Mosses of Mt. Kinabalu, Borneo, Malaysia

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Abstract. The moss flora of Mt. Kinabalu, Borneo, Malaysia was investigated in 2005. The mosses recognized comprise 18 families, 43 genera and 97 species except pleurocarpous mosses. Ditrichum heteromallum, Fissidens braunii and Syrrhopodon tjibodensis are new additions to the moss flora of Borneo Island. For each species recognized here, locality, substrate, specimen number and taxonomic note are provided.

Key words: bryophytes, mosses, Mt. Kinabalu, Borneo, Malaysia

This study deals with the moss flora of Mt. Kinabalu, Borneo, Malaysia based on the collections made under a research program, “Biodiversity inventory in the Western Pacific region,” by the National Museum of Nature and Science, Tokyo. The first author has studied the moss flora of the alpine regions in East Asia with special interest of the endemic taxa (Higuchi & Arikawa, 2005, 2006; Higuchi & Lin, 2005, 2007). In 2005 we made a field research and collected bryophytes mainly from Mt. Kinabalu area and Mahua in Crocker Range Park situated southwest of Mt. Kinabalu.

Mt. Kinabalu (6°04’N, 116°33’E) is located in Sabah, and is the highest (Low’s peak, 4,095 m alt.) in Southeast Asia as well as Borneo Island. Many botanists visited Mt. Kinabalu and studied its flora. In bryophytes, many interesting taxa have been reported from Mt. Kinabalu. The first list of the bryophytes in the Kinabalu Park was presented by Frahm et al. (1990). Subsequently several authors have contributed additions to the bryophyte flora of the area (cf. Akiyama et al., 2001). The moss flora of Borneo Island has been compiled by Touw (1978) who enumerated 649 taxa from Borneo Island. Recently Suleiman et al. (2006) revised the catalog of the mosses of Borneo Island and listed 721 taxa from Borneo Island. Tan and Iwatsuki (1999) proposed that Mt. Kinabalu is one of the four hot spots of the moss diversity in Malesia.

The purpose of this study is to investigate the moss flora of Mt. Kinabalu and to compile it based on the specimens collected.

Materials and Methods

Field studies were carried out in September, 2005, and a total of ca. 450 specimens were collected. The main sites investigated are divided as follows (Fig. 1).

I: Mt. Kinabalu, from Timpohon Gate (1860 m alt.) to Laban Rata (3270 m alt.), along trail, September 7, 2005.

II: Mt. Kinabalu, from Laban Rata (3270 m alt.) to Paka Cave (3000 m alt.), along trail, September 8, 2005.
III: Mt. Kinabalu, from Laban Rata (3270 m alt.) to Low’s Peak (4095 m alt.), along trail, September 9, 2005.

IV: Mt. Kinabalu, from Laban Rata (3270 m alt.) to Timpohon Gate (1860 m alt.), along trail, September 10, 2005.

V: Mt. Kinabalu, Headquater, along Silau-silau Taril (1550 m alt.) (Fig. 1: 5) and Bukit Burung Trail (1620 m alt.), September 11, 2005.

VI: Mt. Kinabalu, Headquater, along Liwagu Taril (1500–1700 m alt.), September 12,
2005.

VII: northern part of Crocker Range Park, around the entrance of Mahua Waterfalls (1080 m alt.), September 15, 17, 2005.

VIII: northern part of Crocker Range Park, from entrance to Mahua Waterfalls (1080–1160 m alt.) (Fig. 1: 6), September 16, 2005.

Results and Discussion

The mosses recognized in this study comprise 18 families, 43 genera and 97 species except pleurocarpous mosses. Among them *Ditrichum heteromallum*, *Fissidens braunii* and *Syrrhopodon tjibodensis*, are new additions to the moss flora of Borneo Island, although the area investigated is bryologically well-explored as compared with other areas in Southeast Asia. Touw (1978) and Suleiman et al. (2006) enumerated 447 and 582 taxa from Sabah in Borneo Island respectively. Sabah is evidently the richest district of mosses in Borneo Island. The richness of bryophyte species in Sabah is probably due to the presence of Mt. Kinabalu which has resulted in the development of species confined to this area. For example, *Takakia lepidozioides* was recorded from Borneo by Hattori (1963a, b), which is a hyper-oceanic element and has an interesting disjunctive range from Himalaya to West and North Pacific Arc (Schuster, 1983). The occurrence of *Takakia lepidozioides* may give a hint of the origin of bryophyte flora of Mt. Kinabalu. Because its sporophytes and antheridia have never been found. The presence of many endemic taxa as well as the relict taxa such as *Takakia* suggests that the bryophyte flora of Mt. Kinabalu have an old origin. While the new record of *Ditrichum heteromallum* from Mt. Kinabalu is easier to comprehend, since they have numerous sporophytes with mature spores, which enable it to extend the range.

