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Molecular phylogenetic analysis of Podostemaceae: implications for taxonomy of major groups

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The river-weed family Podostemaceae (*c.* 300 species in *c.* 54 genera) shows a number of morphological innovations to be adapted to its unusual aquatic habitat, and its unique or rare bauplan features have been reflected in the traditional (i.e. non-molecular) classification recognizing numerous monotypic or oligospecific genera. The infra-subfamilial relationships of many genera remained unclear. The present study used molecular phylogenetic analysis of *matK* sequences for 657 samples (*c.* 132 species/*c.* 43 genera). The family was traditionally divided into three subfamilies (Podostemoideae, Tristichoideae and Weddellinoideae). American Podostemoideae were shown to be polyphyletic and divided into four clades, i.e. *Ceratolacis*, *Diamantina*, *Podostemum* and all other genera. Among the podostemoid clades, *Diamantina* was the first branching clade and a clade comprising *Mourera* and the *Apinagia* subclade was then sister to the remainder of the New World and Old World Podostemoideae with low statistic supports. The Old World Podostemoideae comprised four monophyletic clades, i.e. two African clades, one Madagascan clade and one Asian clade, although the relationships among these clades and American *Ceratolacis* and *Podostemum* were poorly resolved. African Podostemoideae were polyphyletic, with *Saxicolella pro parte* being weakly supported as sister to the remaining Old World Podostemoideae plus *Ceratolacis* and *Podostemum*. In contrast to the American and African clades, monophyly of four Asian subclades was well supported. Plants of *Tristicha* (Tristichoideae) and of *Weddellina* (Weddellinoideae), which are currently treated as monospecific, had great *matK* differentiation equivalent to at least interspecific variation. *Botanical Journal of the Linnean Society*, 2012, **169**, 461–492.

ADDITIONAL KEYWORDS: biogeography – clusioid Malpighiales – *matK* – molecular evolution.

INTRODUCTION

Podostemaceae (river-weeds) are an ecologically and morphologically unusual aquatic angiosperm family. The plants live in rapids and waterfalls in the Tropics and the Subtropics. The vegetative plants of most species are composed of shoot with roots firmly adhering to water-worn rock surfaces. The plants grow vegetatively underwater in the rainy season. The plants flower and fruit during the dry season when the water level drops and, finally, they wither and die.

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The body plans of Podostemaceae exhibit great diversity. For example, root morphology ranges from subcylindrical to flattened ribbon-like and to crustose (foliose), and shoots are highly diverse with respect to size, proportion of stem and leaf and branching (Rutishauser, 1997). Some species are devoid of roots (Rutishauser & Grubert, 1994, 1999). Podostemaceae comprise *c.* 280 species classified in 49 genera, of which 26 genera are monospecific, many genera contain < 10 species, and only a few genera consist of ten species or more (Cook & Rutishauser, 2007). Thus, the obvious morphological differences between the taxa were traditionally taken as significant enough for creating many small (especially monotypic) genera instead of accepting few large ones.

The phylogenetic position of Podostemaceae among angiosperms was controversial until recently and has been resolved now by several molecular phylogenetic analyses. Studies with large data sets show that Podostemaceae are members of the clusioid Malpighiales (within fabids = eurosids I), with Hypericaceae as their sister family (Savolainen *et al*., 2000; Soltis *et al*., 2000, 2011; Gustafsson, Bittrich & Stevens, 2002; Davis *et al*., 2005; Tokuoka & Tobe, 2006; APG III, 2009; Korotkova *et al*., 2009; Wurdack & Davis, 2009; Ruhfel *et al*., 2011).

The relationships in Podostemaceae have been analysed for various groups and geographical regions. They are useful to understand the phylogeny, classification, biogeography and morphological evolution of Podostemaceae as a whole (Kita & Kato, 2001, 2004a, b; Kato, Kita & Koi, 2003; Moline *et al*., 2006, 2007; Koi, Kita & Kato, 2008; Koi *et al*., 2009; Pfeifer *et al*., 2009; Thiv *et al*., 2009; Kelly, Ameka & Chase, 2010; Koi & Kato, 2010a; Ruhfel *et al*., 2011; Tippery *et al*., 2011). In the earliest molecular phylogenetic study, with plastid *matK* sequences of 31 worldwide samples of 29 species assigned to 20 genera except African species, Kita & Kato (2001) suggested that the family is divided into three subfamilies, Podostemoideae, Weddellinoideae and Tristichoideae, as proposed by Engler (1930), the former two being sister to each other. Podostemoideae, which were the largest subfamily in their tree, comprised paraphyletic American clades and a monophyletic Madagascan and a monophyletic Asian clade. Moline *et al*. (2007) analysed eight species of three African genera and combined their analyses with the data of Kita & Kato (2001), showing the monophyly of the taxa from continental Africa. Tippery *et al*. (2011) analysed internal transcribed spacer (ITS), *rbcL* and *trnL* regions from 38 taxa of 15 genera, with the result that the Neotropical Podostemoideae, except *Podostemum*, are divided into ten clades. A recent large-scale analysis by Ruhfel *et al*. (2011), using plastid *matK*, *ndhF* and *rbcL* and mitochondrial *matR* genes of 49 species of 35 genera, showed the monophyly of the African, Madagascan and Asian Podostemoideae, and the polyphyly of the American Podostemoideae. Most molecular phylogenetic trees suggested that some large genera, for example, American *Apinagia* Tul. and African *Ledermanniella* Engl. *sensu* Cusset (1983, 1984), are polyphyletic. Based on those phylogenetic relationships, studies of taxonomic reclassification are in progress, resulting in the recognition of *c.* 300 species assigned to *c.* 54 genera (Table 1; e.g. Kato, 2004, 2006a; Kato & Koi, 2009; Bove & Philbrick, 2010; Koi & Kato, 2010a; Philbrick, Bove & Stevens, 2010; Ruhfel *et al*., 2011; Tippery *et al*., 2011).

This paper describes phylogenetic relationships of major lineages in the subfamilies of Podostemaceae, deduced from *matK* sequences of all available taxa, including some undescribed taxa (in total 657 samples). Based on the phylogenetic tree obtained, we discuss the infrasubfamilial classification of Podostemaceae. Regional (e.g. African and Asian) taxonomic revisions and biogeography will be published in separate papers.

MATERIAL AND METHODS

Plant samples

A total of 365 samples (*c.* 82 species/*c.* 33 genera) of Podostemaceae, two samples (two species/one genus) of Hypericaceae and one sample of Calophyllaceae were collected from the field (Appendix 1). They were dried in silica gel. Vouchers are deposited in: the Herbarium (TNS), Department of Botany, National Museum of Nature and Science (Tsukuba, Japan); Forest Herbarium (BKF), Department of National Parks, Wildlife and Plant Conservation (Bangkok, Thailand); Herbarium (TI), University of Tokyo (Tokyo, Japan); and Herbarium (TAIF), Taiwan Forestry Research Institute. Duplicates of many vouchers from Africa and America will be deposited in the combined herbaria of the University and ETH Zürich (Z/ZT).

DNA extraction, amplification and sequencing

Extraction of total DNA from dried material was performed with the DNeasy Plant Mini Kit (Qiagen, Valencia, CA, USA). The plastid *matK* region was amplified via polymerase chain reaction (PCR) using Ampdirect plus (Shimadzu, Kyoto, Japan) and TaKaRa Ex Taq polymerase (TaKaRa, Tokyo, Japan) under the following conditions: 3 min at 94 °C; 35 cycles of 30 s at 94 °C, 30 s at 55 °C, 90 s at 72 °C; and 7 min at 72 °C. The primers used for the DNA amplification and the cycle sequencing are listed in Appendix 2. The PCR products were treated with ExoSap-IT (GE Healthcare, Cleveland, OH, USA) to remove the extra primers. Sequencing was conducted using the BigDye Terminator v3.1 Cycle Sequencing Kit (Applied Biosystems, Foster City, CA, USA) and the ABI 3130xl Genetic Analyser (Applied Biosystems).

Phylogenetic analyses

Phylogenetic analysis was performed with the sequences obtained in this study (365 samples) and from GenBank (292 samples), in total 657 samples from *c.* 132 species of *c.* 43 genera of Podostemaceae and five samples (five species/four genera/three families) of Malpighiales (Appendix 1; Kita & Kato, 2001, 2004a, b; Kato *et al*., 2003; Davis & Wurdack, 2004; Moline *et al*., 2007; Koi *et al*., 2008, 2009; Thiv *et al*.,

Table 1. Current taxonomy of the genera and number of species of Podostemaceae, based on Cook & Rutishauser (2007) and others listed below

America[31]		Africa and Madagascar[20]		Asia and Australia[5,6]	
(20 genera/137 spp.)		(17 genera/80 spp.)		(18 genera/84 spp.)	
Podostemoideae (47 genera/280 spp.)					
Apinagia Tul.	51[1,31] (< 50[34])	*Angolaea* Wedd.	1[20]	*Cladopus* H.Möller	9[10,17,21,23]
Autana C.T.Philbrick	1[33]	*Dicraeanthus* Engl.	2[20]	*Farmeria* Willis	1[6] (2[8])
Castelnavia Tul. & Wedd.	6[27,34]	*Djinga* C.Cusset	1[20]	*Griffithella* (Tul.) Warm.	1[6]
Ceratolacis (Tul.) Wedd.	2[15]	*Endocaulos* C.Cusset	1[20]	*Hanseniella* C.Cusset	2[12]
Cipoia C.T.Philbrick, Novelo & Irgang	2[14,16]	*Inversodicraea* Engl. ex R.E.Fr.	20[20,28]	*Hydrobryopsis* Engl.	1[6] (0[19])
Devillea Tul. & Wedd.	1[3,18] (0[13])	*Ledermanniella* Engl.	26[20,28]	*Hydrobryum* Endl.	23[12,21,24,35]
Diamantina Novelo, C.T.Philbrick & Irgang	1[14]	*Leiothylax* Warm.	3[20]	*Hydrodiscus* Koi & M.Kato	1[30,35]
Jenmaniella Engl.	7[1]	*Letestuella* G.Taylor	1[20]	*Maferria* C.Cusset	1[6] (0[8])
Lophogyne Tul.	1[32]	*Macropodiella* Engl.	6[20]	*Paracladopus* M.Kato	2[17,22]
Macarenia P.Royen	1[1]	*Paleodicraeia* C.Cusset	1[20]	*Polypleurum* (Taylor ex Tul.) Warm.	17[6,17,24,35] (20[11])
Marathrum Humb. & Bonpl.	10[34]	*Saxicolella* Engl.*	6[20] (7[29])	*Thawatchaia* M.Kato, Koi & Y.Kita	1[17]
Monostylis Tul.	1[1]	*Sphaerothylax* Bis. ex Krauss	2[20]	*Willisia* Warm.	2[6,9]
Mourera Aubl.	8[2,34]	*Stonesia* G.Taylor	5[20,26]	*Zeylanidium* Engl.	5[6,8] (6[19])
Noveloa C.T.Philbrick	2[34]	*Thelethylax* C.Cusset	2[20]		
Oserya Tul. & Wedd.	5[3,7,34]	*Winklerella* Engl.	1[20]		
Podostemum Michx.	10[18] (11[13])	*Zehnderia* C.Cusset	1[20]		
Rhyncholacis Tul.	23[1] (22[31])				
Wettsteiniola Suess.	3[1,4]				
Weddellinoideae (1 genus/1 sp.)					
Weddellina Tul.	1[2]				
Tristichoideae (6 genera/19 spp.)					
Tristicha Thouars	1[2]	*Tristicha* Thouars	1[20]	*Cussetia* M.Kato	2[17]
				Dalzellia Wight	5[5,17]
				Indodalzellia Koi & M.Kato	1[25]
				Indotristicha P.Royen	2[5]
				Terniopsis C.H.Chao	8[10,17,24]

[1]van Royen (1951); [2]van Royen (1953); [3]van Royen (1954); [4]Tur (1975); [5]Cusset & Cusset (1988a); [6]Cusset (1992); [7]Novelo & Philbrick (1995); [8]Mathew & Satheesh (1997); [9]Shivamurthy & Sadanand (1997); [10]Kato & Kita (2003); [11]Mathew, Jäger-Zürn & Nileena (2003); [12]Kato (2004); [13]Philbrick & Novelo (2004); [14]Philbrick *et al.* (2004a); [15]Philbrick *et al.* (2004b); [16]Bove *et al.* (2006); [17]Kato (2006a); [18]Moline *et al.* (2006); [19]Cook & Rutishauser (2007); [20]Rutishauser *et al.* (2007); [21]Kato (2008); [22]Koi *et al.* (2008); [23]Kato (2009); [24]Kato & Koi (2009); [25]Koi *et al.* (2009); [26]Pfeifer *et al.* (2009); [27]Philbrick *et al.* (2009); [28]Thiv *et al.* (2009); [29]Kelly *et al.* (2010); [30]Koi & Kato (2010a); [31]Philbrick *et al.* (2010); [32]Bove, Philbrick & Costa (2011); [33]Philbrick *et al.* (2011); [34]Tippery *et al.* (2011); [35]Koi & Kato (in press).
*The genus *Aulea* (2 spp.) was proposed by Cusset as a segregate of *Saxicolella*, although it was not published properly (Lebrun & Stork, 1991).

2009; Kelly *et al*., 2010; Koi & Kato, 2010a; Ruhfel *et al*., 2011). The sequences were assembled using SeqMan II (DnaStar, Madison, WI, USA) and aligned by MacClade 4.0 (Maddison & Maddison, 2000). Gaps were treated as missing data. Maximum likelihood (ML) analysis was performed using RAxML 7.2.7 (Stamatakis, Hoover & Rougemont, 2008) from Bital-IT and Cipres cluster web servers (Miller *et al*., 2009) with a general time reversible (GTR) model + G (shape parameter of the gamma distribution) model (Posada & Crandall, 1998). Bootstrap probability (BP) values were calculated for 1000 replicates. In the Bayesian analysis, the GTR model + I (proportion of invariable sites) + G was selected by the program MrModeltest 2.2 (Nylander, 2004). Nucleotide frequencies were A = 0.3282, C = 0.1399, G = 0.1194, T = 0.4125; the substitution rate matrix was A to C = 1.1407, A to G = 1.1470, A to T = 0.1821, C to G = 0.7971, C to T = 0.9452, G to T = 1.0000; the proportion of invariable sites was 0.1166; and the gamma distribution shape parameter was 1.2290. Markov chain Monte Carlo (MCMC) iterations with four chains were conducted for 5 000 000 generations, sampling a tree every 100 generations, with the program MrBayes 3.1.2 (Ronquist & Huelsenbeck, 2003). The first 12 500 trees were discarded as burn-in and the remaining 37 500 trees were used to determine the posterior probabilities (PP) for branches. The species other than Podostemaceae were treated as outgroups.

RESULTS

In the ML tree (Fig. 1), Podostemaceae were divided into two clades, Tristichoideae and a clade consisting of Podostemoideae and Weddellinoideae, and monophyly of each subfamily was supported robustly (100% BP, 1.00 PP). In Tristichoideae, *Terniopsis* H.C.Chao is sister to *Tristicha* Thou. plus a clade of *Dalzellia* Wight, *Indodalzellia* Koi & M.Kato and *Indotristicha* P.Royen (Figs 1, 2A–C). Weddellinoideae comprised only *Weddellina* Tul. (Figs 1, 2D). Podostemoideae were divided into several clades. *Diamantina* Novelo, C.T.Philbrick & Irgang was sister to the remaining Podostemoideae, the monophyly of which was, however, poorly supported (54% BP, 0.96 PP) (Figs 1, 2E). The second branching clade, supported weakly (76% BP, 1.00 PP), included *Mourera* Aubl. as sister to *Apinagia* Tul., *Castelnavia* Tul. & Wedd., *Jenmaniella* Engl., *Marathrum* Humb. & Bonpl. (with *Vanroyenella* Novelo & C.T.Philbrick merged into *Marathrum*), *Monostylis* Tul., *Noveloa* C.T.Philbrick (syn. *Oserya* Tul. & Wedd. *pro parte*), *Rhyncholacis* Tul. and *Wettsteiniola* Suess., all of which are distributed in South and Central America (Figs 1, 2F, G). The remaining species comprised six clades: two American, two African, a Madagascan and one Asian. One American clade with poor support (41% BP, 0.67 PP) was composed of *Podostemum* Michx., including *Crenias* Spreng. (syn. *Mniopsis* Mart.), and the other comprised only *Ceratolacis pedunculatum* C.T.Philbrick, Novelo & Irgang (Figs 1, 2I). *Saxicolella agumatsa* Ameka & Cheek and *S. amicorum* J.B.Hall formed one of the African clades (100% BP, 1.00 PP) (Figs 1, 2H). The other African clade (100% BP, 1.00 PP) included *Dicraeanthus* Engl., *Djinga* C. Cusset, *Inversodicraea* Engl. ex R.E.Fr. (syn. *Ledermanniella* subgenus *Phyllosoma* C.Cusset), *Ledermanniella* (syn. *Ledermanniella* subgenus *Ledermanniella*), *Leiothylax* Warm., *Letestuella* G.Taylor, *Macropodiella* Engl., *Monandriella* Engl., *Saxicolella nana* Engl., *Stonesia* G.Taylor and *Winklerella* Engl. (Figs 1, 2J). The Madagascan clade (89% BP, 1.00 PP) was composed of *Endocaulos* C.Cusset and *Thelethylax* C.Cusset (Figs 1, 2K). The Asian clade (97% BP, 1.00 PP) was divided into four subclades (Figs 1, 2L–N). The *Cladopus* subclade (100% BP) was composed of *Cladopus* H.A.Möller and *Paracladopus* M.Kato, and the *Hydrobryum* subclade (100% BP, 1.00 PP) was composed of *Hanseniella* C.Cusset, *Hydrobryum* Endl., *Hydrodiscus* Koi & M.Kato and *Thawatchaia* M.Kato, Koi & Y.Kita. These two subclades formed a strongly supported monophyletic group (96% BP, 1.00 PP). The *Zeylanidium* subclade (83% BP, 0.98 PP) consisted of *Hydrobryopsis* Engl., *Willisia* Warm. and *Zeylanidium* Engl. except *Z. subulatum* (Gardner) C.Cusset, and the *Polypleurum* subclade (87% BP, 1.00 PP) consisted of *Farmeria* Willis ex Hook.f., *Griffithella* (Tul.) Warm., *Polypleurum* (Tul.) Warm. and *Z. subulatum*. The sistergroup relationship of the *Polypleurum* subclade and the *Zeylanidium* subclade was moderately supported (80% BP, 0.97 PP).

