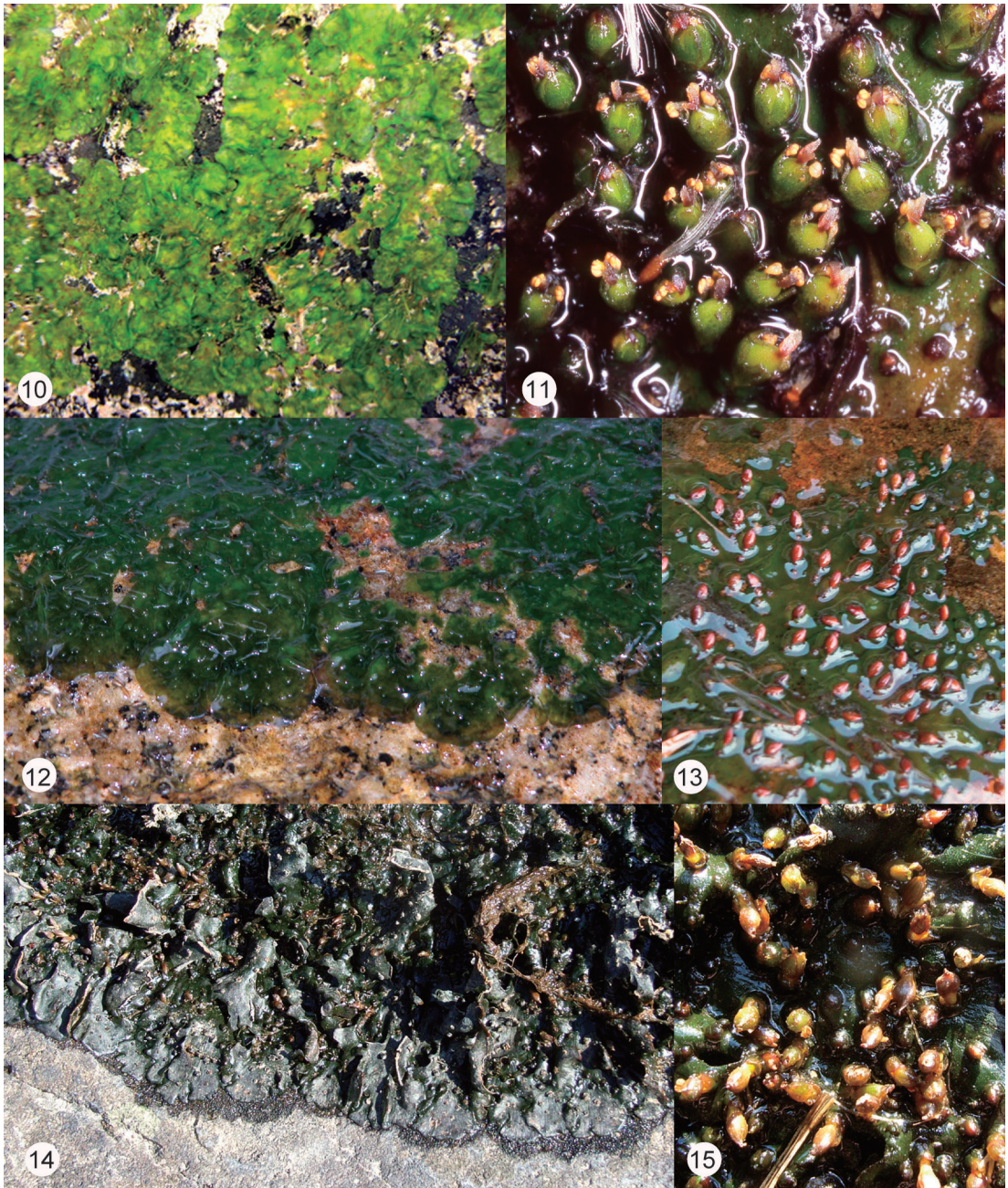
J. Jap. Bot. **6**: 1 cum photos, 1929; Ohwi, Fl. Jap. 394, 1965; Shin in Satake *et al.* (eds.), Wild Fl. Jap. Herb. Pl. **2**: 214, 1982—*Hydroanzia floribunda* (Koidz.) Koidz., Acta Phytotax. Geobot. **4**: 27, 1935—*Hydrobryum griffithii* var. *floribundum* (Koidz.) Koidz., in Doi, Florula Satsum. **2**: 100, 1931. Type—Japan: Maegawa River, Shibushi, Kagoshima Pref. (Kyushu), *Y. Doi s.n.* (KYO?).