Enumeration of species

The families, genera and species are arranged alphabetically. The generic position follows Goffinet and Buck (2004). In the following enumeration an asterisk (*) preceding a species indicates “new to Borneo.” Each species is referred by collecting site (I-VIII), substrate and specimen number, and some species taxonomic notes. The specimens cited here are deposited in the herbaria of the Department of Botany, National Museum of Nature and Science (formerly National Science Museum) (TNS), the Institute for Tropical Biology & Conservation, Universiti Malaysia Sabah (UMS), and the Kinabalu National Park.

**Andreaeaceae**


III: on rock-cliff, Higuchi 44908 (+*Grimmia affinis*), 44914, 44922 (+*Grimmia affinis*); on rock, Arikawa 5242, 5245 (+*Grimmia affinis*).

**Bartramiaceae**


III: on soil, Higuchi 44912; on rock-crevice, Higuchi 44915; on soil, Arikawa 5251, 5252 (+*Pohlia flexuosa*), 5254.


IV: on rock-cliff, Higuchi 44980, 44999; on tree-trunk, Arikawa 5323.


IV: on rock, Arikawa 5270.


VII: on soil at trail bank, Arikawa 5429. VIII: on rock-cliff, Higuchi 45226 (+*Bryum apiculatum*), 45305 (+*Weissia controversa*).


VIII: on rock-cliff, Higuchi 45314.

*Philonotis secunda* (Dozy & Molk.) Bosch & Sande Lac., Bryol. Jav. 1: 156 (1861).

IV: on rock-cliff, Higuchi 44940; on soil, Arikawa 5266. VI: on rock-cliff, Arikawa 5420.
Higuchi 45184; on soil at trail bank, Higuchi 45181.

**Bryaceae**


V: on trunk of tree fern, Higuchi 45013.


VIII: on soil at trail bank, Higuchi 45226 (+Philonotis calamicra).


II: on soil, Higuchi 44899; Arikawa 5236. III: on rock-crevice, Higuchi 44903, 44905 (+Oxystegus tenuirostris), 44909, 44910 (+Leptodontium flexifolium); on soil, Arikawa 5239, 5240 (+Oxystegus tenuirostris).


VIII: on soil, Higuchi 45241.


II: on rock, Arikawa 5195. IV: on soil at trail bank, Higuchi 44978.

*Bryum* sp.

VIII: on rock-cliff, Higuchi 45310.

Notes. Plants (Higuchi 45310) have oblong-lanceolate leaves somewhat twisted when dry, reddish basal part of leaves and tomenta of rhizoids on stems. These characteristics indicate the plants to be closely related to *Bryum pseudodotriquetrum*. However, leaf margins are plane and not well-bordered and the habitat is rather lowland, which shows the difference from alpine *Bryum pseudodotriquetrum*.


III: on rock-crevice, Higuchi 44924. IV: on soil, Higuchi 44990; on soil-cliff, Higuchi 44976; on humus, Arikawa 5297; on rock covered with soil, Arikawa 5308.

Notes. Plants growing at the Low’ s peak (Higuchi 44924) are small, and have leaves spirally twisted when dry. They look like *Bryum capillare* in appearance, but they are different from *B. capillare* by the absence of long apicus at the leaf apex.


III: on soil at trail bank, Higuchi 44939.


VIII: on rock, Arikawa 5457; on boulder, Higuchi 45229, Arikawa 5455; on soil, Arikawa 5478, 5483.


VI: on humus, Arikawa 5423.

**Calyptraceae**


V: on rock-cliff, Higuchi 45052.

*Leucophanes octoblepharioioides* Brid., Bryol. Univ. 1: 763 (1827).

VIII: on basal part of tree, Higuchi 45259; on tree-trunk, Arikawa 5446; on decaying log, Higuchi 45212; on rock, Arikawa 5463.


V: on fallen tree-trunk, Higuchi 45026.


VII: on tree-trunk, Higuchi 45215.

*Octoblephalum albidum* Hedw., Spec. Musc. 50 (1801).

VI: on basal part of tree, Higuchi 45161.


V: on root, Higuchi 45068; on decaying log, Higuchi 45043 (+Syrhopodon prolifer).