DISCUSSION

Three subfamilies

Our phylogenetic tree with the largest sampling data so far is consistent with the previous trees (Kita & Kato, 2001; Moline *et al*., 2007; Ruhfel *et al*., 2011) in that the family Podostemaceae consists of three major clades proposed systematically by Engler (1930), i.e. subfamilies Podostemoideae, Weddellinoideae and Tristichoideae, of which the first two are sister to each other. It is in good accordance with the currently accepted three-subfamilial classification (Cook & Rutishauser, 2007). The subfamilies are characterized primarily by floral morphology (Table 2; Jäger-Zürn, 1997b). Tristichoideae and Weddellinoideae share actinomorphic flowers with prominent tepals (fused or free), whereas Podostemoideae are characterized by

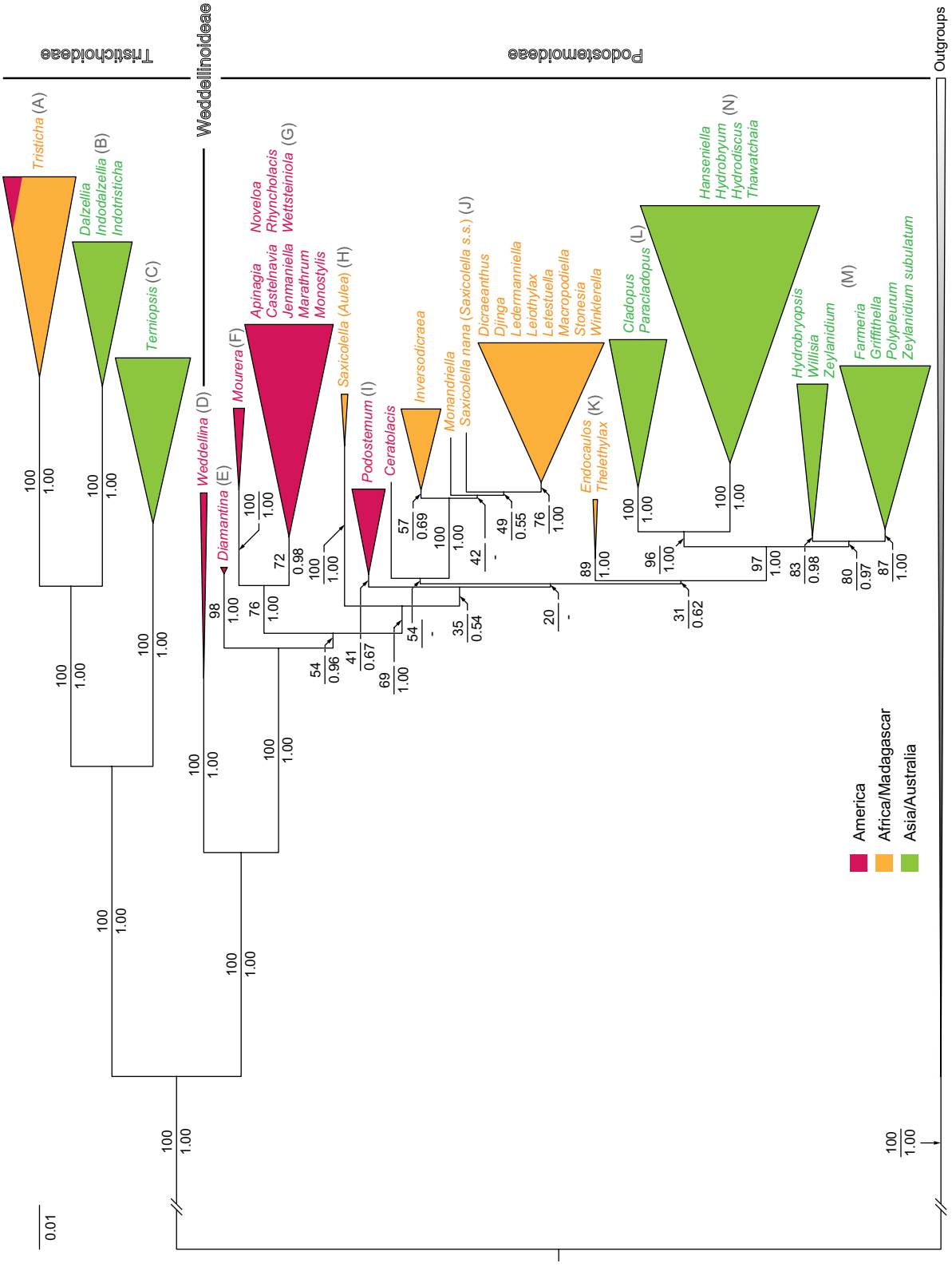

Figure 1. Phylogenetic tree of Podostemaceae deduced from RAxML analysis of *matK* sequences. Numbers above and below branches indicate bootstrap values and Bayesian posterior probabilities, respectively. Triangles indicate clades composed of multiple species (samples) examined, and the vertical lengths of triangles reflect the number of species (samples) examined. Colours indicate continents on which the species are distributed. (A)–(N) correspond to Figure 2A–N.

Figure 2. RAxML trees of Podostemaceae showing all samples examined. A, *Tristicha* clade. B, *Dalzellia–Indodalzellia–Indotristicha* clade. C, *Terniopsis* clade. D, *Weddellina* clade. E, *Diamantina* clade. F, *Mourera* clade. G, Large early branching clade of additional American Podostemoideae including *Apinagia*, *Castelnavia*, *Jenmaniella*, *Marathrum*, *Monostylis*, *Noveloa*, *Rhyncholacis* and *Wettsteiniola*. H, *Saxicolella pro parte* (i.e. Ghanaian *Aulea*) clade. I, *Podostemum* (including *Crenias*) clade. J, African clade of Podostemoideae including *Dicraeanthus*, *Djinga*, *Inversodicraea*, *Ledermanniella*, *Leiothylax*, *Letestuella*, *Macropodiella*, *Monandriella*, *Saxicolella s.s.*, *Stonesia* and *Winklerella*. K, Madagascan clade of Podostemoideae including *Endocaulos* and *Thelethylax*. L, *Cladopus* clade (from Asia and Australia) including *Cladopus* and *Paracladopus*. M, Asian *Polypleurum* and *Zeylanidium* subclades including *Farmeria*, *Griffithella*, *Polypleurum* and *Z. subulatum*, and *Hydrobryopsis*, *Willisia* and *Zeylanidium*, respectively. N, Asian *Hydrobryum* subclade including *Hanseniella*, *Hydrobryum*, *Hydrodiscus* and *Thawatchaia*. Numbers above and below branches indicate bootstrap values (> 50%) and Bayesian posterior probabilities (> 0.80), respectively.

Table 2. Flower characters of subfamilies of Podostemaceae [as compiled from Jäger-Zürn (1997b) and Cook & Rutishauser (2007)]

Character	Tristichoideae	Weddellinoideae	Podostemoideae
Flower (perianth) symmetry	Actinomorphic	Actinomorphic	Actinomorphic or zygomorphic
Spathella*	Absent	Absent	Present
Tepal	Fused into three-lobed 'calyx'	Four to six (usually five) free tepals	Spathulate to filiform; two to many
Stamen	Three, sometimes one or two	Five to 25	One to 44
Ovary	Tricarpellate and trilocular	Bicarpellate and bilocular	Bicarpellate; bilocular or unilocular (attributable to loss of septum)
Stigma	Three	One	Usually two
Pollen	Pantoporate	Tricolporate	Tricolpate, rarely tetra- or pentacolpate

*Sac-like envelope covering flower bud.

zygomorphic flowers with reduced tepals and flower buds enclosed by spathellas, i.e. special envelops. In contrast, Weddellinoideae and Podostemoideae share bicarpellate flowers.

Vegetative characters also characterize the subfamilies. Tristichoideae and Weddellinoideae share nearly radially symmetrical root apical meristems and root caps, with exceptions of the rootless *Dalzellia* and the capless *Tristicha* (Koi *et al*., 2006), sympodially branching shoots with shoot apical meristems (SAMs) and scale-like leaves (Koi & Kato, 2007; Fujinami & Imaichi, 2009). In Podostemoideae, root apical meristems are bilateral-symmetric with dorsiventral root caps, but some species are capless (e.g. *Jenmaniella*) (Koi *et al*., 2006) or have linear elongate root meristems resembling fasciation (e.g. *Hydrobryum*) (Ota, Imaichi & Kato, 2001). The shoots are devoid of SAMs in a morphological sense in Podostemoideae examined (Hammond, 1936; Imaichi, Hiyama & Kato, 2005; Koi, Imaichi & Kato, 2005). Recent analyses of the gene expression patterns of *SHOOT MERISTEMLESS*, *WUSCHEL* and *ASYMMETRIC LEAVES 1* homologues during shoot development suggested that a species of Tristichoideae (*Terniopsis minor* M.Kato) has typical SAMs, like model angiosperm plants, whereas species of Podostemoideae (*Cladopus doianus* (Koidz.) Koriba and *Hydrobryum japonicum* Imamura) have markedly specialized meristems of mixed shoot and leaf nature (Katayama, Koi & Kato, 2010). The phylogenetic tree shown here confirms the previous suggestions that those floral and vegetative characters shared by Tristichoideae and Weddellinoideae are probably plesiomorphic.

Tristichoideae and weddellinoideae

Subfamily Tristichoideae comprise six genera (Kato, 2006a), of which *Cussetia* M.Kato was not examined in this study. The present result that the subfamily is divided into three clades, *Terniopsis*, *Tristicha* and a clade of *Dalzellia*, *Indodalzellia* and *Indotristicha*, is congruent with the trees of Koi *et al*. (2009) and Ruhfel *et al*. (2011), who analysed smaller sampling data sets than ours.

Terniopsis comprises several morphologically similar species and is apparently similar to *Tristicha* in the short leafy shoots (called ramuli) borne

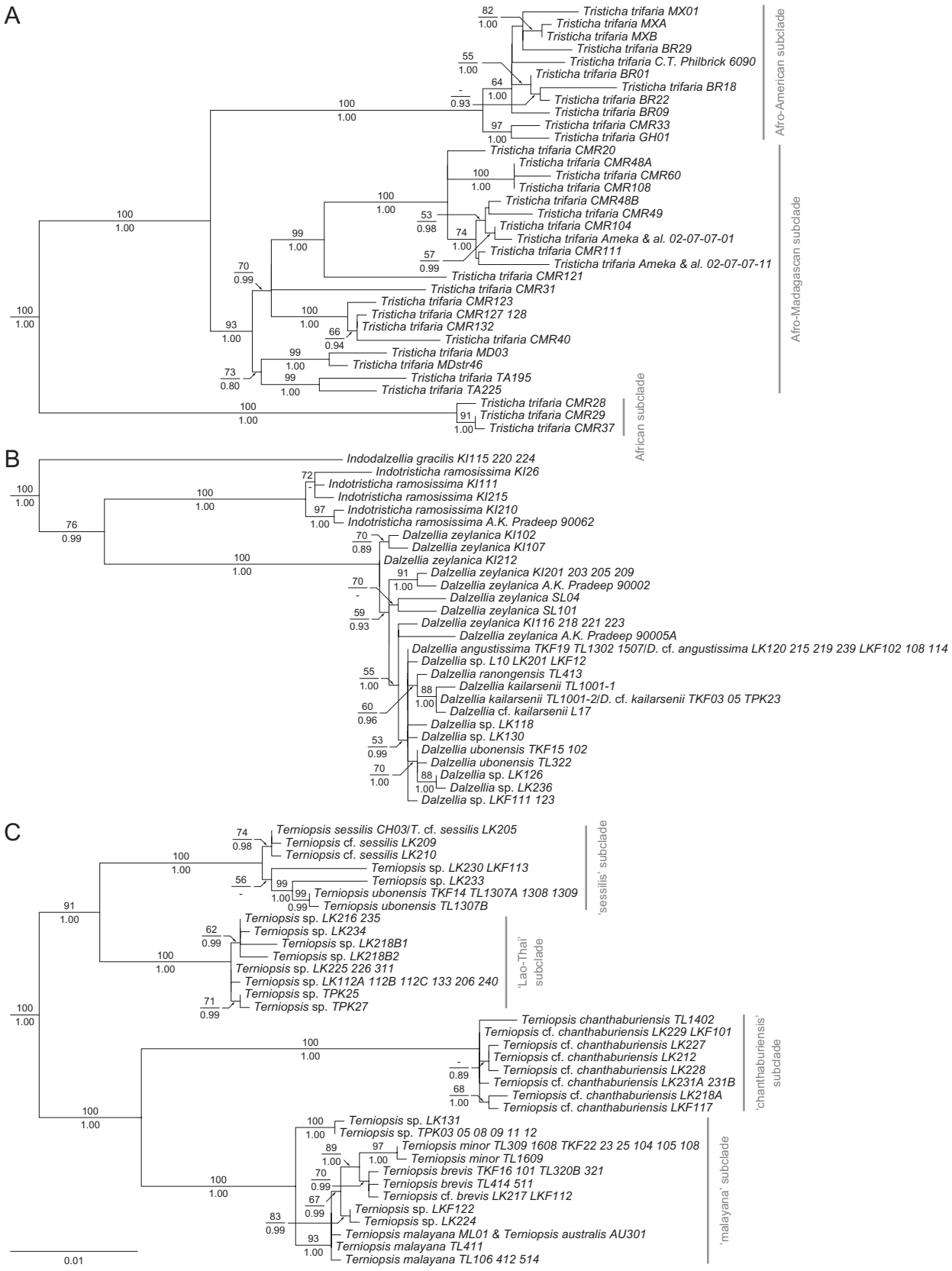

Figure 2. See caption on previous page.