Distribution. Japan (Kagoshima Pref., southern Kyushu).

Habitat. On rocks in streams.

Notes. This is endemic to a small area of southern Kyushu, Japan, where *H. japonicum* does not occur together. It grows together with *Cladopus doianus*, a rare case compared with all other Japanese species, which occur in single rivers or river systems. However, co-occurrences of multiple species are frequent in tropical rivers.

Hydrobryum floribundum is the most similar to *H. japonicum* in the leaves 4–9 per tuft, 4–7 mm long, the bracts 4(–6), the ovary ca. 2 mm long, the septum fissured in the distal part, and the ovules 23–32 per capsule. The other Japanese species have the ovary septum not fissured. *Hydrobryum floribundum* differs from *H. japonicum* in the thickness of the root, as shown in Key: 0.1–0.2 mm in *H. floribundum* and 0.3–0.5 mm in *H. japonicum*. Molecular phylogenetic analyses (Kita and Kato, 2004; S. Koi, unpubl. data) show that *H. floribundum* is nested within *H. japonicum*. Cusset (1992) reduced *H. floribundum*, along with *H. puncticulatum*, under *H. japonicum*. Because the two are distinct morphologi-



Figs. 10–15. *Hydrobryum* of Japan. Figs. 10–11. *Hydrobryum floribundum*. Fig. 10. Thin (0.1–0.2 mm thick), crustose roots adhering on rock surface. Photo by N. Katayama. Fig. 11. Flowers, with two stamens beside ellipsoid ovaries, dense on root. Ovaries are ca. 2 mm long, 1 mm thick. Photo by M. Kato. Figs. 12–13. *Hydrobryum puncticulatum*. Fig. 12. Crustose roots on rock surface, with hair-like leaves on dorsal surface. Photo by S. Koi. Fig. 13. Young fruits (ca. 1.5 mm long) on dorsal surface of root. Photo by M. Kato. Figs. 14–15. *Hydrobryum koribanum*. Photo by M. Kato. Fig. 14. Dull-brownish green, coarse, crustose root on rock surface. Fig. 15. Flowers at anthesis on dorsal surface of root. Ovaries are ca. 2 mm long.

cally (in the thickness of the root), I consider that *H. floribundum* is a local species recently derived from the widely distributed *H. japonicum*. If this treatment is accepted, *H. japonicum* is a “paraphyletic” species ancestral to *H. floribundum*.

5. *Hydrobryum puncticulatum* Koidz.

(Figs. 12–13)

Acta Phytotax. Geobot. 3: 178, 1934; Ohwi, Fl. Jap. 394, 1965; Shin in Satake *et al.* (eds.), Wild Fl. Jap. Herb. Pl. 2: 214, 1982—*Hydroanzia puncticulatum* (Koidz.) Koidz., Acta Phytotax. Geobot. 4: 29, 1935. Type—Japan: Isso River, Yakushima Island, Kagoshima pref. (Kyushu), *Y. Doi s.n.* (KYO?).