V: on decaying log, Higuchi 45043 (+Syrhopodon japonicus). VI: on soil at trail bank, Arikawa 5380.

*Syrhkopodon tjibodensis* M.Fleisch., Musci Fl. Buitenzorg 1: 209 (1904). (Fig. 1)

V: on tree-trunk, Higuchi 45059.
Fig. 2. *Syrrhopodon tjibodensis*. 1. Leaf. 2. Median laminal cells. 3. Gemmae arising from near limb base of adaxial leaf surface. 4. Gemma. Scales for 1 in 1 mm, for 2 in 10 μm and for 3 & 4 in 100 μm. (All from Higuchi 45059.)
Notes. *Syrrhopodon tjibodensis* is characterized by its narrowly lingulate-lanceolate leaves (Fig. 2: 1), apex of cancelline tissue ending in an approximately transverse line (Fig. 2: 1), leaf margins bordered by a narrow, pellucid marginal stereome and gemmae arising from the edges of the costa above the cancelline (Fig. 2: 3). This species is widely distributed in tropical Asia and Malesia but generally uncommon (Eddy, 1990). This species grows on tree-trunk in the forest at ca. 1550 m alt. along Bukit Burung Trail.

**Dicranaceae**


IV: on tree-stump, Arikawa 5316. VI: on soil at bank, Higuchi 45176, Arikawa 5418; on rock-cliff, Arikawa 5422.


VI: on tree-trunk, Higuchi 45123; on decorticated log, Arikawa 5394.


IV: on root, Higuchi 44983; on tree-trunk, Arikawa 5285, 5300. V: on decaying log, Higuchi 45047 (+*Dicranoloma reflexum*).


II: on decaying stump, Arikawa 5223. IV: on base of tree-trunk, Higuchi 44970.


II: on boulder, Higuchi 44874.


V: on decaying log, Higuchi 45047.


VIII: on basal part of tree, Higuchi 45262.

*Microdus sumatranus* (Dixon) A.Eddy, A Hand-


VI: on soil at trail bank, Higuchi 45138, Arikawa 5416.

**Diphyisciaceae**


II: on rock-cliff, Arikawa 44876. V: on rock-cliff, Higuchi 45053. VI: on rock-cliff, Higuchi 45137; on boulder, Higuchi 45143. VIII: on boulder, Higuchi 45295.

**Ditrichaceae**


II: on soil-cliff, Higuchi 44901; on rock-crevice, Arikawa 5191; on soil, Arikawa 5196.

*Ditrichum heteromallum* (Hedw.) Britt., N. Am. Fl. 15: 64 (1913). (Fig. 3)

II: on soil, Higuchi 44897; on rock covered with soil, Arikawa 5234.

Notes. *Ditrichum heteromallum* is characterized by leaves gradually tapering to a long subula (Fig. 3: 1), leaf margins plane, elongate rectangular to linear basal cells at sheathing base (Fig. 3: 2), erect capsule (Fig. 3: 3) and lightly papillose peristome teeth (Fig. 3: 4). This species is distributed in Europe, northern, central and eastern Asia, North and South Americas, New Guinea, Australia and New Zealand (Matsui & Iwatsuki, 1990). Eddy (1988) wrote in the note of *Ditrichum difficile*, “The widespread, temperate species, *D. heteromallum* (Hedw.) Britt. has not been recorded from the region but could well occur in mountainous areas.” This species grows on soil at 3000–3150 m alt. between Paka Cave and Laban Rata.

**Fissidentaceae**

*Fissidens braunii* (Müll.Hal.) Dozy & Molk.,

Fig. 3. *Ditrichum heteromallum*. 1. Leaf. 2. Basal laminal cells. 3. Capsule. 4. Peristome. 5. Annulus. 6. Exothecial cells. 7. Spores. Scales for 1 & 3 in 1 mm, for 2, 4 & 5 in 100 µm, for 6 in 50 µm and for 7 in 10 µm. (All from Higuchi 44897.)
Notes. *Fissidens braunii* is characterized by its epiphytic habitat, elimate leaves with percurrent costa (Fig. 4: 2) and rounded base to the dorsal lamina (Fig. 4: 3). This species is widespread in Malesia from New Guinea to Sumatra and the Malay Peninsula and Polynesia (Eddy, 1988). This species grows on the trunk of tree fern at ca. 2600 m alt. between Layang Layang and Timpo-hon Gate.


*Fissidens hyalinus* Hook.f. & Wilson, J. Bot. 3: 89 (1840).