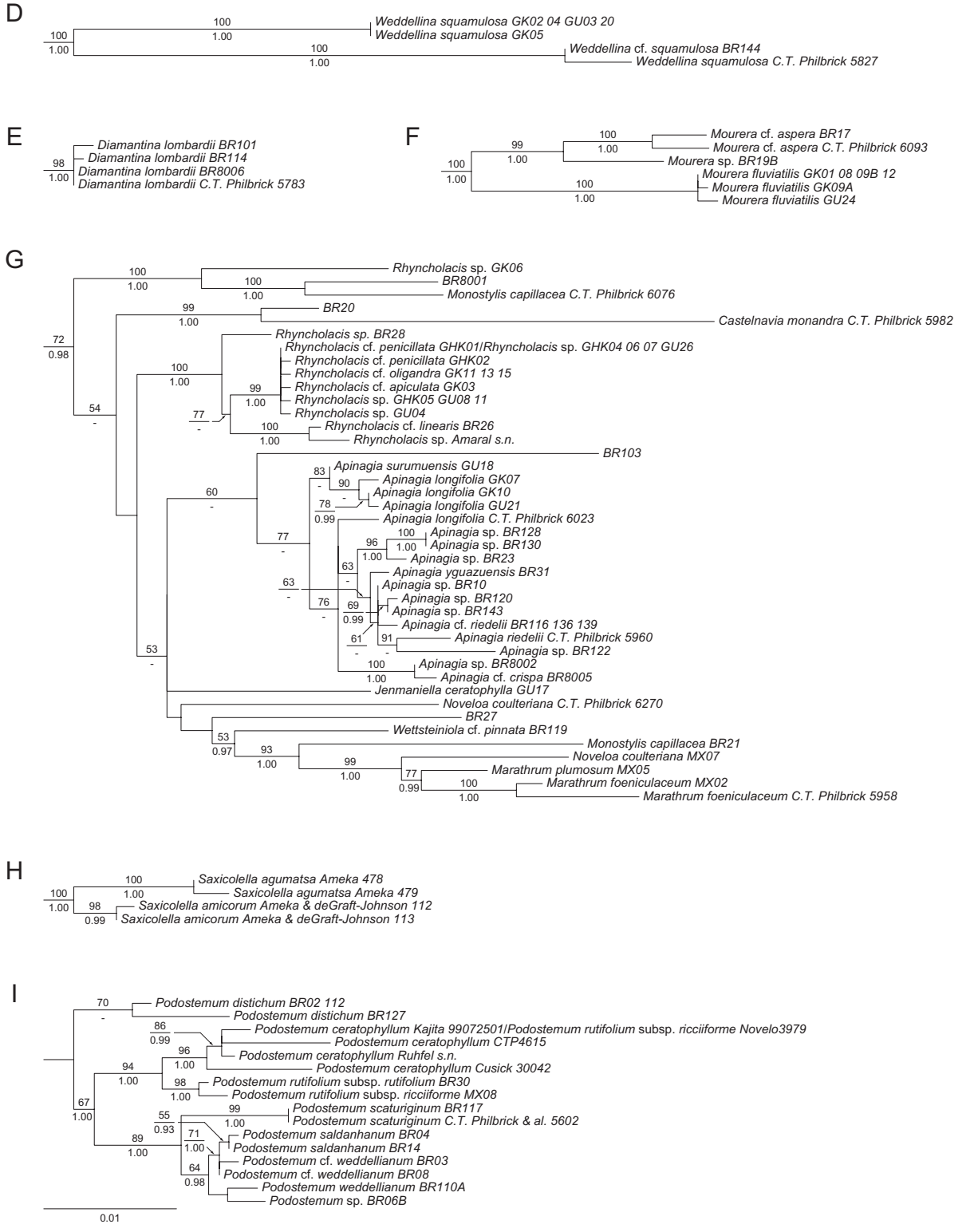

Figure 2. *Continued*

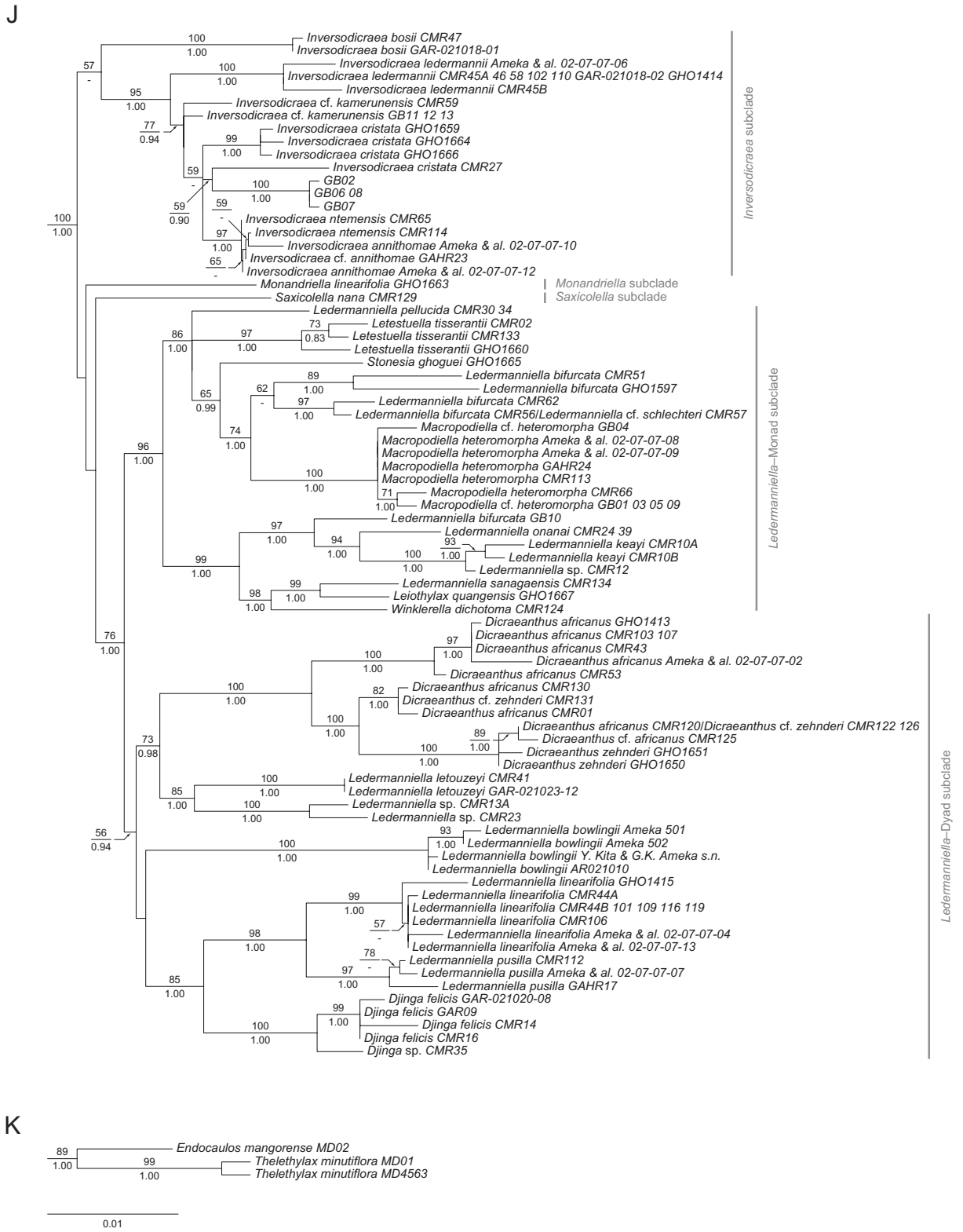

Figure 2. *Continued*

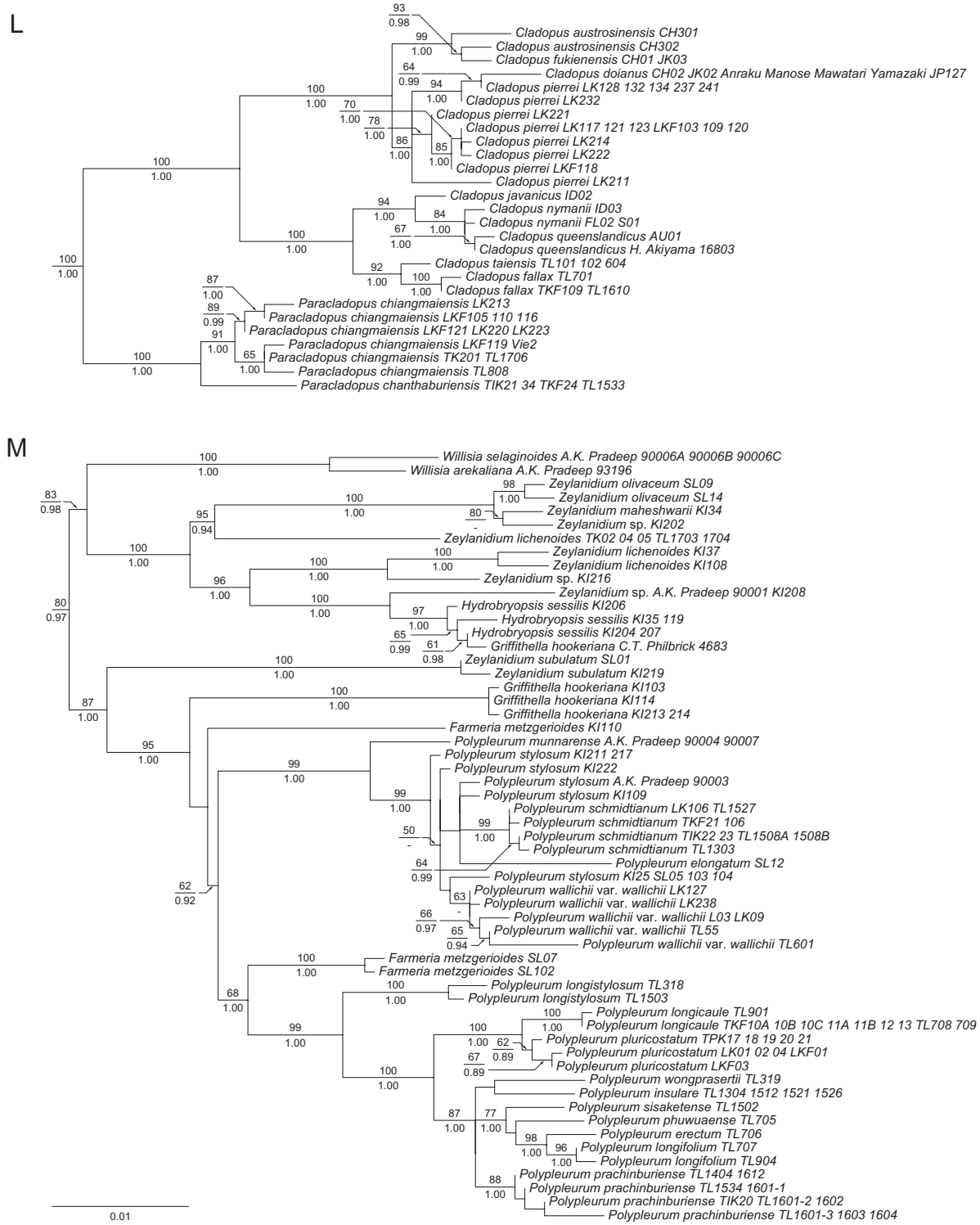

Figure 2. *Continued*

*Hydrobryum japonicum JK01 LK302 303 304 305 306 308 318 TIF115 TK01 03 08 TL206 426 1004 1006 1201 1203 1204 1701 1702 1705 1708

Figure 2. *Continued*

endogenously along the flank of the root and the trimerous flower subtended by two bracts (Kato *et al*., 2003; Kato, 2006a; S. Koi & M. Kato, unpubl. data). The diagnostic characters that distinguish *Terniopsis* and *Tristicha* are root cap (present vs. absent), number of stamens (two or three vs. one or two), stigma (laciniate and free vs. oblong–elliptic and united) and ramuli associated with the flower (present vs. absent) (Cusset & Cusset, 1988a; Kato *et al*., 2003). In contrast, *Dalzellia*, *Indodalzellia* and

Indotristicha are distinct from each other in the shoot organization (ribbon-like to foliose vs. ribbon-like vs. cylindrical), phyllotaxis (dorsal leaves without obvious pattern and marginal leaf in alternate in the former two vs. spiral or non-spiral scale arrangement in the last) and root (absent in the former vs. present in the last two) (Cusset & Cusset, 1988b; Rutishauser & Huber, 1991; Jäger-Zürn, 1992, 1995, 1997a; Mathew, Nileena & Jäger-Zürn, 2001; Imaichi *et al*., 2004; Koi *et al*., 2009; Koi & Kato, 2010b). It is therefore likely that the remarkable differences appeared for an equivalent geological time to the relatively uniform sister genus *Tristicha*.

Our phylogenetic analysis using new samples shows that *Tristicha* is divided into three distinct subclades, i.e. the Afro-American subclade, the Afro-Madagascan subclade and, as sister to both, a truly African sublclade (Fig. 2A). The present phylogenetic relationship of these subclades strongly supports the hypothesis by Kita & Kato (2004b) that *Tristicha* occurred in Africa and migrated to America. Our ML analysis also indicates that the molecular variations in *matK* between the three subclades of *Tristicha* (0.025–0.068 expected amount of change per site) are nearly equivalent to those between four subclades of *Terniopsis* (the '*chanthaburiensis*' subclade, the 'Lao-Thai' subclade, the '*malayana*' subclade and the '*sessilis*' subclade) (0.023–0.052) and those between *Dalzellia*, *Indodalzellia* and *Indotristicha* (0.038–0.051) (Fig. 2A–C; Appendix 3). *Tristicha* is usually treated as monotypic (*T. trifaria* (Bory ex Willd.) Spreng.), even although many local species have been described (Cusset & Cusset, 1988a, c). It is necessary to clarify whether there are multiple species in *Tristicha* by morphological observation and barcoding analysis (Kelly *et al*., 2010).

Subfamily Weddellinoideae are composed of only *Weddellina*, which has been considered monospecific (van Royen, 1953; Cook & Rutishauser, 2007). The present study shows that central Brazilian and Guyanan *Weddellina* form a monophyletic clade. Although the two are similar in vegetative characters (S. Koi & M. Kato, unpubl. data), the samples differ considerably in the *matK* sequence (Fig. 2D). No floral material is available for the Brazilian specimen and therefore further morphological and molecular analyses on specimens collected from its wide distribution area are necessary to test whether *Weddellina* is monospecific with infraspecific taxa (Philbrick *et al*., 2010) or comprises at least two species.

Podostemoideae

Our analysis with 493 podostemoid samples produced similar results to those published by Ruhfel *et al*. (2011), that *Diamantina lombardii* Novelo, C.T.Philbrick & Irgang is first-branching in the subfamily, although the monophyly of the rest is poorly supported. This species is characterized by minute digitate non-vascularized leaves, absence of double-sheathed leaf, a whorl of two to four (usually three) tepals and one to three (usually two) stamens in the zygomorphic flower, and the open bract-like spathella incompletely covering the subterminal flower bud (Philbrick, Novelo & Irgang, 2004a; Rutishauser *et al*., 2005). Although a whorl of tepals and stamens is shared by many other American species, the open spathella is not seen in other Podostemoideae and the digitate leaves suggested an affinity to Asian *Cladopus* (Rutishauser *et al*., 2005). The present molecular tree indicates that *Diamantina* is probably sister to all other Podostemoideae.

The second branching American clade consists of *Apinagia*, *Castelnavia*, *Jenmaniella*, *Marathrum* including *Vanroyenella*, *Monostylis*, *Mourera*, *Noveloa* (syn. *Oserya pro parte*), *Rhyncholacis* and *Wettsteiniola*. The phylogenetic position and the monophyly of this clade are supported with moderate bootstrap value and high posterior probability in this analysis. Such a monophyletic relationship is consistent with that of Ruhfel *et al*. (2011), who did not analyse *Jenmaniella* and *Wettsteiniola*. This clade is characterized by pollen in monads and free stamens (i.e. without andropods) (van Royen, 1951, 1953, 1954; Rutishauser, 1997; Rutishauser & Grubert, 1999, 2000; Rutishauser, Novelo & Philbrick, 1999; Cook & Rutishauser, 2007; Philbrick, Bove & Edson, 2009; Philbrick *et al*., 2010; S. Koi & M. Kato, unpubl. data). *Wettsteiniola*, analysed for the first time, is nested within this second American clade, and has two to four stamens in an incomplete whorl and pollen in monads (Cook & Rutishauser, 2007). Tippery *et al*. (2011) analysed a wider range of Neotropical Podostemoideae and revealed that South American *Lonchostephus* Tul. (merged into *Mourera*) with widely flattened filaments and *Lophogyne* Tul. are nested within this clade, based on combined ITS, *rbcL* and *trnL* data. The remaining genera with monad pollen and free stamens such as *Devillea* Tul. & Wedd., *Macarenia* P.Royen and *Tulasneantha* P.Royen [merged into *Mourera* by Tippery *et al*. (2011)] (van Royen, 1954; Cook & Rutishauser, 2007) have still to be investigated with molecular phylogenetic analysis. Some genera have many (up to 44) stamens and many (six or more) tepals in complete whorls. Tepals and stamens are white to pink and slightly scented, as an adaptation to insect pollination (Okada & Kato, 2002; Cook & Rutishauser, 2007; Sobral-Leite *et al*., 2011). Such stamens and tepals occur only in this clade of Podostemoideae. The phylogenetic positions of *Monostylis* are inconsistent between the specimens used in the Ruhfel *et al.* (2011) study and the present one, requiring further investigation.

Table 3. Key characters to define clades of Podostemoideae

	Root cap	Root branching	Flower position within spathella	Pollen
Diamantina	Present	Endogenous	Erect	Monad/tetrad?
Podostemum	Present	Endogenous	Erect	Dyad
Ceratolacis & *Cipoia*	Present	Endogenous	Erect	Dyad
American genera*	Present¶	Endogenous	Erect	Monad
Aulea (*Saxicolella pro parte*)	Present	Endogenous	Erect	Dyad
African genera†	Absent	Endogenous/exogenous	Erect/inverted	Monad/dyad
Madagascan genera‡	Present	Endogenous	Inverted	Dyad
Asian/Australian genera§	Present¶	Exogenous**	Erect	Dyad

**Apinagia, Castelnavia, Jenmaniella, Marathrum, Monostylis, Mourera, Noveloa, Rhyncholacis, Wettsteiniola*.
†*Inversodicraea, Dicraeanthus, Djinga, Ledermanniella, Leiothylax, Letestuella, Macropodiella, Monandriella, Saxicolella s.s., Stonesia, Winklerella*.
‡*Endocaulos, Thelethylax*.
§*Cladopus, Farmeria, Griffithella, Hanseniella, Hydrobryum, Hydrodiscus, Paracladopus, Polypleurum, Thawatchaia, Willisia, Zeylanidium*.
¶Some species have capless roots.
***Farmeria* exhibits endogenous branching (Willis, 1902).

American *Podostemum* (including *Crenias*) and *Ceratolacis* are isolated from other American genera in our *matK* tree. Like the tree of Ruhfel *et al*. (2011), *Ceratolacis* is placed as the sister, with low support, to African Podostemoideae except *Saxicolella agumatsa* and *S. amicorum* [both equalling the informal genus *Aulea* as segregated and proposed by Cusset in Lebrun & Stork (1991), see below]. Pollen is the character to distinguish *Podostemum* and *Ceratolacis* from the other American genera, i.e. they have dyad, not monad pollen (Table 3; Philbrick & Novelo, 2004; Philbrick, Novelo & Irgang, 2004b; Moline *et al*., 2006; Cook & Rutishauser, 2007; Tippery *et al*., 2011). *Cipoia* C.T.Philbrick, Novelo & Irgang, sharing characters such as presence of root cap, endogenous root branching and pollen dyads with *Ceratolacis* and *Podostemum*, requires molecular phylogenetic analysis (Philbrick *et al*., 2004a; Bove, Philbrick & Novelo, 2006; Cook & Rutishauser, 2007).

Our results suggest that African Podostemoideae are not monophyletic and are divided into two isolated clades, i.e. a small clade of *Saxicolella agumatsa* and *S. amicorum* from Ghana, and a large clade of all other species examined. The latter clade comprises large genera, such as *Ledermanniella* and *Inversodicraea*, and small genera *Dicraeanthus*, *Djinga*, *Leiothylax*, *Letestuella*, *Macropodiella*, *Monandriella*, *Saxicolella nana*, *Stonesia* and *Winklerella*. The large African clade is characterized by the capless root (Table 3; Thiv *et al*., 2009; S. Koi, unpubl. data). *Saxicolella nana* has also capless roots, which discriminate the Ghanaian *Saxicolella* spp. (see below).

Thiv *et al*. (2009) examined the phylogenetic relationships of African genera with three plastid markers (*matK*, *trnD–trnT*, *rpoB–trnC*) for 23 samples. Based on sample data more than three times larger than those used by Thiv *et al*. (2009), our tree suggests that the large African clade is divided into five subclades: the *Inversodicraea* subclade; the *Ledermanniella*–Monad subclade comprising *Ledermanniella pro parte*, *Leiothylax*, *Letestuella*, *Macropodiella*, *Stonesia* and *Winklerella*; the *Ledermanniella*–Dyad subclade comprising *Ledemanniella pro parte*, *Dicraeanthus* and *Djinga*; the *Monandriella* subclade; and the *Saxicolella* subclade (Fig. 2J). Our grouping of *Ledermanniella*–Monad and *Ledermanniella*–Dyad is congruent with Thiv *et al*. (2009), but our result differs from them in the position of *Inversodicraea bosii* (C.Cusset) R.Rutish. & Thiv, *Saxicolella nana* and *Winklerella*. Key characters for each subclade are summarized in Table 4. Comparing with the other African subclades, the *Saxicolella* subclade with *Saxicolella nana* is unique in having endogenously branching capless roots, a scaleless stem, an erect flower within a spathella and dyad pollen (Tables 3 and 4; Cusset, 1987; Rutishauser *et al*., 2007; S. Koi, unpubl. data). Our tree shows that *Winklerella*, which has a strongly flattened capsule with lateral wings, is nested within the *Ledermanniella*–Monad subclade, and this phylogenetic placement is not in conflict with the definition of the subclade by the key characters shown in Table 4 (Cusset, 1987; Rutishauser *et al*., 2007). Unlike the result of Thiv *et al*. (2009), that *Inversodicraea bosii* is isolated from the others, our result shows that it is

Table 4. Key characters to define subclades of African Podostemoideae shown in Figure 2J (Cusset, 1987; Cook & Rutishauser, 2007; Rutishauser *et al*., 2007; Thiv *et al*., 2009; R. Rutishauser, unpubl. data; S. Koi, unpubl. data)

Character	*Inversodicraea*†	*Ledermanniella*–Monad‡	*Ledermanniella*–Dyad‡	*Monandriella*	*Saxicolella**
Stem scale	Present	Absent	Absent	Absent	Absent
Pollen	Monad/dyad	Monad	Dyad	Monad	Dyad
Flower position in spathella	Inverted	Erect/inverted	Erect/inverted	Inverted	Erect
Root morphology	Ribbon-like	Ribbon-like/foliose	Ribbon-like/foliose	Ribbon-like	Ribbon-like
Root branching	Endogenous	Exogenous	Exogenous	Endogenous	Endogenous

†*Inversodicraea* Engl. as resurrected and redefined by Thiv *et al*. (2009) comprising all African podostemoid species showing stem scales. These 'scaly species' were added to *Ledermanniella* subgenus *Phyllosoma* by Cusset (1983, 1987), but turned out to be a separate subclade as sister to all other Podostemoideae from continental Africa that lack stem scales (Thiv *et al*., 2009; Ruhfel *et al*., 2011; cladogram Fig. 2J in the present paper).

‡*Ledermanniella s.s.* as redefined by Thiv *et al*. (2009) consists of those *Ledermanniella* spp. that were added to subgenus *Ledermanniella* by Cusset (1983, 1987), except *L. monandra*, which was recognized as the monotypic genus *Monandriella* (with *M. linearifolia*) by Engler (1930).

**Saxicolella s.s.* consists of all non-Ghanaian *Saxicolella* spp. (e.g. *S. nana*) that differ from the Ghanaian species (e.g. *S. agumatsa, S. amicorum*) in having unilocular ovaries (attributable to loss of septum) and roots devoid of caps. The Ghanaian species are taken as members of the informal genus *'Aulea'* (see Table 3).

placed at the base of *Inversodicraea* clade, but with weak statistical supports. Small genera, such as *Angolaea* Wedd., *Butumia* G.Taylor, *Sphaerothylax* Bisch. ex Krauss and *Zehnderia* C.Cusset, require phylogenetic and taxonomic analysis.

The separation of Ghanaian *Saxicolella amicorum* and *S. submersa* from *S. nana* is consistent with Cusset's proposal to divide the genus *Saxicolella s.l.* into two genera: *Saxicolella s.s.* [i.e. *sensu* Engler, 1926] with *S. flabellata* (G.Taylor) C.Cusset, *S. laciniata* (Engl.) C.Cusset, *S. marginalis* (G.Taylor) C.Cusset ex Cheek and *S. nana*, and the new genus *Aulea* C.Cusset ex Lebrun & Stork with *A. amicorum* (syn. *S. amicorum*) and *A. submersa* (syn. *S. submersa*) (Lebrun & Stork, 1991). Although the two genera share many characters, such as endogenously branching roots, erect flowers and dyad pollen (Table 3), *Saxicolella s.s.* has unilocular ovaries, i.e. without a septum, whereas *Aulea* has bilocular ovaries, i.e. with a septum (Ameka, Pfeifer & Rutishauser, 2002). Furthermore, *Saxicolella s.s.* has capless roots, whereas *Aulea* has capped ones (Ameka *et al*., 2002; S. Koi, unpubl. data). *Saxicolella s.s.* shares the loss of the ovary septum and the loss of the root cap as synapomorphies with the other podostemoids of continental Africa, whereas *Aulea* retains an ovary septum and root cap as plesiomorphies (Table 3; Ameka *et al*., 2002, 2003; Moline *et al*., 2007; Pfeifer *et al*., 2009; Thiv *et al*., 2009). *Aulea* shares capped, endogenously branching roots and dyad pollen with the Madagascan genera, i.e. *Endocaulos* and *Thelethylax*, but differs in the position of flowers in spathellas (Table 3; Grob, Pfeifer & Rutishauser, 2007).

In Madagascar, four podostemoid genera occur, of which *Endocaulos* (one species) and *Thelethylax* (two species) are endemic, whereas *Sphaerothylax* (*c*. two species) and probably *Paleodicraeia* C.Cusset (one species) are also distributed in Africa (Cusset, 1972; Cook & Rutishauser, 2007; R. Rutishauser, unpubl. data). Because *Paleodicraeia* and *Sphaerothylax* were not examined, it remains uncertain whether all Madagascan genera form a monophyletic group. Further analysis promises to resolve the phylogenetic and biogeographic relationships between Madagascan and African Podostemoideae.

Our analysis is based on much wider sampling data than previous ones (Kita & Kato, 2001; Ruhfel *et al*., 2011), with a congruent result that Asian Podostemoideae are monophyletic with high support (Figs 1, 2L–N). We found that the clade is divided into four subclades: the *Cladopus* subclade, the *Hydrobryum* subclade, the *Polypleurum* subclade, and the *Zeylanidium* subclade. The former two are concentrated in South-East and East Asia, whereas the latter two with small satellite genera are diverse in South and South-East Asia (Kato, 2006b). The species in the mainly Asian clade, like those in the American and African clades, exhibit high diversity in morphology, whereas Asian Podostemoideae are distinguished from the other Podostemoideae only in having capped (except some species), exogenously branched roots (except *Farmeria*) (Table 3).