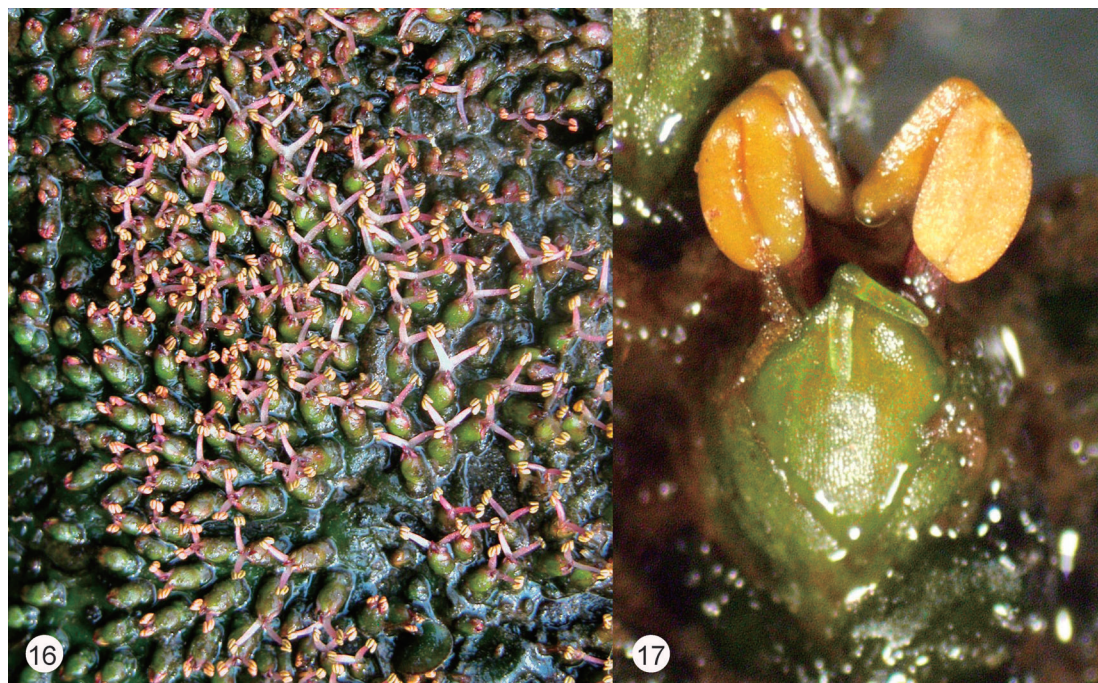
Distribution. Japan (Yakushima Island, southern Kyushu).

Habitat. On rocks in stream (Isso R.).

Notes. This is recorded only from the river on Yakushima Island. It grows not only on natural rocks but also on concrete bank surfaces of a small dam. This artificial environment is useful

to protect the podostemads, as in the case of *Cladopus doianus*.

Kita and Kato (2004) showed that this species is sister to *H. koribanum*. This relationship is confirmed by a molecular analysis with a larger set of species (samples) (S. Koi, unpubl. data). It is consistent with morphological data such as the shared non-fissured ovary-septum (Nakayama and Minamitani, 1999). The phylogeny is interesting in light of distribution, because both species grow in small areas (one river or river system) and *H. koribanum* occurs in Miyazaki Prefecture separately from Yakushima Island. In comparison, *H. japonicum* and *H. floribundum* are distributed on the Osumi Peninsula, which lies between the localities of those two species. Kita and Kato (2004) implies that this distribution pattern may have reflected range disturbances due to frequent volcanic eruptions in southern Kyushu during the Quaternary, range contraction due to climate cooling during the Pleistocene, and/or the disjunction of Kyushu



Figs. 16–17. *Hydrobryum japonicum* of Thailand. Photo by M. Kato. Fig. 16. Flowers with forked stamens and flower buds (ellipsoids) dense on dorsal surface of crustose root. Fig. 17. Flower with two stamens (anthers, yellow) connected by common andropod behind ovary (not seen) and ligulate stigmas on top of ellipsoid ovary (ca. 1.5 mm wide). An ovary is subtended at the base by a breaking spathella.

from Asian continent by formation of the East China Sea.

Cusset (1992) combined both *H. puncticulatum* with *H. japonicum*, but this treatment is not supported by molecular data showing that the three are deeply diverged (Kita and Kato, 2004; K. Koi, unpubl. data).

6. *Hydrobryum koribanum* Imamura ex Nakayama et Minamitani (Figs. 14–15) J. Jap. Bot. **74**: 314, f. 1, 5, 1999. Type—Japan: Iwase River, Nishimorokata, Miyazaki pref, Kyushu, *S. Nakayama and T. Minamitani s.n.*, Dec. 21, 1996 (TI!).

Distribution. Japan (Iwase River, Oyodo River, Miyazaki pref., southern Kyushu).

Habitat. On rocks in rivers.

Notes. This species has long been noticed to occur since the discovery by S. Imamura, but was described rather recently by Nakayama and Minamitani (1999) who made a detailed comparison of this and other Japanese species.

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