Table 5. Characters of genera of Asian Podostemoideae (see also Appendix 4)

	Root morphology	Shoot position*	Bract	Capsule	Capsule valve
Cladopus subclade					
Cladopus	Ribbon-like	C	Digitate/ trilobed	Globose, smooth†	Unequal
Paracladopus	Ribbon-like	P	Digitate/ trilobed	Globose, smooth/ ellipsoidal, ribbed	Equal/ unequal
Hydrobryum subclade					
Hydrodiscus	–‡	–‡	Simple	Ellipsoidal, ribbed	Equal
Hanseniella	Foliose	D	Simple/ bilobed	Ellipsoidal, ribbed	Equal
Thawatchaia	Foliose	D	Trilobed	Ellipsoidal, ribbed	Equal
Hydrobryum	Foliose/ribbon-like	D/C	Simple	Ellipsoidal, ribbed	Equal/ unequal
Polypleurum subclade					
Polypleurum	Ribbon-like	C/P	Simple	Ellipsoidal§, ribbed	Equal/ unequal
Farmeria	Ribbon-like	P	Simple	Globose/ellipsoidal, smooth	Unequal
Griffithella	Cup-like/ribbon-like	P	Simple	Globose, smooth	Unequal
Zeylanidium subulatum	Ribbon-like	C	Simple	Ellipsoidal, ribbed	Unequal
Zeylanidium subclade					
Zeylanidium	Ribbon-like/foliose	C/D	Simple	Ellipsoidal, ribbed	Unequal
Hydrobryopsis	Ribbon-like	C	Simple	Globose, smooth	Unequal
Willisia	Foliose/ribbon-like	D/C	Simple/ dentate	Ellipsoidal, smooth	Unequal

*C (*Cladopus*-type), only at sinus of root branching; P (*Paracladopus*-type), on lateral flank along length of root including sinus of root branching; D, dorsal surface in foliose root.
†*Cladopus queenslandicus* has ribbed capsule.
‡*Hydrodiscus* is devoid of root.
§*Polypleurum sisaketense* has globose to ellipsoidal capsule.

Cladopus and *Paracladopus* of the *Cladopus* subclade share exogenously branched ribbon-like roots, and digitate or lobed bracts, a unique combination of characters in this subclade of Asian Podostemoideae (Table 5; Cusset, 1992). *Paracladopus* is discriminated from *Cladopus* by the shoots borne on the lateral flank of the root between successive root branches, the presence of a holdfast and the ensiform leaf (Kato, 2006a; Koi *et al*., 2008). It is difficult to define diagnostic characters for the *Hydrobryum* subclade to discriminate it from the other subclades because of its heterogeneity (Table 5). In the *Hydrobryum* subclade, *Hanseniella* and *Thawatchaia* differ from *Hydrobryum* by the lobed bracts (Cusset, 1992; Kato, 2004) and *Hydrodiscus* is unique in the absence of root (Koi & Kato, 2010a).

Our study provides the first large-scale phylogenetic relationships of Podostemoideae in India and Sri Lanka, which together represent a species-rich region in Asia. The *Polypleurum* subclade includes *Griffithella*, *Farmeria* and *Zeylanidium subulatum*, in addition to *Polypleurum*. *Griffithella* has been treated as congeneric with *Cladopus*, which is characterized by having globose, smooth-surfaced capsules (Table 5; Cusset, 1992), but this treatment is not supported by the present tree, like that of Ruhfel *et al*. (2011). *Griffithella* differs from *Cladopus* in having a simple bract and from the other genera in having occasionally a cup-like root attached to rocks by the central holdfast (Willis, 1902; Cusset, 1992; Mathew & Satheesh, 1997). *Farmeria metzgerioides* has single stamens, fewer seeds (one or two), and markedly unequal, smooth capsules (Willis, 1902; Cusset, 1992; Mathew & Satheesh, 1997) and is closely related to *Polypleurum*. *Zeylanidium subulatum* has been traditionally assigned to *Podostemum* (Willis, 1902; Mathew & Satheesh, 1997), but it should be excluded from the American *Podostemum* and even from *Zeylanidium* (Philbrick & Novelo, 2004; Cook & Rutishauser, 2007). Our tree also reveals that the *Zeylanidium* subclade includes *Hydrobryopsis*, *Willisia* and *Zeylanidium* [and *Griffithella* examined in Ruhfel *et al.* (2011)]. *Willisia* is well defined by the simple or dentate bracts (leaves) in four or six rows on

the long shoots (Cusset, 1992; Mathew & Satheesh, 1997; Shivamurthy & Sadanand, 1997). *Hydrobryopsis* is characterized by the simple bract, sessile ovary, smooth-surfaced capsule and unequal capsule valves (Cusset, 1992; Mathew & Satheesh, 1997). The rest of the *Zeylanidium* subclade has simple bracts on reduced shoots (Cusset, 1992; Mathew & Satheesh, 1997). Cook & Rutishauser (2007) embedded the monotypic genus *Hydrobryopsis* into *Zeylanidium* (as *Z. sessilis*), and the present result probably supports such a taxonomic treatment. Indian and Sri Lankan Podostemoideae require substantial reclassification based on phylogenetic relationships with further sampling.

CONCLUSIONS

The present phylogenetic analysis confirmed three subfamilies in Podostemaceae, and revealed three clades in subfamily Tristichoideae and several clades in Podostemoideae, providing a basis for a future infrasubfamilial classification of Podostemoideae. American *Diamantina* is isolated from the rest of Podostemoideae. American and African Podostemoideae are possibly not monophyletic, implying complicated evolutionary and biogeographic histories, in contrast to the monophyletic Asian Podostemoideae. The three American clades, i.e. *Ceratolacis*, *Podostemum* and the rest of American Podostemoideae (*Apinagia–Mourera* clade), and *Diamantina*, the two African clades, i.e. *Aulea* (= Ghanaian *Saxicolella*) and the rest of African genera (*Inversodicraea–Ledermanniella* clade), the Madagascan clade and the Asian clade may warrant tribal rank in a worldwide classification of Podostemoideae. Among the clades, the *Dalzellia–Indodalzellia–Indotristicha* clade (Tristichoideae), the *Apinagia–Mourera* clade (Podostemoideae) and the *Inversodicraea–Ledermanniella* clade (Podostemoideae) are multigeneric and morphologically diverse, whereas the other clades are monogeneric or bigeneric and much less diverse. The monospecific *Tristicha* and *Weddellina* have sequence variation equivalent to that of a multi-specific genus or even a clade of multiple genera. A sharp contrast between DNA variation and morphological diversity is seen in the sisters of the *Dalzellia–Indodalzellia–Indotristicha* clade and *Tristicha*.

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APPENDIX 1

MATERIALS USED IN THIS STUDY

Species names are followed by localities, voucher acronyms of herbaria where vouchers are deposited and GenBank accession numbers of *matK* sequences (in parentheses). The superscript letters (a–m) indicate the sources, which are defined at the end of Appendix 1.

TRISTICHOIDEAE (157 SAMPLES/*C.* 15 SPECIES/5 GENERA)

Dalzellia angustissima M. Kato – Saphanhin waterfall, Ban Tha Sen, Trat, Thailand, *S. Koi, R. Fujinami, N. Katayama & T. Wongprasert TKF-19* (BKF, TI, TNS, AB698081); *loc. cit.*, *M. Kato, S. Koi & T. Wongprasert TL-1302* (BKF, TI, TNS, AB698082); *TL-1507* (AB450016[h]). ***Dalzellia* cf. *angustissima*** M. Kato – Tat Yuang waterfall, Champasak, Laos, *S. Koi, N. Katayama & T. Wongprasert LK-120* (BKF, TNS, AB698083); Tad Champy waterfall, Champasak, Laos, *S. Koi & T. Wongprasert LK-215* (BKF, TNS, AB698084); Houay Pa Lai river, Ban Kaeng Yao, Bajiang, Champasak, Laos, *S. Koi & T. Wongprasert LK-219* (BKF, TNS, AB698085); Tad Hiew Khon waterfall, Ban Muen Hua Mueang, Attapeu, Laos, *S. Koi & T. Wongprasert LK-239* (BKF, TNS, AB698086); Houay Champy river, Champasak, Laos, *S. Koi, R. Fujinami & T. Wongprasert LKF-102* (BKF, TNS, AB698087); Tad Pha Suam waterfall, Bajiang National Park, Champasak, Laos, *S. Koi, R. Fujinami & T. Wongprasert LKF-108* (BKF, TNS, AB698088); Tad Lo waterfalls, Salavan, Laos, *S. Koi, R. Fujinami*

& T. Wongprasert LKF-114 (BKF, TNS, AB698089). ***Dalzellia kailarsenii*** M. Kato – *TL-1001-1* (AB450017[h]); *TL-1001-2* (AB450018[h]). ***Dalzellia* cf. *kailarsenii*** M. Kato – *L-17* (AB450024[h]); Namthob station, Phu Luang Wildlife Sanctuary, Loei, Thailand, *S. Koi, R. Fujinami, N. Katayama & T. Wongprasert TKF-3* (BKF, TNS, AB698090); *loc. cit.*, *S. Koi, R. Fujinami & T. Wongprasert TKF-5* (BKF, TNS, AB698091); *loc. cit.*, *L. Ampornpan, P. Werukamkul, W. Sumanochitrapon, A. Sathapattayanon, S. Koi & T. Wongprasert TPK-23* (BKF, TNS, AB698092). ***Dalzellia ranongensis*** M. Kato – *TL-413* (AB450019[h]). ***Dalzellia ubonensis*** M. Kato – Kaeng Lamduam waterfall, Yoddome Wildlife Sanctuary, Ubon Ratchathani, Thailand, *S. Koi, R. Fujinami, N. Katayama & T. Wongprasert TKF-15* (BKF, TNS, AB698093); *loc. cit.*, *S. Koi, R. Fujinami & T. Wongprasert TKF-102* (BKF, TNS, AB698094); *TL-322* (AB450027[h]). ***Dalzellia zeylanica*** (Gardner) Wight – *A. K. Pradeep 90002* (AB450025[h]); *A. K. Pradeep 90005A* (AB450026[h]); *KI-102* (AB450020[h]); *KI-107* (AB450021[h]); *KI-116* (AB450022[h]); Pooyam Kutty River, near Kothamanglam, Ernakuram, Kerala, India, *M. Kato, N. Katayama & A. K. Pradeep KI-218* (CALI, TNS, AB698095); Punavoorthodu Urulanthanni, near Kothamanglam, Ernakuram, Kerala, India, *M. Kato, N. Katayama & A. K. Pradeep KI-221* (CALI, TNS, AB698096); *loc. cit.*, *M. Kato, N. Katayama & A. K. Pradeep KI-223* (CALI, TNS, AB698097); Thippalikayam near Alungalchattam, Palakkad, Kerala, India, *M. Kato, N. Katayama & A. K. Pradeep KI-201* (CALI, TNS, AB698098); *loc. cit.*, *M. Kato, N. Katayama & A. K. Pradeep KI-203* (CALI, TNS, AB698099); *loc. cit.*, *M. Kato, N. Katayama & A. K. Pradeep KI-205* (CALI, TNS, AB698100); Valayah River, Palakkad, Kerala, India, *M. Kato, N. Katayama & A. K. Pradeep KI-209* (CALI, TNS, AB698101); Cheenganni Puzha near Iritti, Kannur, Kerala, India, *M. Kato, N. Katayama & A. K. Pradeep KI-212* (CALI, TNS, AB698102); *SL-04* (AB038190[a]); Mahaweli Ganga, Kandy, Sri Lanka, *M. Kato & N. Katayama SL-101* (CALI, TNS, AB698103). ***Dalzellia* sp.** – *L-10* (AB450023[h]); Tham Champee waterfall, Champasak, Laos, *S. Koi, N. Katayama & T. Wongprasert LK-118* (BKF, TNS, AB698104); Tad Hiew Khon waterfall, Ban Muen Hua Mueang, Attapeu, Laos, *S. Koi, N. Katayama & T. Wongprasert LK-126* (BKF, TNS, AB698105); Tad Nam Pa (Tad Jo) waterfall, Ban Xan Sai, Attapeu, Laos, *S. Koi, N. Katayama & T. Wongprasert LK-130* (BKF, TNS, AB698106); Tad Xai waterfall, Phuu Khao Khouay National Park, Bolikhamsai, Laos, *S. Koi & T. Wongprasert LK-201* (BKF, TNS, AB698107); *loc. cit.*, *S. Koi, R. Fujinami, N. Katayama & T. Wongprasert LKF-12* (BKF, TNS, AB698108); Tad Faek waterfall, Sekong, Laos, *S. Koi & T. Wongprasert LK-236* (BKF, TNS, AB698109); Huay Banglieng, Ban Lak Saosee, Champasak, Laos, *S. Koi, R. Fujinami & T. Wongprasert LKF-111* (BKF, TNS, AB698110); *loc. cit.*, *S. Koi, R. Fujinami & T. Wongprasert LKF-123* (BKF, TNS, AB698111). ***Indodalzellia gracilis*** (Mathew, Jäger-Zürn & Nileena) Koi & M. Kato – *KI-115* (AB450015[h]); Punavoorthode Urulanthanni, near Kothamangla, Ernakuram, Kerala, India, *M. Kato, N. Katayama & A. K. Pradeep KI-220* (CALI, TNS, AB698112); *loc. cit.*, *M. Kato, N. Katayama & A. K. Pradeep KI-224* (CALI, TNS, AB698113). ***Indotristicha ramosissima*** (Wight) P. Royen – *A. K. Pradeep 90062* (AB450029[h]); *KI-26* (AB038193[a]); *KI-111* (AB450028[h]); Cheenganni Puzha near Iritti, Kannur, Kerala, India, *M. Kato, N. Katayama & A. K. Pradeep KI-210* (CALI, TNS, AB698114); Pooyam Kutty River, near Kothamanglam, Ernakuram, Kerala, India, *M. Kato, N. Katayama & A. K. Pradeep KI-215* (CALI, TNS, AB698115). ***Terniopsis australis*** (C. Cusset & G. Cusset) M. Kato – *AU-301* (AB083094[b]). ***Terniopsis brevis*** M. Kato – Kaeng Lamduam waterfall, Yoddome Wildlife Sanctuary, Ubon Ratchathani, Thailand, *S. Koi, R. Fujinami, N. Katayama & T. Wongprasert TKF-16* (BKF, TNS, AB698116); *loc. cit.*, *S. Koi, R. Fujinami & T. Wongprasert TKF-101* (BKF, TNS, AB698117); *loc. cit.*, *M. Kato, Y. Kita & T. Wongprasert TL-320B* (BKF, TI, TNS, AB698118); *loc. cit.*, *M. Kato, R. Imaichi & T. Wongprasert TL-511* (BKF, TI, TNS, AB698119); *TL-321* (AB450031[h]); *TL-414* (AB450032[h]). ***Terniopsis* cf. *brevis*** M. Kato – Tad Champy, Champasak, Laos, *S. Koi & T. Wongprasert LK-217* (BKF, TNS, AB698120); Huay Banglieng, Ban Lak Saosee, Champasak, Laos, *S. Koi, R. Fujinami & T. Wongprasert LKF-112* (BKF, TNS, AB698121). ***Terniopsis chanthaburiensis*** M. Kato & Koi – *TL-1402* (AB450035[h]). ***Terniopsis* cf. *chanthaburiensis*** M. Kato & Koi – Houay Champy, Champasak, Laos, *S. Koi & T. Wongprasert LK-212* (BKF, TNS, AB698122); *loc. cit.*, *S. Koi, R. Fijinami & T. Wongprasert LKF-101* (BKF, TNS, AB698123); Houay Pa Lai river, Ban Kaeng Yao, Bajiang, Champasak, Laos, *S. Koi & T. Wongprasert LK-218A* (BKF, TNS, AB698124); Nam Dong, Ban Mai, Salavan, Laos, *S. Koi & T. Wongprasert LK-227* (BKF, TNS, AB698125); Nam Thone stream, Ban Chone, Salavan, Laos, *S. Koi & T. Wongprasert LK-228* (BKF, TNS, AB698126); Sesad river, Ban Viangxai, Salavan, Laos, *S. Koi & T. Wongprasert LK-229* (BKF, TNS, AB698127); Sesad river, Ban Bueng Kham, Salavan, Laos, *S. Koi & T. Wongprasert LK-231A* (BKF, TNS, AB698128); *loc. cit.*, *S. Koi & T. Wongprasert LK-231B* (BKF, TNS, AB698129); Huay Taphung, Salavan, Laos, *S. Koi, R. Fijinami & T. Wongprasert LKF-117* (BKF, TNS, AB698130). ***Terniopsis malayana*** (J. Dransf. & Whitmore) M. Kato – *ML-01* (AB038194[a]); *TL-106* (AB048827[a]); *TL-411* (AB450034[h]); Huay

Namsainue, near Haew Lom waterfalls, Phato, Chumphon, Thailand, *M. Kato, S. Koi, Y. Kita & T. Wongprasert TL-412* (BKF, TI, TNS, AB698131); Wang Mangmai waterfalls, Khao Luang National Park, Thailand, *M. Kato, R. Imaichi & T. Wongprasert TL-514* (BKF, TI, TNS, AB698132). ***Terniopsis minor*** M. Kato & Koi – Sato stream, Klong Sato, Bo Rai, Trat, Thailand, *S. Koi, R. Fujinami, N. Katayama & T. Wongprasert TKF-22* (BKF, TNS, AB698133); *loc. cit.*, *S. Koi, R. Fujinami & T. Wongprasert TKF-105* (BKF, TNS, AB698134); *TL-1609* (AB450033[h]); Klong Yai, Pong Nam Ron, Chanthaburi, Thailand, *S. Koi, R. Fujinami, N. Katayama & T. Wongprasert TKF-23* (BKF, TNS, AB698135); *loc. cit.*, *S. Koi, R. Fujinami & T. Wongprasert TKF-104* (BKF, TNS, AB698136); *loc. cit.*, *M. Kato, S. Koi, C. Tsutsumi, N. Katayama & T. Wongprasert TL-1608* (BKF, TNS, AB698137); Haew Narok waterfalls, Khao Yai National Park, Nakawn Nayok, Thailand, *S. Koi, R. Fujinami, N. Katayama & T. Wongprasert TKF-25* (BKF, TNS, AB698138); Klong Kaeo waterfall, Bo Phloi, Bo Rai, Trat, Thailand, *S. Koi, R. Fujinami & T. Wongprasert TKF-108* (BKF, TNS, AB698139); *TL-309* (AB450030[h]). ***Terniopsis sessilis*** H. C. Chao – *CH-03* (AB048377[a]). ***Terniopsis* cf. *sessilis*** H. C. Chao – Tad Sakhoy rapid, Savannakhet, Laos, *S. Koi & T. Wongprasert LK-205* (BKF, TNS, AB698140); Tad Hai waterfall, Ban Hai, Muang Phin, Savannakhet, Laos, *S. Koi & T. Wongprasert LK-209* (BKF, TNS, AB698141); Sammataek rapid, Muang Phin, Savannakhet, Laos, *S. Koi & T. Wongprasert LK-210* (BKF, TNS, AB698142). ***Terniopsis ubonensis*** M. Kato – Kaeng Saphue, Moon River, Ubon Ratchathani, Thailand, *S. Koi, R. Fujinami, N. Katayama & T. Wongprasert TKF-14* (BKF, TNS, AB698143); *loc. cit.*, M. Kato, *S. Koi & T. Wongprasert TL-1307A* (BKF, TI, TNS, AB698144); *loc. cit.*, *M. Kato, S. Koi & T. Wongprasert TL-1307B* (BKF, TI, TNS, AB698145); *loc. cit.*, *M. Kato, S. Koi & T. Wongprasert TL-1309* (BKF, TI, TNS, AB698146); *TL-1308* (AB450500[h]). ***Terniopsis* sp.** – Tat Namsanam waterfall, Ban Khounkham, Ban Namsanam Hinboun, Khammouane, Laos, *S. Koi, N. Katayama & T. Wongprasert LK-112A* (BKF, TNS, AB698147); *loc. cit.*, *S. Koi, N. Katayama & T. Wongprasert LK-112B* (BKF, TNS, AB698148); *loc. cit.*, *S. Koi, N. Katayama & T. Wongprasert LK-112C* (BKF, TNS, AB698149); Tad Nam Pa (Tad Jo) waterfall, Ban Xan Sai, Attapeu, Laos, *S. Koi, N. Katayama & T. Wongprasert LK-131* (BKF, TNS, AB698150); Sekong river, Kaeng Mueang, Lavy, Attapeu, Laos, *S. Koi, N. Katayama & T. Wongprasert LK-133* (BKF, TNS, AB698151); *loc. cit.*, *S. Koi & T. Wongprasert LK-240* (BKF, TNS, AB698152); stream on the way to Tad Salaen, Savannakhet, Laos, *S. Koi & T. Wongprasert LK-206* (BKF, TNS, AB698153); Tad Champy waterfall, Champasak, Laos, *S. Koi & T. Wongprasert LK-216* (BKF, TNS, AB698154); Houay Pa Lai river, Ban Kaeng Yao, Bajiang, Champasak, Laos, *S. Koi & T. Wongprasert LK-218B1* (BKF, TNS, AB698155); *loc. cit.*, *S. Koi & T. Wongprasert LK-218B2* (BKF, TNS, AB698156); Sedon river, Salavan, Salavan, Laos, *S. Koi & T. Wongprasert LK-225* (BKF, TNS, AB698157); Sedon river, Ban Phonebok, Salavan, Laos, *S. Koi & T. Wongprasert LK-226* (BKF, TNS, AB698158); Sesad river, Ban Viangxai, Salavan, Laos, *S. Koi & T. Wongprasert LK-230* (BKF, TNS, AB698159); Kaeng Koo rapid, Vapy, Salavan, Laos, *S. Koi & T. Wongprasert LK-233* (BKF, TNS, AB698160); *loc. cit.*, *S. Koi & T. Wongprasert LK-234* (BKF, TNS, AB698161); Tat Hia waterfall, Sekong, Laos, *S. Koi & T. Wongprasert LK-235* (BKF, TNS, AB698162); Nam Tha river, Ban Soptout, Luang Namtha, Laos, *S. Koi, N. Katayama & T. Wongprasert LK-311* (BKF, TNS, AB698163); Tad Lo waterfalls, Salavan, Laos, *S. Koi, R. Fujinami & T. Wongprasert LKF-113* (BKF, TNS, AB698164); Huay Banglieng, Ban Lak Saosee, Champasak, Laos, *S. Koi, R. Fujinami & T. Wongprasert LKF-122* (BKF, TNS, AB698165); Houay Taphuen, Ban Nonsoong, Salavan, Laos, *S. Koi & T. Wongprasert LK-224* (BKF, TNS, AB698166); Gang Tham, Huaylad, Dansai, Loei, Thailand, L. Ampornpan, P. Werukamkul, W. Sumanochitrapon, A. Sathapattayanon, *S. Koi & T. Wongprasert TPK-03* (BKF, TNS, AB698167); Gang Ree, Huaylad, Dansai, Loei, Thailand, *L. Ampornpan, P. Werukamkul, W. Sumanochitrapon, A. Sathapattayanon, S. Koi & T. Wongprasert TPK-05* (BKF, TNS, AB698168); Gang Ladkrai, Huaylad, Dansai, Loei, Thailand, *L. Ampornpan, P. Werukamkul, W. Sumanochitrapon, A. Sathapattayanon, S. Koi & T. Wongprasert TPK-08* (BKF, TNS, AB698169); Gang Kongom, Huaylad, Dansai, Loei, Thailand, *L. Ampornpan, P. Werukamkul, W. Sumanochitrapon, A. Sathapattayanon, S. Koi & T. Wongprasert TPK-09* (BKF, TNS, AB698170); Gang Gwang, Huaylad, Dansai, Loei, Thailand, *L. Ampornpan, P. Werukamkul, W. Sumanochitrapon, A. Sathapattayanon, S. Koi & T. Wongprasert TPK-11* (BKF, TNS, AB698171); Gang Tha Laad, Loei, Thailand, *L. Ampornpan, P. Werukamkul, W. Sumanochitrapon, A. Sathapattayanon, S. Koi & T. Wongprasert TPK-12* (BKF, TNS, AB698172); Gog-tab waterfall, Phu Luang, Loei, Thailand, *L. Ampornpan, P. Werukamkul, W. Sumanochitrapon, A. Sathapattayanon, S. Koi & T. Wongprasert TPK-25* (BKF, TNS, AB698173); Gang Hua Wang Hai, Phu Luang, Loei, Thailand, *L. Ampornpan, P. Werukamkul, W. Sumanochitrapon, A. Sathapattayanon, S. Koi & T. Wongprasert TPK-27* (BKF, TNS, AB698174). ***Tristicha trifaria*** (Bory ex Willd.) Spreng. – *Ameka & al. 02–07-07-01* (FN357254[j]); *Ameka & al. 02–07-07–11* (FN357255[j]); *BR-01* (AB113736[d]); *BR-09* (AB083163[b]); *BR-18* (AB113737[d]); *BR-22* (AB113738[d]); *BR-29* (AB113740[d]);

Nkam river, Kekem, Cameroon, *R. Imaichi, Y. Kita & J.-P. Ghogue CMR-20* (TNS, AB698175); Mawonge river, Ebone, Cameroon, *R. Imaichi, Y. Kita & J.-P. Ghogue CMR-28* (TNS, AB698176); *loc. cit.*, *R. Imaichi, Y. Kita & J.-P. Ghogue CMR-29* (TNS, AB698177); Manengile village, Cameroon, *R. Imaichi, Y. Kita & J.-P. Ghogue CMR-31* (TNS, AB698178); CMR-33 (AB451723[h]); Ekouk river, Kolasongo, Loum, Cameroon, *R. Imaichi, Y. Kita & J.-P. Ghogue CMR-37* (TNS, AB698179); Chide river, Muambong village, Cameroon, *R. Imaichi, Y. Kita & J.-P. Ghogue CMR-40* (TNS, AB698180); Lobé waterfall, Bwambe, Kribi, Cameroon, *R. Imaichi, Y. Kita & J.-P. Ghogue CMR-48A* (TNS, AB698181); *loc. cit.*, *R. Imaichi, Y. Kita & J.-P. Ghogue CMR-48B* (TNS, AB698182); *loc. cit.*, *R. Imaichi, Y. Kita & J.-P. Ghogue CMR-49* (TNS, AB698183); *loc. cit.*, *R. Imaichi, Y. Kita & J.-P. Ghogue CMR-60* (TNS, AB698184); *loc. cit.*, *S. Koi, N. Katayama, R. Rutishauser, K. Huber, G. K. Ameka & J.-P. Ghogue CMR-104* (TNS, AB698185); *loc. cit.*, *S. Koi, N. Katayama, R. Rutishauser, K. Huber, G. K. Ameka & J.-P. Ghogue CMR-108* (TNS, AB698186); Kienke River, Kribi, Cameroon, *S. Koi, N. Katayama, R. Rutishauser, K. Huber, G. K. Ameka & J.-P. Ghogue CMR-111* (TNS, AB698187); Sanaga River, near electric power station, Edéa, Cameroon, *R. Imaichi, S. Koi & N. Katayama CMR-121* (TNS, AB698188); Channel near electric power station, Sanaga River, Edéa, Cameroon, *R. Imaichi, S. Koi & N. Katayama CMR-123* (TNS, AB698189); Assock sóo, Nyong River, Ebogo, Mbalmayo, Cameroon, *M. Kato, R. Imaichi, S. Koi & N. Katayama CMR-127* (TNS, AB698190); *loc. cit.*, *M. Kato, R. Imaichi, S. Koi & N. Katayama CMR-128* (TNS, AB698191); Sanaga River, Nachtigal, Cameroon, *M. Kato, R. Imaichi, S. Koi & N. Katayama CMR-132* (TNS, AB698192); *C. T. Philbrick 6090* (HQ331691[l]); *GH-01* (AB113739[d]); *MD-03* (AB038198[a]); *MD-str46* (AB113743[d]); *MX-01* (AB038197[a]); *MX-A* (AB113741[d]); *MX-B* (AB113742[d]); *TA-195* (AB113744[d]); *TA-225* (AB113745[d]).

PODOSTEMOIDEAE (493 SAMPLES/*C.* 116 SPECIES/*C.* 37 GENERA)

Apinagia* cf. *crispa P. Royen – Itapecurú waterfall, Carolina, Maranhao, Brazil, *R. Montana & L. F. Pozza BR-8005* (TNS, AB698193). ***Apinagia longifolia*** (Tul.) P. Royen – *C. T. Philbrick 6023* (HQ331543[l]); Martete Falls, Essequibo River, Guyana, *S. Koi & N. Katayama GK-07* (TNS, AB698194); Kurupukari Falls, Essequibo River, Guyana, *S. Koi & N. Katayama GK-10* (TNS, AB698195); Goldfast Rapids, Essequibo River, Guyana, *M. Kato, H. Okada, R. Imaichi, Y. Kita & K. Suzuki GU-21* (TI, TNS, AB698196). ***Apinagia* cf. *riedelii*** Tul. – Goias, Brazil, *M. Kato, H. Okada & R. Imaichi BR-116* (TI, TNS, AB698197); Tributary of Rio Claro near Caiaponia, Goias, Brazil, *M. Kato, H. Okada & R. Imaichi BR-136* (TI, TNS, AB698198); *loc. cit.*, *M. Kato, H. Okada & R. Imaichi BR-139* (TI, TNS, AB698199); *C. T. Philbrick 5960* (HQ331544[l]). ***Apinagia surumuensis*** (Engl.) P. Royen – *GU-18* (AB048367[a]). ***Apinagia yguazuensis*** Chodat & Vischer – waterfall near Iguaçu Waterfalls, Foz do Iguaçu, Brazil, *M. Kato, Y. Kita & K. Suzuki BR-31* (TI, TNS, AB698200). ***Apinagia* sp.** – Rio Serragem II, Mato Grosso, Brazil, *M. Kato, Y. Kita & K. Suzuki BR-10* (TI, TNS, AB698201); Salto do Ceu, Mato Grosso, Brazil, *M. Kato, Y. Kita & K. Suzuki BR-23* (TI, TNS, AB698202); Rio Claro on BR060 near Jatai, Goias, Brazil, *M. Kato, H. Okada & R. Imaichi BR-120* (TI, TNS, AB698203); Balneario Municipal Saltinho, Goias, Brazil, *M. Kato, H. Okada & R. Imaichi BR-122* (TI, TNS, AB698204); Costa Rica, Rio Baucinho, Goias, Brazil, *M. Kato, H. Okada & R. Imaichi BR-128* (TI, TNS, AB698205); *loc. cit.*, *M. Kato, H. Okada & R. Imaichi BR-130* (TI, TNS, AB698206); Pantano waterfall near Caiaponia, Goias, Brazil, *M. Kato, H. Okada & R. Imaichi BR-143* (TI, TNS, AB698207); Esteito, Carolina, Maranhao, Brazil, *R. Montana & L. F. Pozza BR-8002* (TNS, AB698208). ***Castelnavia monandra*** Tul. & Wedd. – *C. T. Philbrick 5982* (HQ331567[l]). ***Ceratolacis pedunculatum*** C. T. Philbrick, Novelo & Irgang – *C. T. Philbrick 5761* (HQ331568[l]). ***Cladopus austrosinensis*** M. Kato & Y. Kita – *CH-301* (AB104560[c]); *CH-302* (AB104559[c]). ***Cladopus doianus*** (Koidz.) Koriba – *CH-02* (AB179654[c]); *JK-02* (AB038189[a]); *JK-Anraku* (AB038189[c]); *JK-Manose* (AB179656[c]); *JK-Mawatari* (AB179655[c]); *JK-Yamazaki* (AB038189[c]); Channel from Omaru river, Kijo, Miyazaki, Japan, *M. Kato & N. Katayama JP-127* (TI, TNS, AB698209). ***Cladopus fallax*** C. Cusset – Klong Kaeo waterfall, Bo Phloi village, Bo Rai, Trat, Thailand, *S. Koi, R. Fujinami & T. Wongprasert TKF-109* (TI, TNS, AB698210); *TL-701* (AB293561[g]); *TL-1610* (AB537378[k]). ***Cladopus fukienensis*** (H. C. Chao) H. C. Chao – *CH-01* (AB179653[c]); *JK-03* (AB048371[a]). ***Cladopus javanicus*** M. Kato & Hambali – *ID-02* (AB066175[c]). ***Cladopus nymanii*** H. Möller – Wae Garit river, Ruteng, Flores Island, Indonesia, *Kato et al*. *FL-02* (TI, TNS, AB698211); *ID-03* (AB104561[c]); *S-01* (AB104577[c]). ***Cladopus pierrei*** C. Cusset – *LK-117* (AB610213[m]); *LK-121* (AB610214[m]); *LK-123* (AB610215[m]); *LK-128* (AB610219[m]); *LK-132* (AB610220[m]); *LK-134* (AB610221[m]); *LK-211* (AB610224[m]); *LK-214* (AB610225[m]); *LK-221* (AB610226[m]); *LK-222* (AB610227[m]); *LK-232* (AB610228[m]); *LK-237* (AB610222[m]); *LK-241* (AB610223[m]); *LKF-103* (AB537379[k]); *LKF-109* (AB610217[m]); *LKF-118* (AB537380[k]); *LKF-120* (AB610218[m]). ***Cladopus queenslandicus*** (Domin) C. D. K. Cook & Rutish. – *AU-01* (AB038199[a]); *H. Akiyama 16803* (AB300702[g]).

Cladopus taiensis C. Cusset – *TL-101* (AB048372[a]); Wang Takrai Falls, Nakhon Nayok, Thailand, *M. Kato, R. Imaichi & T. Wongprasert TL-102* (BKF, TI, TNS, AB698212); Nang Rong waterfall, Khao Yai National Park, Nakhon Nayok, Thailand, *M. Kato, R. Imaichi & T. Wongprasert TL-604* (BKF, TI, TNS, AB698213). ***Diamantina lombardii*** Novelo, C. T. Philbrick & Irgang – *C. T. Philbrick 5783* (HQ331591[l]); Cascatinha waterfall, Caraça, Minas Gerais, Brazil, *M. Kato, H. Okada & R. Imaichi BR-101* (TNS, AB698214); Cristais waterfall, Diamantina, Minas Gerais, Brazil, *M. Kato, H. Okada & R. Imaichi BR-114* (TNS, AB698215); Cascatinha waterfall, Parque Natural do Caraça, Minas Gerais, Brazil, *R. Montana & L. F. Pozza BR-8006* (TNS, AB698216). ***Dicraeanthus africanus*** Engl. – *Ameka & al. 02–07-07-02* (FN357239[j]); Sanaga River, Nachtigal, Cameroon, *R. Imaichi, Y. Kita & J.-P. Ghogue CMR-01* (TNS, AB698217); *loc. cit.*, *M. Kato, R. Imaichi, S. Koi & N. Katayama CMR-130* (TNS, AB698218); Lobé waterfall, Bwambe, Kribi, Cameroon, *R. Imaichi, Y. Kita & J.-P. Ghogue CMR-43* (TNS, AB698219); *loc. cit.*, *S. Koi, N. Katayama, R. Rutishauser, K. Huber, G. K. Ameka & J.-P. Ghogue CMR-103* (TNS, AB698220); *loc. cit.*, *S. Koi, N. Katayama, R. Rutishauser, K. Huber, G. K. Ameka & J.-P. Ghogue CMR-107* (TNS, AB698221); Nyong River, Dehane, Cameroon, *R. Imaichi, Y. Kita & J.-P. Ghogue CMR-53* (TNS, AB698222); Sanaga River, Edéa, Cameroon, *R. Imaichi, S. Koi & N. Katayama CMR-120* (TNS, AB698223); *GHO-1413* (DQ168436[f]). ***Dicraeanthus* cf. *africanus*** Engl. – Sanaga River, Edéa, Cameroon, *R. Imaichi, S. Koi & N. Katayama CMR-125* (TNS, AB698224). ***Dicraeanthus zehnderi*** H. Hess – *GHO-1650* (FM877834[i]); *GHO-1651* (FM877836[i]). ***Dicraeanthus* cf. *zehnderi*** H. Hess – Sanaga River, Edéa, Cameroon, *R. Imaichi, S. Koi & N. Katayama CMR-122* (TNS, AB698225); *loc. cit.*, *R. Imaichi, S. Koi & N. Katayama CMR-126* (TNS, AB698226); Sanaga River, Nachtigal, Cameroon, *M. Kato, R. Imaichi, S. Koi & N. Katayama CMR-131* (TNS, AB698227). ***Djinga felicis*** C. Cusset – Fundong, Cameroon, *R. Imaichi, Y. Kita & J.-P. Ghogue CMR-14* (TNS, AB698228); Anyanjua River near Belo, Cameroon, *R. Imaichi, Y. Kita & J.-P. Ghogue CMR-16* (TNS, AB698229); *GAR-021020-08* (DQ168433[f]); *GAR-09* (HQ331593[l]). ***Djinga* sp.** – Mbo river, Manjo (Manengile), Cameroon, *R. Imaichi, Y. Kita & J.-P. Ghogue CMR-35* (TNS, AB698230). ***Endocaulos mangorense*** (Perr.) C. Cusset – *MD-02* (AB038191[a]). ***Farmeria metzgerioides*** Willis – Bhimanadi, Kasaragod, Kerala, India, *M. Kato, S. Koi, P. Mathew & A. K. Pradeep KI-110* (TNS, AB698231); *SL-07* (AB104580[e]); Mahaweli Ganga, Ivory Island, Kandy, Sri Lanka, *M. Kato & N. Katayama SL-102* (TNS, AB698232). ***Griffithella hookeriana*** (Tul.) Warm. – *C. T. Philbrick 4683* (HQ331612[l]); Kabbani river, Panamaram, Wynad, Kerala, India, *M. Kato, S. Koi & A. K. Pradeep KI-103* (TNS, AB698233); Bhimanadi, Kasaragod, Kerala, India, *M. Kato, S. Koi, P. Mathew & A. K. Pradeep KI-114* (TNS, AB698234); Cheenganni Puzha near Iritti, Kannur, Kerala, India, *M. Kato, N. Katayama & A. K. Pradeep KI-213* (TNS, AB698235); *loc. cit.*, *M. Kato, N. Katayama & A. K. Pradeep KI-214* (TNS, AB698236). ***Hanseniella heterophylla*** C. Cusset – *TL-311* (AB104562[e]); *TL-1104* (AB537388[k]); *TPK-13* (AB610229[m]); *TPK-15* (AB610230[m]). ***Hydrobryopsis sessilis*** Engl. – *KI-35* (AB048828[a]); Arippara waterfall, Kozhikode, Kerala, India, *M. Kato, S. Koi & A. K. Pradeep KI-119* (TNS, AB698237); Thippalikayam near Alungalchattam, Palakkad, Kerala, India, *M. Kato, N. Katayama & A. K. Pradeep KI-204* (TNS, AB698238); *loc. cit.*, *M. Kato, N. Katayama & A. K. Pradeep KI-206* (TNS, AB698239); *loc. cit.*, *M. Kato, N. Katayama & A. K. Pradeep KI-207* (TNS, AB698240). ***Hydrobryum austrolaoticum*** Koi & M. Kato – *LK-116* (AB610232[m]); *LK-122* (AB610233[m]); *LK-125* (AB610234[m]); *LKF-104* (AB537417[k]); *LKF-106* (AB610231[m]); *LKF-115* (AB537418[k]). ***Hydrobryum bifoliatum*** C. Cusset – *TL-310* (AB104564[e]). ***Hydrobryum chiangmaiense*** M. Kato – *TK-07* (AB537389[k]); *TL-63* (AB048373[a]); Monthatharn waterfall, Doi Suthep National Park, Chiang Mai, Thailand, *M. Kato, S. Koi, Y. Kita & T. Wongprasert TL-430* (BKF, TI, TNS, AB698241); *loc. cit.*, *M. Kato, S. Koi, Y. Kita & T. Wongprasert TL-431* (BKF, TI, TNS, AB698242); *loc. cit.*, *M. Kato, S. Koi, Y. Kita & T. Wongprasert TL-432* (BKF, TI, TNS, AB698243); *loc. cit.*, *M. Kato, C. Tsutsumi, Y. Hirayama, N. Katayama & T. Wongprasert TL-1707* (BKF, TNS, AB698244); Wachiratharn waterfall, Doi Inthanon National Park, Chiang Mai, Thailand, *M. Kato, R. Imaichi, T. Santisuk & T. Wongprasert TL-64* (BKF, TI, TNS, AB698245); *loc. cit.*, *M. Kato, S. Koi, Y. Kita & T. Wongprasert TL-421* (BKF, TI, TNS, AB698246); *TL-65* (AB537390[k]); *TL-422* (AB537391[k]); Siriphoom waterfall, near National Park Headquarters, Doi Inthanon National Park, Chiang Mai, Thailand, *M. Kato, S. Koi, Y. Kita & T. Wongprasert TL-423* (BKF, TI, TNS, AB698247); *TL-424* (AB537392[k]); Pha Mon waterfall, Doi Inthanon National Park, Chiang Mai, Thailand, *M. Kato, S. Koi, Y. Kita & T. Wongprasert TL-425* (BKF, TI, TNS, AB698248); *TL-428* (AB537393[k]); *TL-429* (AB104570[e]); *TL-801* (AB537394[k]); Siritharn waterfall, Doi Inthanon National Park, Chiang Mai, Thailand, *M. Kato, R. Imaichi & T. Wongprasert TL-807* (BKF, TI, TNS, AB698249). ***Hydrobryum floribundum*** Koidz. – *JK-Anraku2* (AB104571[e]); *JK-Mae* (AB104571[e]). ***Hydrobryum griffithii*** (Wall. ex Griff.) Tul. – *CH-102* (AB104568[e]); *TL-205* (AB104569[e]). ***Hydrobryum japonicum*** Imamura – *CH-101* (AB104573[e]); *JK-01* (AB038192[a]); *J. Murata & al. 041232* (AB537396[k]);

Nam Kad waterfall, Ban Faen, Oudom Xai, Laos, *S. Koi, N. Katayama & T. Wongprasert LK-301* (TNS, AB698250); Nam Lueang stream, along the route 17A, 43 km from Muang Sing, Luang Namtha, Laos, *S. Koi, N. Katayama & T. Wongprasert LK-302* (TNS, AB698251); Nam Lueang stream, along the route 17A, Ban Bone Xay, Luang Namtha, Laos, *S. Koi, N. Katayama & T. Wongprasert LK-303* (TNS, AB698252); stream at entrance of Phagneung Phoukulom waterfall, along the route 17A, 17 km from Muang Sing, Nam Ha National Protected Area, Luang Namtha, Laos, *S. Koi, N. Katayama & T. Wongprasert LK-304* (TNS, AB698253); stream under the bridge on the route 17A, at the border of Nam Ha National Protected Area, Luang Namtha, Laos, *S. Koi, N. Katayama & T. Wongprasert LK-305* (TNS, AB698254); stream along the route 17B, 17 km from Muang Sing, Luang Namtha, Laos, *S. Koi, N. Katayama & T. Wongprasert LK-306* (TNS, AB698255); stream along the route 17B, Ban Kang Kao, Luang Namtha, Laos, *S. Koi, N. Katayama & T. Wongprasert LK-308* (TNS, AB698256); stream, Ban Ta Pha, Bokeo, Laos, *S. Koi, N. Katayama & T. Wongprasert LK-318* (TNS, AB698257); Pa La-U waterfall, Kaeng Krajan National Park, Phetchaburi, Thailand, *R. Imaichi, R. Fujinami & T. Wongprasert TIF-115* (BKF, TNS, AB698258); *TK-01* (AB610235[m]); Huay Kaew stream, Maetakhra National Park, Mae On, Chiang Mai, Thailand, *S. Koi & T. Wongprasert TK-03* (BKF, TNS, AB698259); *loc. cit.*, *M. Kato, C. Tsutsumi, Y. Hirayama, N. Katayama & T. Wongprasert TL-1702* (BKF, TNS, AB698260); *loc. cit.*, *M. Kato, C. Tsutsumi, Y. Hirayama, N. Katayama & T. Wongprasert TL-1705* (BKF, TNS, AB698261); Mork Fa fall, Doi Suthep Pui National Park, Chiang Mai, Thailand, *S. Koi & T. Wongprasert TK-08* (BKF, TNS, AB698262); *loc. cit.*, *M. Kato, C. Tsutsumi, Y. Hirayama, N. Katayama & T. Wongprasert TL-1708* (BKF, TNS, AB698263); None Phatana village, Phu Luang Wildlife Reservation, Leoi, Thailand, *S. Koi, R. Fujinami, N. Katayama & T. Wongprasert TKF-09* (BKF, TNS, AB698264); Mae Nam Fang National Park, Chiang Mai, Thailand, *M. Kato, S. Koi & T. Wongprasert TL-206* (BKF, TI, TNS, AB698265); *TL-415* (AB537397[k]); *TL-420* (AB537398[k]); *TL-427* (AB537399[k]); Mae Pan waterfall, Doi Inthanon National Park, Chiang Mai, Thailand, *M. Kato, S. Koi, Kita & T. Wongprasert TL-426* (BKF, TI, TNS, AB698266); Mae Wang stream, Doi Inthanon National Park, Chiang Mai, Thailand, *M. Kato, R. Imaichi, S. Koi & T. Wongprasert TL-1004* (BKF, TI, TNS, AB698267); Mae Laka river, Ban Nong Haeng, Khoon Yuam, Mae Hongson, Thailand *M. Kato, R. Imaichi, S. Koi & T. Wongprasert TL-1006* (BKF, TI, TNS, AB698268); *TL-1103* (AB537400[k]); Sobwak village, Mae Chaem, Chiang Mai, Thailand, *M. Kato & T. Wongprasert TL-1201* (BKF, TI, TNS, AB698269); Pang Ma Pha, Mae Hongson, Thailand, *M. Kato & T. Wongprasert TL-1203* (BKF, TI, TNS, AB698270); Hmopaeng waterfall, Pai, Mae Hongson, Thailand, *M. Kato & T. Wongprasert TL-1204* (BKF, TI, TNS, AB698271); Tard Muey waterfall, Maetakhra National Park, Mae On, Chiang Mai, Thailand, *M. Kato, C. Tsutsumi, Y. Hirayama, N. Katayama & T. Wongprasert TL-1701* (BKF, TNS, AB698272); *Vie1* (AB610236[m]). ***Hydrobryum kaengsophense*** M. Kato – *TL-312* (AB104565[c]). ***Hydrobryum khaoyaiense*** M. Kato – Haew Narok waterfall, Khao Yai National Park, Nakhon Nayok, Thailand, *R. Imaichi, R. Fujinami & T. Wongprasert TIF-53* (BKF, TNS, AB698273); *loc. cit.*, *S. Koi, R. Fujinami, N. Katayama & T. Wongprasert TKF-26* (BKF, TNS, AB698274); *TK-09* (AB537395[k]). ***Hydrobryum koribanum*** Imamura ex Nakayama & Minamitani – *JK-05* (AB048374[a]). ***Hydrobryum loeicum*** M. Kato – Tard Huang international waterfall, Na Haew National Park, Loei, Thailand, *S. Koi, R. Fujinami, N. Katayama & T. Wongprasert TKF-06* (BKF, TNS, AB698275); Chang Tok waterfall, Na Haew National Park, Loei, Thailand, *S. Koi, R. Fujinami, N. Katayama & T. Wongprasert TKF-07* (BKF, TNS, AB698276); Khring waterfall, Loei, Thailand, *S. Koi, R. Fujinami, N. Katayama & T. Wongprasert TKF-08* (BKF, TNS, AB698277); Khae stream, Loei, Thailand, *M. Kato, S. Koi & T. Wongprasert TL-209* (BKF, TI, TNS, AB698278); *TL-210* (AB104566[c]); *TL-211* (AB537401[k]); Gang Ree, Huaylad, Loei, Thailand, *L. Ampornpan, P. Werukamkul, W. Sumanochitrapon, A. Sathapattayanon, S. Koi & T. Wongprasert TPK-06* (BKF, TNS, AB698279); Gang Kongom, Huaylad, Loei, Thailand, *L. Ampornpan, P. Werukamkul, W. Sumanochitrapon, A. Sathapattayanon, S. Koi & T. Wongprasert TPK-10* (BKF, TNS, AB698280). ***Hydrobryum micrantherum* var. *crassum*** M. Kato – *TL-57* (AB038205[a]); *TL-58* (AB104574[c]); *TL-306* (AB104576[c]). ***Hydrobryum micrantherum* var. *micrantherum*** (P. Royen) C. D. K. Cook & Rutish. – *TL-62* (AB104575[c]); Khao Soi Dao, Chanthaburi, Thailand, *M. Kato, S. Koi & T. Wongprasert TL-1505* (BKF, TNS, AB698281). ***Hydrobryum phetchabunense*** M. Kato & Koi – *TKF-01* (AB537414[k]); *TL-1102* (AB537415[k]). ***Hydrobryum puncticulatum*** Koidz. – *JK-Yaku* (AB104572[c]). ***Hydrobryum ramosum*** (C. Cusset) Koi & M. Kato – *LK-05* (AB537383[k]); *LKF-05* (AB610237[m]). ***Hydrobryum somranii*** M. Kato – *TL-703* (AB537402[k]); *TL-704* (AB537403[k]). ***Hydrobryum subcrustaceum*** Koi & M. Kato – *L-15* (AB537408[k]); *LK-03* (AB537409[k]); *LKF-02* (AB537410[k]); *LKF-04* (AB537411[k]). ***Hydrobryum subcylindricum*** Koi & M. Kato – *L-09* (AB537405[k]); *L-13* (AB610238[m]); *LKF-17* (AB537406[k]). ***Hydrobryum taeniatum*** Koi & M. Kato – *L-08* (AB537404[k]); *LK-107* (AB610239[m]). ***Hydrobryum takakioides*** Koi & M. Kato – *L-14* (AB610240[m]); *LK-202* (AB610241[m]);

LKF-16 (AB537407[k]). ***Hydrobryum tardhuangense*** M. Kato – *LK-113* (AB610242[m]); *TL-208* (AB104567[c]). ***Hydrobryum verrucosum*** Koi & M. Kato – *L-07* (AB537412[k]); *L-12* (AB610243[m]); *LK-105* (AB610244[m]); *LKF-14* (AB537413[k]). ***Hydrobryum vientianense*** (M. Kato & Fukuoka) Koi & M. Kato – *L-01* (AB537384[k]); *L-02* (AB610245[m]); *L-16* (AB537385[k]); *LK-06* (AB537386[k]); *LK-07* (AB610246[m]); *LK-08* (AB537387[k]); *TKF-02* (AB537416[k]); Namthob station, Phu Luang Wildlife Sanctuary, Loei, Thailand, *S. Koi, R. Fujinami, N. Katayama & T. Wongprasert TKF-04* (BKF, TNS, AB698282); *loc. cit.*, *L. Ampornpan, P. Werukamkul, W. Sumanochitrapon, A. Sathapattayanon, S. Koi & T. Wongprasert TPK-24* (BKF, TNS, AB698283); *TPK-26A* (AB610247[m]); *TPK-26B* (AB610248[m]); *TPK-28* (AB610249[m]); *TPK-29* (AB610250[m]). ***Hydrobryum* sp.** – Nam Tha river at the bridge 24 km from Luang Namtha, near Ban Sop Shin, Nam Ha National Protected Area, Luang Namtha, Laos, *S. Koi, N. Katayama & T. Wongprasert LK-313* (TNS, AB698284); *loc. cit.*, *S. Koi, N. Katayama & T. Wongprasert LK-314* (TNS, AB698285); *loc. cit.*, *S. Koi, N. Katayama & T. Wongprasert LK-315* (TNS, AB698286); Nam Tha river, Ban Sin Oudom, Luang Namtha, Laos, *S. Koi, N. Katayama & T. Wongprasert LK-316* (TNS, AB698287); Nam Tha river, Ban Sloy, Luang Namtha, Laos, *S. Koi, N. Katayama & T. Wongprasert LK-317* (TNS, AB698288); *TPK-01* (AB610253[m]); *TPK-16* (AB610251[m]); *TPK-22* (AB610252[m]). ***Hydrodiscus koyamae*** (M. Kato & Fukuoka) Koi & M. Kato – *L-06* (AB537381[k]); *L-11* (AB537382[k]); *LK-104* (AB610255[m]); *LKF-13* (AB610254[m]). ***Inversodicraea annithomae*** C. Cusset – *Ameka & al. 02–07-07–10* (FN357240[j]); *Ameka & al. 02–07-07–12* (FN357241[j]). ***Inversodicraea* cf. *annithomae*** (C. Cusset) R. Rutish. & Thiv – *GAHR-23* (HQ331633[l]). ***Inversodicraea bosii*** C. Cusset – Lobé River, Kribi, Cameroon, *R. Imaichi, Y. Kita & J.-P. Ghogue CMR-47* (TNS, AB698289); *GAR-021018-01* (DQ168431[f]). ***Inversodicraea cristata*** Engl. – Mawongge River, en route to Maujo, south of Nkongsanmba, Cameroon, *R. Imaichi, Y. Kita & J.-P. Ghogue CMR-27* (TNS, AB698290); *GHO-1659* (FM877837[i]); *GHO-1664* (FM877838[i]); *GHO-1666* (FM877839[i]). ***Inversodicraea* cf. *kamerunensis*** Engl. – Kienke River, Kribi, Cameroon, *R. Imaichi, Y. Kita & J.-P. Ghogue CMR-59* (TNS, AB698291); Langke River, Gabon, *M. Kato, R. Imaichi & S. Koi GB-11* (TNS, AB698292); *loc. cit.*, *M. Kato, R. Imaichi & S. Koi GB-12* (TNS, AB698293); *loc. cit.*, Gabon, *M. Kato, R. Imaichi & S. Koi GB-13* (TNS, AB698294). ***Inversodicraea ledermannii*** Engl. – *Ameka & al. 02–07-07-06* (FN357244[j]); Lobé waterfall, Bwambe, Kribi, Cameroon, *R. Imaichi, Y. Kita & J.-P. Ghogue CMR-45A* (TNS, AB698295); *loc. cit.*, *R. Imaichi, Y. Kita & J.-P. Ghogue CMR-45B* (TNS, AB698296); *loc. cit.*, *R. Imaichi, Y. Kita & J.-P. Ghogue CMR-46* (TNS, AB698297); *loc. cit.*, *S. Koi, N. Katayama, R. Rutishauser, K. Huber, G. K. Ameka & J.-P. Ghogue CMR-102* (TNS, AB698298); Kienke River, Kribi, Cameroon, *R. Imaichi, Y. Kita & J.-P. Ghogue CMR-58* (TNS, AB698299); *loc. cit.*, *S. Koi, N. Katayama, R. Rutishauser, K. Huber, G. K. Ameka & J.-P. Ghogue CMR-110* (TNS, AB698300); *GAR-021018-02* (DQ168432[f]); *GHO-1414* (DQ168442[f]). ***Inversodicraea* (= *Ledermanniella*) *ntemensis*** Y. Kita, Koi, Rutish. & M. Kato – Ntem River, Cameroon, *R. Imaichi, Y. Kita & J.-P. Ghogue CMR-65* (TNS, AB698301); 'M've'ele waterfall, Campo Ma'an, Cameroon, *S. Koi, N. Katayama, R. Rutishauser, K. Huber, G. K. Ameka & J.-P. Ghogue CMR-114* (TNS, AB698302). ***Jenmaniella ceratophylla*** Engl. – Potaro River, Tumatumari, Guyana, *M. Kato, H. Okada, R. Imaichi, Y. Kita & K. Suzuki GU-17* (TI, TNS, AB698303). ***Ledermanniella bifurcata*** (Engl.) C. Cusset – Nyong River, Dehane, Cameroon, *R. Imaichi, Y. Kita & J.-P. Ghogue CMR-51* (TNS, AB698304); Kienke River, Kribi, Cameroon, *R. Imaichi, Y. Kita & J.-P. Ghogue CMR-56* (TNS, AB698305); Lokoundje River, Lolodorf, Cameroon, *R. Imaichi, Y. Kita & J.-P. Ghogue CMR-62* (TNS, AB698306); Langke River, Gabon, *M. Kato, R. Imaichi & S. Koi GB-10* (TNS, AB698307); *GHO-1597* (DQ168439[f]). ***Ledermanniella bowlingii*** (J.B. Hall) C. Cusset – *Ameka 501* (FN357242[j]); *Ameka 502* (FN357243[j]); *AR-021010* (DQ168429[f]); Asuboni River, Kwahu-Nteso, Ghana, *Y. Kita & G. K. Ameka s.n.* (TNS, AB698308). ***Ledermanniella keayi*** (G. Taylor) C. Cusset – Vi River, Kumbo, Bamenda, Cameroon, *R. Imaichi, Y. Kita & J.-P. Ghogue CMR-10A* (TNS, AB698309); *loc. cit.*, *R. Imaichi, Y. Kita & J.-P. Ghogue CMR-10B* (TNS, AB698310). ***Ledermanniella letouzeyi*** C. Cusset – Ngombo waterfall, Muambong, Cameroon, *R. Imaichi, Y. Kita & J.-P. Ghogue CMR-41* (TNS, AB698311); *GAR-021023-12* (DQ168435[f]). ***Ledermanniella linearifolia*** Engl. – *Ameka & al. 02–07-07-04* (FN357246[j]); *Ameka & al. 02–07-07–13* (FN357245[j]); Lobé waterfall, Bwambe, Kribi, Cameroon, *R. Imaichi, Y. Kita & J.-P. Ghogue CMR-44A* (TNS, AB698312); *loc. cit.*, *R. Imaichi, Y. Kita & J.-P. Ghogue CMR-44B* (TNS, AB698313); *loc. cit.*, *S. Koi, N. Katayama, R. Rutishauser, K. Huber, G. K. Ameka & J.-P. Ghogue CMR-101* (TNS, AB698314); *loc. cit.*, *S. Koi, N. Katayama, R. Rutishauser, K. Huber, G. K. Ameka & J.-P. Ghogue CMR-106* (TNS, AB698315); *loc. cit.*, *S. Koi, N. Katayama, R. Rutishauser, K. Huber, G. K. Ameka & J.-P. Ghogue CMR-109* (TNS, AB698316); *loc. cit.*, *S. Koi, N. Katayama, R. Rutishauser, K. Huber, G. K. Ameka & J.-P. Ghogue CMR-116* (TNS, AB698317); *loc. cit.*, *S. Koi, N. Katayama, R. Rutishauser, K. Huber, G. K. Ameka & J.-P. Ghogue CMR-119* (TNS, AB698318); *GHO-1415* (DQ168437[f]). ***Ledermanniella onanai*** Cheek – Mamuwata water-

fall, Apouh, Fongo Tango, Dschang, Cameroon, *R. Imaichi, Y. Kita & J.-P. Ghogue CMR-24* (TNS, AB698319); Chide River, Muambong, Cameroon, *R. Imaichi, Y. Kita & J.-P. Ghogue CMR-39* (TNS, AB698320). ***Ledermanniella pellucida*** (Engl.) C. Cusset – Manengile, Cameroon, *R. Imaichi, Y. Kita & J.-P. Ghogue CMR-30* (TNS, AB698321); Mbo River, Manjo (Manengile), Cameroon, *R. Imaichi, Y. Kita & J.-P. Ghogue CMR-34* (TNS, AB698322). ***Ledermanniella pusilla*** (Warm.) C. Cusset – *Ameka & al. 02–07-07-07* (FN357247[j]); Kienke River, Kribi, Cameroon, *S. Koi, N. Katayama, R. Rutishauser, K. Huber, G. K. Ameka & J.-P. Ghogue CMR-112* (TNS, AB698323); *GAHR-17* (HQ331646[l]). ***Ledermanniella sanagaensis*** C. Cusset – Sanaga River, Nachtigal, Cameroon, *M. Kato, R. Imaichi, S. Koi & N. Katayama CMR-134* (TNS, AB698324). ***Ledermanniella* cf. *schlechteri*** (Engl.) C. Cusset – Kienke River, Kribi, Cameroon, *R. Imaichi, Y. Kita & J.-P. Ghogue CMR-57* (TNS, AB698325). ***Ledermanniella* sp.** – waterfall on route from Tuba to Ndop, Cameroon, *R. Imaichi, Y. Kita & J.-P. Ghogue CMR-12* (TNS, AB698326); Fundong, Cameroon, *R. Imaichi, Y. Kita & J.-P. Ghogue CMR-13A* (TNS, AB698327); Ling Gang-foto, Cameroon, *R. Imaichi, Y. Kita & J.-P. Ghogue CMR-23* (TNS, AB698328). ***Leiothylax quangensis*** (Engl.) Warm. – *GHO-1667* (FM877842[i]). ***Letestuella tisserantii*** G. Taylor – Sanaga River, Nachtigal, Cameroon, *R. Imaichi, Y. Kita & J.-P. Ghogue CMR-02* (TNS, AB698329); *loc. cit.*, *M. Kato, R. Imaichi, S. Koi & N. Katayama CMR-133* (TNS, AB698330); *GHO-1660* (FM877840[i]). ***Macropodiella heteromorpha*** (Baill.) C. Cusset – *Ameka & al. 02–07-07–08* (FN357248[j]); *Ameka & al. 02–07-07–09* (FN357249[j]); Ntem River, Cameroon, *R. Imaichi, Y. Kita & J.-P. Ghogue CMR-66* (TNS, AB698331); 'M've'ele waterfall, Campo Ma'an, Cameroon, *S. Koi, N. Katayama, R. Rutishauser, K. Huber, G. K. Ameka & J.-P. Ghogue CMR-113* (TNS, AB698332); *GAHR-24* (HQ331649[l]). ***Macropodiella* cf. *heteromorpha*** (Baill.) C. Cusset – Ogooué River, Booué, Gabon, *M. Kato, R. Imaichi & S. Koi GB-01* (TNS, AB698333); *loc. cit.*, *M. Kato, R. Imaichi & S. Koi GB-03* (TNS, AB698334); *loc. cit.*, *M. Kato, R. Imaichi & S. Koi GB-04* (TNS, AB698335); *loc. cit.*, *M. Kato, R. Imaichi & S. Koi GB-05* (TNS, AB698336); *loc. cit.*, *M. Kato, R. Imaichi & S. Koi GB-09* (TNS, AB698337). ***Marathrum foeniculaceum*** Bonpl. – *C. T. Philbrick 5958* (WCSU, HQ331658[l]); *MX-02* (AB038195[a]). ***Marathrum plumosum*** (Novelo & C. T. Philbrick) C. T. Philbrick & C. P. Bove – *MX-05* (AB048378[a]). ***Monandriella linearifolia*** Engl. – *GHO-1663* (HQ331658[l]). ***Monostylis capillacea*** Tul. – Salto Maciel, Mato Grosso, Brazil, *M. Kato, Y. Kita & K. Suzuki BR-21* (TI, TNS, AB698338); *C. T. Philbrick 6076* (HQ331663[l]). ***Mourera* cf. *aspera*** Tul. – Salto Maciel, Mato Grosso, Brazil, *M. Kato, Y. Kita & K. Suzuki BR-17* (TNS, AB698339); *C. T. Philbrick 6093* (HQ331666[l]). ***Mourera fluviatilis*** Aubl. – Head Falls, Essequibo River, Hipaia, Guyana, *S. Koi & N. Katayama GK-01* (TNS, AB698340); Martete Falls, Essequibo River, Iwokrama, Guyana, *S. Koi & N. Katayama GK-08* (TNS, AB698341); Goat (Gold) Falls, Essequibo River, Iwokrama, Guyana, *S. Koi & N. Katayama GK-09A* (TNS, AB698342); *loc. cit*, *S. Koi & N. Katayama GK-09B* (TNS, AB698343); Kurupukari Falls, Essequibo River, Iwokrama, Guyana, *S. Koi & N. Katayama GK-12* (TNS, AB698344); *GU-24* (AB038200[a]). ***Mourera* sp.** – Salto Maciel, Mato Grosso, Brazil, *M. Kato, Y. Kita & K. Suzuki BR-19B* (TNS, AB698345); ***Noveloa coulteriana*** (Tul.) C. T. Philbrick – *C. T. Philbrick 6270* (HQ331667[l]); *MX-07* (AB048375[a]). ***Paracladopus chanthaburiensis*** Koi & M. Kato – *TIK-21* (AB293559[g]); *TIK-34* (AB300701[g]); Klong Yai, Pong Nam Ron, Chanthaburi, Thailand, *S. Koi, R. Fujinami, N. Katayama & T. Wongprasert TKF-24* (BKF, TNS, AB698346); *TL-1533* (AB293558[g]). ***Paracladopus chiangmaiensis*** M. Kato – *LK-213* (AB610258[m]); *LK-220* (AB610259[m]); *LK-223* (AB611703[m]); *LKF-105* (AB610256[m]); *LKF-110* (AB537419[k]); *LKF-116* (AB610257[m]); *LKF-119* (AB537420[k]); *LKF-121* (AB537421[k]); *TL-808* (AB293560[g]); *TL-1706* (AB537422[k]); Lao river near Mae Khachan Hot Spa, Chiang Mai, Thailand, *S. Koi, N. Katayama & T. Wongprasert TK-201* (TNS, AB698347); Bu Gia Map National Park, Vietnam, *S.-W. Chung* s.n. (*Vie2*) (TAIF, AB698348). ***Podostemum ceratophyllum*** Michx. – *CTP-4615* (DQ168440[f]); *Cusick 30042* (EF135584[e]); *Kajita 99072501* (AB038203[a]); *Ruhfel s.n.* (HQ331671[l]). ***Podostemum distichum*** Wedd. – Brotas waterfall, São Paulo, Brazil, *M. Kato, Y. Kita & K. Suzuki BR-02* (TI, TNS, AB698349); Pocinhos waterfall, Caldas, Minas Gerais, Brazil, *M. Kato, H. Okada & R. Imaichi BR-112* (TNS, AB698350); Costa Rica, Baucinho, Goias, Brazil, *M. Kato, H. Okada & R. Imaichi BR-127* (TNS, AB698351). ***Podostemum rutifolium* subsp. *ricciforme*** (Liebm.) A. Novelo & C. T. Philbrick – *MX-08* (AB038201[a]). ***Podostemum rutifolium* subsp. *rutifolium*** Warm. – waterfall near Iguaçu waterfalls, Foz do Iguaçu, Brazil, *M. Kato, Y. Kita & K. Suzuki BR-30* (TI, TNS, AB698352); *Novelo 3979* (DQ168441[f]). ***Podostemum saldanhanum*** (Warm.) C. T. Philbrick & Novelo – Quebra Frasco, Rio de Janeiro, Brazil, *M. Kato, Y. Kita & K. Suzuki BR-04* (TNS, AB698353); Rio Formoso, Rio de Janeiro, Brazil, *M. Kato, Y. Kita & K. Suzuki BR-14* (TNS, AB698354). ***Podostemum scaturiginum*** (Mart.) C. T. Philbrick & Novelo – Rio Claro, Goias, Brazil, *M. Kato, H. Okada & R. Imaichi BR-117* (TNS, AB698355); *C. T. Philbrick et al. 5602* (HQ331672[l]). ***Podostemum weddellianum*** (Tul.) C. T. Philbrick & Novelo – Pocinhos waterfall, Caldas, Minas Gerais, Brazil, *M. Kato, H.*

Okada & R. Imaichi BR-110A (TNS, AB698356). ***Podostemum* cf. *weddellianum*** (Tul.) C. T. Philbrick & Novelo – Serra dos Órgãos, en route from Petropolis to Teresopolis, Rio de Janeiro, Brazil, *M. Kato, Y. Kita & K. Suzuki BR-03* (TNS, AB698357); Rio Soberbo, Rio de Janeiro, Brazil, *M. Kato, Y. Kita & K. Suzuki BR-08* (TNS, AB698358). ***Podostemum* sp.** – Rio de Janeiro, Brazil, *M. Kato, Y. Kita & K. Suzuki BR-06B* (TNS, AB698359). ***Polypleurum elongatum*** (Gardn.) J. B. Hall – *SL-12* (AB048376[a]). ***Polypleurum erectum*** M. Kato – *TL-706* (AB610260[m]). ***Polypleurum insulare*** M. Kato & Koi – Khlong Phu waterfall, Ko Chang, Trat, Thailand, *M. Kato, S. Koi & T. Wongprasert TL-1304* (BKF, TNS, AB698360); *TL-1512* (AB610261[m]); Tharn Mayom waterfall, Ko Chang, Trat, Thailand, *M. Kato, S. Koi & T. Wongprasert TL-1521* (BKF, TNS, AB698361); *loc. cit.*, *M. Kato, S. Koi & T. Wongprasert TL-1526* (BKF, TNS, AB698362). ***Polypleurum longicaule*** M. Kato – Tharn Ngam waterfall, Ubon Thani, Thailand, *M. Kato & T. Wongprasert TL-708* (BKF, TI, TNS, AB698363); *TL-709* (AB610262[m]); *TL-901* (AB610263[m]); *loc. cit.*, *S. Koi, R. Fujinami, N. Katayama & T. Wongprasert TKF-10A* (BKF, TNS, AB698364); *loc. cit.*, *S. Koi, R. Fujinami, N. Katayama & T. Wongprasert TKF-10B* (BKF, TNS, AB698365); *loc. cit.*, *S. Koi, R. Fujinami, N. Katayama & T. Wongprasert TKF-10C* (BKF, TNS, AB698366); *loc. cit.*, *S. Koi, R. Fujinami, N. Katayama & T. Wongprasert TKF-11A* (BKF, TNS, AB698367); *loc. cit.*, *S. Koi, R. Fujinami, N. Katayama & T. Wongprasert TKF-11B* (BKF, TNS, AB698368); *loc. cit.*, *S. Koi, R. Fujinami, N. Katayama & T. Wongprasert TKF-12* (BKF, TNS, AB698369); *loc. cit.*, *S. Koi, R. Fujinami, N. Katayama & T. Wongprasert TKF-13* (BKF, TNS, AB698370). ***Polypleurum longifolium*** M. Kato – *TL-707* (AB610264[m]); *TL-904* (AB610265[m]). ***Polypleurum longistylosum*** M. Kato – *TL-318* (AB104578[c]); *TL-1503* (AB610266[m]). ***Polypleurum munnarense*** *Nagendran & Arekal – A. K. Pradeep 90004* (AB610267[m]); Karappara River, Muthuvarachal, Parambikulam Wildlife Sanctuary, Trichur, Kerala, India, *A. K. Pradeep 90007* (TNS, AB698371). ***Polypleurum phuwuaense*** M. Kato – *TL-705* (AB610268[m]). ***Polypleurum pluricostatum*** Koi & M. Kato – *LK-01* (AB610269[m]); *LK-02* (AB610270[m]); *LK-04* (AB610271[m]); *LKF-01* (AB610272[m]); *LKF-03* (AB610273[m]); Huai Toei waterfall, Phu Rua National Park, Loei, Thailand, *L. Ampornpan, P. Werukamkul, W. Sumanochitrapon, A. Sathapattayanon, S. Koi & T. Wongprasert TPK-17* (BKF, TNS, AB698372); Hin Sam Chan waterfall, Phu Rua National Park, Loei, Thailand, *L. Ampornpan, P. Werukamkul, W. Sumanochitrapon, A. Sathapattayanon, S. Koi & T. Wongprasert TPK-18* (BKF, TNS, AB698373); Lead Phob waterfall, Phu Rua National Park, Loei, Thailand, *L. Ampornpan, P. Werukamkul, W. Sumanochitrapon, A. Sathapattayanon, S. Koi & T. Wongprasert TPK-19* (BKF, TNS, AB698374); *TPK-20* (AB610274[m]); Huai Phai waterfall, Phu Rua National Park, Loei, Thailand, *L. Ampornpan, P. Werukamkul, W. Sumanochitrapon, A. Sathapattayanon, S. Koi & T. Wongprasert TPK-21* (BKF, TNS, AB698375). ***Polypleurum prachinburiense*** M. Kato & Koi – *TL-1404* (AB610275[m]); Kaeng Hin Phoeng waterfall, Khao Yai National Park, Na Dee, Prachinburi, Thailand, *R. Imaichi, S. Nishida, S. Koi, R. Fujinami & T. Wongprasert TIK-20* (BKF, TNS, AB698376); *loc. cit.*, *M. Kato, S. Koi & T. Wongprasert TL-1534* (BKF, TNS, AB698377); *loc. cit.*, *M. Kato, S. Koi, C. Tsutsumi, N. Katayama & T. Wongprasert TL-1601-2* (BKF, TNS, AB698378); *loc. cit.*, *M. Kato, S. Koi, C. Tsutsumi, N. Katayama & T. Wongprasert TL-1601-3* (BKF, TNS, AB698379); *loc. cit.*, *M. Kato, S. Koi, C. Tsutsumi, N. Katayama & T. Wongprasert TL-1603* (BKF, TNS, AB698380); *loc. cit.*, *M. Kato, S. Koi, C. Tsutsumi, N. Katayama & T. Wongprasert TL-1604* (AB610278[m]); *TL-1601-1* (AB610276[m]); *TL-1602* (AB610277[m]); Takro waterfall, Khao Yai National Park, Prachinburi, Thailand, *M. Kato, S. Koi, C. Tsutsumi, N. Katayama & T. Wongprasert TL-1612* (BKF, TNS, AB698381). ***Polypleurum schmidtianum*** Warm. – *LK-106* (AB610279[m]); Saphan Hin waterfall, Trat, Thailand, *R. Imaichi, S. Nishida, S. Koi, R. Fujinami & T. Wongprasert TIK-22* (BKF, TNS, AB698382); *loc. cit.*, *R. Imaichi, S. Nishida, S. Koi, R. Fujinami & T. Wongprasert TIK-23* (BKF, TNS, AB698383); *TKF-21* (AB610463[m]); Sato stream, Klong Sato, Bo Rai, Trat, Thailand, *S. Koi, R. Fujinami & T. Wongprasert TKF-106* (BKF, TNS, AB698384); *TL-1303* (AB610280[m]); *TL-1508A* (AB610281[m]); *TL-1508B* (AB610282[m]); Tharn Mayom waterfall, Ko Chang, Trat, Thailand, *M. Kato, S. Koi & T. Wongprasert TL-1527* (BKF, TNS, AB698385). ***Polypleurum sisaketense*** M. Kato & Koi – *TL-1502* (AB610464[m]). ***Polypleurum stylosum*** (Wight) J. B. Hall – *A. K. Pradeep 90003* (AB610465[m]); Chaithravahinipuzha, Ponganchal, Eleri Panihayath, Hosdurg Taluk, Kasaragod, Kerala, India, *M. Kato & R. Imaichi KI-25* (TI, TNS, AB698386); *KI-109* (AB610466[m]); *KI-211* (AB610467[m]); Pooyam Kutty river, Ernakuram, Kerala, India, *M. Kato, N. Katayama & A. K. Pradeep KI-217* (TNS, AB698387); *KI-222* (AB610468[m]); *SL-05* (AB066174[c]); Mahaweli Ganga, Ivory Island, Kandy, Sri Lanka, *M. Kato & N. Katayama SL-103* (TNS, AB698388); *loc. cit.*, *M. Kato & N. Katayama SL-104* (TNS, AB698389). ***Polypleurum wallichii* var. *wallichii*** (R. Br. ex Griff.) Warm. – *L-03* (AB610470[m]); *LK-09* (AB610471[m]); *LK-127* (AB610472[m]); *LK-238* (AB610473[m]); *TL-55* (AB038204[a]); *TL-601* (AB610469[m]). ***Polypleurum wongprasertii*** M. Kato – *TL-319* (AB104579[c]). ***Rhyncholacis* cf. *apiculata*** P. Royen – Crab Falls, Mazaruni River, Guyana, *S. Koi & N. Katayama GK-03* (TNS, AB698390). ***Rhyncholа-***

cis* cf. *linearis Tul. – San Gabriel da Cachoeira, Amazonas, Brazil, *M. Kato, Y. Kita & K. Suzuki BR-26* (TI, TNS, AB698391). ***Rhyncholacis* cf. *oligandra* –** Kurupukari Falls, Essequibo River, Iwokrama, Guyana, *S. Koi & N. Katayama GK-11* (TNS, AB698392); *loc. cit.*, *S. Koi & N. Katayama GK-13* (TNS, AB698393); downstream of Kurupukari Falls, Essequibo River, Iwokrama, Guyana, *S. Koi & N. Katayama GK-15* (TNS, AB698394). ***Rhyncholacis* cf. *penicillata*** Matthiesen – Papikai Falls, Mazaruni River, Guyana, *M. Hasebe & S. Koi GHK-01* (TNS, AB698395); Parika Falls, Cuyuni River, Guyana, *M. Hasebe & S. Koi GHK-02* (TNS, AB698396). ***Rhyncholacis* sp.** – *Amaral s.n.* (EF135564[l]); Correheira, Santa Barbara, Amazonas, Brazil, *M. Kato, Y. Kita & K. Suzuki BR-28* (TI, TNS, AB698397); Apakash Falls, Mazaruni River, Guyana, *M. Hasebe & S. Koi GHK-04* (TNS, AB698398); *loc. cit.*, *M. Hasebe & S. Koi GHK-05* (TNS, AB698399); *loc. cit.*, *M. Hasebe & S. Koi GHK-06* (TNS, AB698400); Moses Falls, Essequibo River, Guyana, *M. Hasebe & S. Koi GHK-07* (TNS, AB698401); Puppikai Falls, Mazaruni River, Guyana, *S. Koi & N. Katayama GK-06* (TNS, AB698402); Head Falls, Essequibo River, Guyana, *M. Kato, H. Okada, R. Imaichi, Y. Kita & K. Suzuki GU-04* (TI, TNS, AB698403); Maripa Falls, Mazaruni River, Guyana, *M. Kato, H. Okada, R. Imaichi, Y. Kita & K. Suzuki GU-08* (TI, TNS, AB698404); Potaro River, Tumatumari, Guyana, *M. Kato, H. Okada, R. Imaichi, Y. Kita & K. Suzuki GU-11* (TI, TNS, AB698405); Matope Falls, Cuyuni River, Guyana, *M. Kato, H. Okada, R. Imaichi, Y. Kita & K. Suzuki GU-26* (TI, TNS, AB698406). ***Saxicolella agumatsa*** Ameka & Cheek – *Ameka 478* (FN357250[j]); *Ameka 479* (FN357251[j]). ***Saxicolella amicorum*** J. B. Hall – *Ameka & deGraft-Johnson 112* (FN357252[j]); *Ameka & deGraft-Johnson 113* (FN357253[j]). ***Saxicolella nana*** Engl. – Assock sóo, Nyong River, Ebogo, Mbalmayo, Cameroon, *M. Kato, R. Imaichi, S. Koi & N. Katayama CMR-129* (TNS, AB698407). ***Stonesia ghoguei*** E. Pfeifer & Rutish. – *GHO-1665* (FM877841[i]). ***Thawatchaia trilobata*** M. Kato, Koi & Y. Kita – stream along the route 17B, between Ban Houay Mo and Ban Kang Kao, Luang Namtha, Laos, *S. Koi, N. Katayama & T. Wongprasert LK-307* (TNS, AB698408); stream along the route 17B, Ban Kang Kao, Luang Namtha, Laos, *S. Koi, N. Katayama & T. Wongprasert LK-309* (TNS, AB698409); Nam Tha river, Ban Soptout, Luang Namtha, Laos, *S. Koi, N. Katayama & T. Wongprasert LK-310* (TNS, AB698410); Nam Tha river at the bridge 24 km from Luang Namtha, near Ban Sop Shin, Nam Ha National Protected Area, Luang Namtha, Laos, *S. Koi, N. Katayama & T. Wongprasert LK-312* (TNS, AB698411); Houay Kalok stream, Bokeo, Laos, *S. Koi, N. Katayama & T. Wongprasert LK-319* (TNS, AB698412); *TL-419* (AB104563[c]); Wang Kwai waterfall, Doi Inthanon National Park, Chiang Mai, Thailand, *M. Kato, R. Imaichi & T. Wongprasert TL-804* (BKF, TNS, AB698413); Mae Wang stream, Doi Inthanon National Park, Chiang Mai, Thailand, *M. Kato, R. Imaichi & T. Wongprasert TL-809* (BKF, TNS, AB698414); *TPK-02* (AB610474[m]); *TPK-04* (AB610475[m]); Gang Ree, Huaylad, Dansai, Loei, Thailand, *L. Ampornpan, P. Werukamkul, W. Sumanochitrapon, A. Sathapattayanon, S. Koi & T. Wongprasert TPK-07* (BKF, TNS, AB698415); *TPK-14* (AB610476[m]). ***Thelethylax minutiflora*** (Tul.) C. Cusset – *MD-01* (AB038196[a]); Ambanjazamba river, Ambody-port, Antsirabe de Nord, Antsiranana, Madagascar, *R. Imaichi et al. MD-4563* (TNS, AB698416). ***Wettsteiniola* cf. *pinnata*** Suess – Rio Claro near Jatai, Goias, Brazil, *M. Kato, H. Okada & R. Imaichi BR-119* (TI, TNS, AB698417). ***Willisia arekaliana*** Shivam. & K. B. Sadanand – Meenmutty waterfall, Aralam Wildlife Sanctuary, Kannur, Kerala, India, *A. K. Pradeep 93196* (TNS, AB698418). ***Willisia selaginoides*** (Bedd.) Warm. ex J. C. Willis – Karappara river, Muthuvarachal, Parambikulam Wildlife Sanctuary, Trichur, Kerala, India, *A. K. Pradeep 90006A* (TNS, AB698419); *loc. cit.*, *A. K. Pradeep 90006B* (TNS, AB698420); *loc. cit.*, *A. K. Pradeep 90006C* (TNS, AB698421). ***Winklerella dichotoma*** Engl. – Sanaga River, Edéa, Cameroon, *R. Imaichi, S. Koi & N. Katayama CMR-124* (TNS, AB698422). ***Zeylanidium lichenoides*** (Kurz.) Engl. – *KI-37* (AB104582[c]); Panathur, Kasaragod, Kerala, India, *M. Kato, S. Koi, P. Mathew & A. K. Pradeep KI-108* (TNS, AB698423); Huay Kaew stream, Maetakhra National Park, Mae On, Chiang Mai, Thailand, *S. Koi & T. Wongprasert TK-02* (BKF, TNS, AB698424); *loc. cit.*, *S. Koi & T. Wongprasert TK-04* (BKF, TNS, AB698425); *loc. cit.*, *S. Koi & T. Wongprasert TK-05* (BKF, TNS, AB698426); *loc. cit.*, *M. Kato, C. Tsutsumi, Y. Hirayama, N. Katayama & T. Wongprasert TL-1703* (BKF, TNS, AB698427); *loc. cit.*, *M. Kato, C. Tsutsumi, Y. Hirayama, N. Katayama & T. Wongprasert TL-1704* (BKF, TNS, AB698428). ***Zeylanidium maheshwarii*** C. J. Mathew & V. K. Satheesh – *KI-34* (AB048379[a]). ***Zeylanidium olivaceum*** Engl. – *SL-09* (AB038207[a]); *SL-14* (AB104581[c]). ***Zeylanidium subulatum*** (Gardner) C. Cusset – *KI-219* (AB610477[m]), *SL-01* (AB038202[a]). ***Zeylanidium* sp.** – Thippalikayam near Alungalchattam, Palakkad, Kerala, India, *A. K. Pradeep 90001* (TNS, AB698429); *loc. cit.*, *M. Kato, N. Katayama & A. K. Pradeep KI-202* (TNS, AB698430); *loc. cit.*, *M. Kato, N. Katayama & A. K. Pradeep KI-208* (TNS, AB698431); Pooyam Kutty river near Kothamanglam, Ernakuram, Kerala, India, *M. Kato, N. Katayama & A. K. Pradeep KI-216* (TNS, AB698432). **Specimen incertae sedis –** Salto Maciel, Mato Grosso, Brazil, *M. Kato, Y. Kita & K. Suzuki BR-20* (TNS, AB698433); San Gabriel da Cachoeira, Amazonas, Brazil, *M. Kato, Y. Kita & K.*

Suzuki BR-27 (TI, TNS, AB698434); Cascatona waterfall, Caraca, Minas Gerais, Brazil, *M. Kato, H. Okada & R. Imaichi BR-103* (TNS, AB698435); Vale do Paraiso, Alenquer, Pará, Brazil, *R. Montana & L. F. Pozza BR-8001* (TNS, AB698436); Ogooué River, Booué, Gabon, *M. Kato, R. Imaichi & S. Koi GB-02* (TNS, AB698437); *loc. cit.*, *M. Kato, R. Imaichi & S. Koi GB-06* (TNS, AB698438); *loc. cit.*, *M. Kato, R. Imaichi & S. Koi GB-07* (TNS, AB698439); *loc. cit.*, *M. Kato, R. Imaichi & S. Koi GB-08* (TNS, AB698440).

Weddellinoideae (7 samples/1 species/1 genus)

Weddellina squamulosa Tul. – *C. T. Philbrick 5827* (HQ331841[l]); Crab Falls, Mazaruni River, Guyana, *S. Koi & N. Katayama GK-02* (TNS, AB698441); Sarin Falls, Mazaruni River, Guyana, *S. Koi & N. Katayama GK-04* (TNS, AB698442); Puppikai Falls, Mazaruni River, Guyana, *S. Koi & N. Katayama GK-05* (TNS, AB698443); Head Fall, Essequibo River, Guyana, *M. Kato, H. Okada, R. Imaichi, Y. Kita & K. Suzuki GU-03* (TI, TNS, AB698444); *GU-20* (AB038206[a]). ***Weddellina* cf. *squamulosa* –** Sereno waterfall, Rio do Monte near Caiaponia, Goias, Brazil, *M. Kato, H. Okada & R. Imaichi BR-144* (TNS, AB698445).

Outgroup (selected members of clusioid Malpighiales)

Clusia cruiva Cambess. (Clusiaceae) – *SK08071206* (AB450037[h]). ***Cratoxylum ligustrinum*** Blume (Hypericaceae) – *SK08071203* (AB450036[h]). ***Hypericum calycinum*** L. (Hypericaceae) – Ikoma, Nara, Japan, *S. Koi SK090615* (TNS, AB698446). ***Hypericum perforatum*** L. (Hypericaceae) – Research Center for Medicinal Plant Resources, National Institute of Biomedical Innovation, Tsukuba, Japan, *HK-138* (TNS, AB698447). ***Calophyllum* sp.** (Calophyllaceae) – Tat Namsanam waterfall, Ban Khounkham, Ban Namsanam Hinboun, Khammouane, Laos, *S. Koi, N. Katayama & T. Wongprasert LK-114* (TNS, AB698448).

Sources: [a]Kita & Kato (2001); [b]Kato *et al*. (2003); [c]Kita & Kato (2004a); [d]Kita & Kato (2004b); [e]Davis & Wurdack (2004); [f]Moline *et al*. (2007); [g]Koi *et al*. (2008); [h]Koi *et al*. (2009); [i]Thiv *et al*. (2009); [j]Kelly *et al*. (2010); [k]Koi & Kato (2010a); [l]Ruhfel *et al*. (2011); [m]Koi & Kato (in press).

APPENDIX 2

Primers used in this study

Name	Sequence (5′–3′)	Direction	Source
Amplification			
3914F	TGGGTTGCTAACTCAAYGG	F	Johnson & Soltis (1994)
trnK-2R	AACTAGTCGGATGGAGTAG	R	Johnson & Soltis (1994)
MK-2rR	GTCGGGATGGAGTAGATAATWTA	R	Koi *et al*. (2008)
PodMK-F(p.w.d)	TATCGCACTAYGTATCAKTT	F	This study
PodMK-F(t)	TATCGCACTATGTATCCGTT	F	This study
PodMK-R	TATCGCACACGGCTTTC	R	This study
Amplification and sequencing			
HpMK-F1	CTCATTGGGGAAGTTGCATT	F	This study
HpMK-R1	AAAAGGTTCCCAAAAATCCG	R	This study
Sequencing			
MK-F1	TTTCCAAAARCAAAAGAGCG	F	Koi *et al*. (2008)
MK-R1	GCTWCGTAGTGCGATAGAGTCA	R	Koi & Kato (2010a)
MK-F2	TGATTCAAATTCTTCGTTACTGG	F	Koi *et al*. (2008)
MK-F2seq	CTTCGTTACTGGTTAAAAGATT	F	Koi & Kato (2010a)
MK-R2	CAAWCTGCAATAGAAAGACTCAAA	R	Koi *et al*. (2008)
MK-2rRseq	CTTWCCCTACGTAAACATCCA	R	Koi *et al*. (2008)
MK-F3	ATATTATTGACCGATTTGTGCG	F	Koi *et al*. (2008)
MK-R3	GAAAGAAWTGGCGACGAATAA	R	Koi *et al*. (2008)
MK-R4	GAGGTTTTATGTTTACGAGCCA	R	Koi *et al*. (2008)
Pod7Rnew	AATTTTCCTTGATAMCGAATATAATG	R	Koi *et al*. (2008)
MK-F11	TTACAATCAATTCATTCAATATT	F	Koi *et al*. (2009)
MK-R12	ATCATTAATAGAAAGAATATC	R	Koi *et al*. (2009)
MK-F13	TGGATTCCGATATTATTGACCG	F	Koi *et al*. (2009)
MK-F14	CAGATTGCTTCTTTGATCTTCC	F	Koi *et al*. (2009)
MK-F15	ACTCTATCGCACTATGTATC	F	Koi *et al*. (2009)

APPENDIX 2 *Continued*

Name	Sequence (5′–3′)	Direction	Source
MK-F16	CAAAATTTACAATCAATTCA	F	Koi *et al*. (2009)
MK-17F	TATATATATGAATACGAATC	F	This study
MK-F18	GTCTGGTTTCAACCMGAYAA	F	Koi *et al*. (2009)
MK-R19	TAYTCATGAAGAAASAATCG	R	Koi *et al*. (2009)
MK-R20	GAYAATGATTCAATYATTGG	R	Koi *et al*. (2009)
MK-21R	GAAAGAATATCCAAATACCA	R	This study
MK-R22	AAATGGAATATTCAATTAGT	R	Koi *et al*. (2009)
MK-23F	TCAATAAATCCTAACTATTC	F	This study
MK-24F	ATGTATCAACARAATCATTT	F	Koi & Kato (2010a)
MK-25F	TCAATTCATTCMATWTTTCC	F	This study
MK-26F	AAGACCCNAATATGMATTAT	F	Koi & Kato (2010a)
MK-27F	TCATATTWTTATAGTGGATC	F	Koi & Kato (2010a)
MK-28R	CTTTCCCTACGTAAACATCC	R	Koi & Kato (2010a)
MK-29R	GAGGTTTTGTGTTTVCGAGC	R	Koi & Kato (2010a)
MK-30R	GTAACRAARTAGTATTTCCA	R	Koi & Kato (2010a)
MK-31R	GGRTAAGGGAATAAMCCATC	R	Koi & Kato (2010a)
MK-35R	TTCCAATACTCGTGAAAAAA	R	This study
MK-36F	ATRMTAGTTCCAATTATTCT	F	This study
MK-37R	AATATCCAAATACCAAACCC	R	Koi & Kato (2010a)
MK-38F	YCATCCTTTTTAGAAGAATT	F	This study
MK-39R	ATGGTTCCAATTCCAATACT	R	This study
MK-41F	CATCYTTTTTAGARGAATTATT	F	This study
MK-42R	GATCATTAATAGAAATAATATC	R	This study
PpMK-101F	AGACTTTATTTCTATGGAAAAGTAGA	F	This study
MK-102F	GTATCAAATACATTATATACTTCG	F	Koi & Kato (2010a)
MK-103R	CTATAAWAATATGAAATCTTATTGCATAG	R	Koi & Kato (2010a)
PMK-104F	CATTATATTCGATATCAAGG	F	This study
PtMK-105R	GGTTTGCTAAYGGGATGTCC	R	This study
PtMK-106F	ACTTCAAAAATACCATGTCC	F	This study
PMK-107R	TGAATTGATTGTAAATTTTG	R	This study

APPENDIX 3

Expected amount of change per site (= branch length in Fig. 2A–C) inferred with RAxML analysis between subclades of *Tristicha trifaria*, between subclades of *Terniopsis* and between *Indodalzellia*, *Indotristicha* and *Dalzellia*.

	T. trifaria						*Terniopsis*			
	Af-Am	Af-Md	Af	*Indodal*	*Indotri*	*Dal*	'*ses*'	'L-T'	'chan'	'mal'
T. trifaria Afro-American										
T. trifaria Afro-Madagascan	0.025									
T. trifaria African	0.068	0.050								
Indodalzellia	0.152	0.134	0.150							
Indotristicha	0.149	0.131	0.147	0.045						
Dalzellia	0.155	0.137	0.153	0.051	0.038					
Terniopsis '*sessilis*'	0.196	0.178	0.194	0.183	0.180	0.186				
Terniopsis 'Lao-Thai'	0.194	0.176	0.192	0.181	0.178	0.183	0.023			
Terniopsis '*chanthaburiensis*'	0.213	0.195	0.211	0.200	0.197	0.203	0.052	0.050		
Terniopsis '*malayana*'	0.199	0.181	0.197	0.186	0.183	0.188	0.038	0.035	0.039	

Af-Am, Afro-American; Af-Md, Afro-Madagascan; Af, African; *Indodal*, *Indodalzeilla*; *Indotri*, *Indotristicha*; *Dal*, *Dalzellia*; '*ses*', '*sessilis*'; 'L-T', 'Lao-Thai', '*chan*', '*chanthaburiensis*'; '*mal*', '*malayana*'.

APPENDIX 4

Morphological characters of species of Asian clade used in this study*.

	1	2	3	4	5	6	7	8	9	10	11	12
Cladopus austrosinensis[18]	1	?	G	S	2	?	D	A	N	R	?	C
Cladopus fukienensis (syn. *C. austro-osumiensis*)[8,16,19,23]	1(–3)	D	G	S	2	?	D	A	N	R	P	C
Cladopus doianus (syn. *C. japonicus, C. chinensis, C. austrosatumensis*)[1,3,16]	1(2)	D	G	S	2	U	D	A	N	R	P	C
Cladopus pierrei[7,29]	1/2	?	G/E	S	2	U	D	A	N	R	?	C
Cladopus javanicus[12,19]	1/2	?	GE	S	2	U	D	A	N	R	P	C
Cladopus nymanii[1,7,19]	1	D	GE	S	2	U	D	A	N	R	P	C
Cladopus queenslandicus[16]	1	D	G	R	2	U	D	A	N	R	P	C
Cladopus taiensis[7,22,23]	1	D	G	S	2	U	D	A	N	R	P	C
Cladopus fallax[6,7,22]	1	D	G	S	2	U	D	A	N	R	?	C
Paracladopus chiangmaiensis[22,23,29]	1	?	G	S	2	E[22]/U[29]	D	E	N	R	P	P
Paracladopus chanthaburiensis[25]	2	?	E	R	2	U	D	E	N	R	P	P
Hydrodiscus koyamae[28,29]	2	?	E	R	2	E	S	A	B	–	–	–
Hanseniella heterophylla[7,20,21]	2	D	E	R	2	E	S/D	A	N	F	P	D
Thawatchaia trilobata[20,21]	2	?	E	R	2	E	D	A	N	F	P	D
Hydrobryum bifoliatum[7,20]	2	D	E	R	2	E	S	A	N	F	?	D
Hydrobryum kaengsophense[20]	2	?	E	R	2	E	S	A	N	F	?	D
Hydrobryum sp. *TPK16*[31]	2	?	E	R	2	?	S	A	N	F	?	D
Hydrobryum sp. *TPK22*[31]	2	?	E	R	2	?	S	A	N	F	?	D
Hydrobryum tardhuangense[20]	2	?	E	R	2	E	S	A	N	F	?	D
Hydrobryum khaoyaiense[20]	1	?	E	R	2	E	S	A	N	F	?	D
Hydrobryum micrantherum[7,20]	1	?	E	R	1	E	S	A	N	F	?	D
Hydrobryum phetchabunense[26]	2	?	E	R	2	?	S	A	N	F	?	D
Hydrobryum sp. *LK313–317*[30]	2	?	E	R	2	E	S	A	N	F	?	D
Hydrobryum loeicum[20]	2	?	E	R	2	E	S	A	N	F	?	D
Hydrobryum vientianense[15,29]	2	?	E	R	2	E	S	A	N	F	?	D
Hydrobryum koribanum[11]	2	?	E	R	2	?	S	A	N	F	?	D
Hydrobryum puncticulatum[11]	2	?	E	R	2	?	S	A	N	F	?	D
Hydrobryum japonicum[4,7,13,20]	2	D	E	R	2	E	S	A	N	F	P	D
Hydrobryum floribundum[5,11]	2	?	E	R	2	?	S	A	N	F	?	D
Hydrobryum chiangmaiense[20]	2	?	E	R	2	E	S	A	N	F	?	D
Hydrobryum griffithii[7,20]	2	D	E	R	2	E	S	A	N	F	?	D
Hydrobryum austrolaoticum[29]	1	?	E	R	1	E	S	A	N	F	?	D
Hydrobryum verrucosum[29]	2	?	E	R	2	U	S	A	N	F	?	D
Hydrobryum ramosum[7,29]	2	D	E	R	2	E	S	A	N	R	A[30]	C/D
Hydrobryum somranii[20]	2	?	E	R	1	E	S	A	N	F	?	D
Hydrobryum subcrustaceum[29]	2	?	E	R	1	U	S	A	N	F	?	D
Hydrobryum takakioides[29]	1	?	E	R	1	E	S	A	N	F	?	D
Hydrobryum taeniatum[29]	2	?	E	R	1	U	S	A	N	R	?	D
Hydrobryum subcylindricum[29]	1	?	E	R	1	U	S	A	N	R	?	D
Zeylanidium subulatum[7,9,14]	2	D	E	R	2	U	S	A	B	R	A	C
Griffithella hookeriana[2,7,9,24,30]	2	D	G	S	2	U	S	A	B	R/C	A†	P
Farmeria metzgerioides[2,7,9]	1	D	G[7]/E[9]	S	2	U	S	A	N	R	?	P
Polypleurum munnarense[7,9]	2	D	E	R	2	U[9]/E[7]	S	A	N	R	?	P
Polypleurum stylosum[7,9,23]	2	D	E	R	2	E	S	A	N	R	P	P
Polypleurum schmidtianum[7,22,29]	1	D	E	R	2	E[7]/U[29]	S	A	N	R	?	P
Polypleurum elongatum[7,23]	2	D	E	R	2	E	S	A	N	R	P	P
Polypleurum wallichii[7,22,23,29]	2	D	E	R	2	E[7]/U[29]	S	A	N	R	P	P
Polypleurum longistylosum[22]	1	?	E	R	1	U	S	A	N	R	?	P
Polypleurum longicaule[22]	1	?	E	R	2	U	S	A	B	R	?	C
Polypleurum pluricostatum[29]	1	?	E	R	2	U	S	A	N	R	?	C
Polypleurum wongprasertii[22]	1	?	E	R	2	U	S	A	N	R	?	C
Polypleurum insulare[26]	1	?	E	R	2	U	S	A	N	R	?	C
Polypleurum sisaketense[26]	1	?	G/E	R	2	U	S	A	N	R	?	C
Polypleurum phuwuaense[22]	1	?	E	R	2	U	S	A	N	R	?	C
Polypleurum erectum[22]	1	?	E	R	2	U	S	A	N	R	?	C
Polypleurum longifolium[22]	1	?	E	R	2	U	S	A	N	R	?	C
Polypleurum prachinburiense[26]	1	?	E	R	2	U	S	A	N	R	?	C
Willisia selaginoides[7,9]	2	D	E	S‡	2	U	D	A	N	F	?	D
Willisia arekaliana[10]	2	?	GE	S	2[30]	U[30]	D	A	N	F?/R?	?	C?

APPENDIX 4 *Continued*

	1	2	3	4	5	6	7	8	9	10	11	12
Zeylanidium olivaceum[7,9,14]	2	D	E	R	2	U	S	A	N	F	P	D
Zeylanidium maheshwarii[9,14]	2	D	E	R	2	U	S	A	N	F	P	D
Zeylanidium lichenoides[7,9,14,26]	2	D	E	R	2	U	S	A	N	R	A	C
Zeylanidium sp. *A. K. Pradeep 90001 & KI208*	2	?	GE	R	2	U	S	E?	N	R	?	C
Zeylanidium sp. *KI216*	2	?	GE	R	2	U	S	E?	N	R	?	C
Hydrobryopsis sessilis[7,9,27]	2	D	G	S	2	U	S	A	N	R	A?[17]	C

*Character states: 1, stamen (1, single; 2, two); 2, pollen (M, monad; D, dyad); 3, ovary/capsule (G, globose; E, ellipsoidal; GE, globular–ellipsoidal); 4, capsule (R, ribbed; S, smooth); 5, locule (1, one; 2, two); 6, capsule valve (E, equal; U, unequal); 7, bract (S, simple; D, digitate or lobed); 8, leaf (A, adaxi–abaxially dorsiventral; E, ensiform); 9, reproductive-shoot branching (N, non-branched; B, branched); 10, root (R, ribbon-like; F, foliose; C, cup-like); 11, root cap (A, absent; P, present); 12, shoot position (C, only at sinus of root branching; P, on lateral flank along length of root including sinus of root branching; D, dorsal surface in foliose root).

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†Observation on seedling; ‡One middle rib per capsule valve.

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