*Fissidens javanicus* Dozy & Molk., Bryol. Jav. 1: 1 (1854). (Fig. 4)

IV: on trunk of tree fern, Arikawa 5321.

V: on rock-cliff, Arikawa 5358. VI: on boulder, Higuchi 45097.

VII: on boulder, Higuchi 45202.


VIII: on soil-clip, Higuchi 45290.


V: on rock-cliff, Arikawa 5358. VI: on boulder, Higuchi 45097.

*Fissidens hyalinus* Hook.f. & Wilson, J. Bot. 3: 89 (1840).

VIII: on soil-cliff, Higuchi 45286 (+ *Fissidens kinabaluensis*).


Fig. 4. *Fissidens braunii*. 1. Plant. 2. Apical parts of leaves. 3. Basal parts of leaves. Scales for 1 in 1 mm and for 2 & 3 in 100 μm. (All from Arikawa 5321.)


Fissidens pellucidus Hornsch., Linnaea 15: 146 (1841).


Funariaceae


Grimmiaceae


V: on humus, Higuchi 45010; on decaying log, Higuchi 45051. VI: on soil, Higuchi 45107.

VIII: on decaying log, Higuchi 45297.

V: on humus, Higuchi 45011; on soil at trail bank, Higuchi 45031

Leucobryum juniperoides (Brid.) Müll. Hal., Linnaea 18: 689 (1845).
VII: on rotten log, Arikawa 5498.

V: on soil, Arikawa 5343.

Mniaceae

V: on soil, Higuchi 45036.

VI: on root, Higuchi 45151. VII: on soil at trail bank, Arikawa 5430; on buttress root, Higuchi 45205.

Pohlia elongata Hedw., Spec. Musc. 171 (1801).
II: on soil, Higuchi 44894, Arikawa 5231.

Pohlia flexuosa Hook., Icon. Pl. Par. 1: 19 (1836).
II: on soil at trail bank, Arikawa 5198. III: on rock-crevice covered with soil, Higuchi 44917, Arikawa 5252 (+*Bartramia aurescens*), 5253; on soil at trail bank, Higuchi 44933.

Orthotrichaceae

VII: on branch, Higuchi 45223.

VI: on fallen bark, Higuchi 45110.


VI: on fallen tree-trunk, Higuchi 45191.

II: on tree-trunk, Higuchi 44868, Arikawa 5232. IV: on tree-trunk, Arikawa 5265. VI: on fallen branch, Higuchi 45127.

II: on tree-trunk, Higuchi 44891.

VI: on fallen branch, Higuchi 45174.

II: on tree-trunk, Higuchi 44886, 44887.


Syn. Leptodontiopsis orientalis Dixon

III: on tree-trunk, Higuchi 44931. IV: on tree-trunk, Higuchi 44942; on branch, Arikawa 5276 (+*Zygodon reinwardtii*).

II: on tree-trunk, Higuchi 44900; on branch, Arikawa 5193, 5238, 5276 (+*Zygodon orientalis*).

Polytrichaceae

I: on soil at bank, Higuchi 44867. IV: on soil-cliff, Higuchi 44985; on soil, Arikawa 5306.

V: on soil, Higuchi 45069.

VI: on soil at trail bank, Higuchi 45156.

IV: on soil, Higuchi 44989, Arikawa 5307, 5315. V: on soil at trail bank, Higuchi 45021, Arikawa 5355.
II: on rock-cliff, Higuchi 44879.

III: on rock-crevice, Higuchi 44925. IV: on soil, Arikawa 5304. VI: on rock-cliff, Higuchi 45157; on soil at trail bank, Higuchi 45182.

VI: on soil at trail bank, Higuchi 45136, Arikawa 5400.

**Pogonatum urnigerum** (Hedw.) P. Beauv., Prodr. 84 (1805).
II: on rock, Arikawa 5210; on soil, Higuchi 44895, Arikawa 5237. III: on soil, Higuchi 44932, Arikawa 5260.

**Pottiaceae**

**Anoectangium aestivum** (Hedw.) Mitt., J. Linn. Soc. Bot. 12: 175 (1869).
II: on soil-cliff, Arikawa 5197. III: rock, Arikawa 5264.

V: on concrete, Higuchi 45077. VIII: on brick, Higuchi 44981.

III: on rock-crevice, Higuchi 44904, Arikawa 5247; on soil, Arikawa 5243. IV: on rock, Higuchi 44967.

II: on boulder, Higuchi 44898; on decaying stump, Higuchi 44885. III: on rock-crevice covered with soil, Higuchi 44905 (+ *Bryum argenteum*), 44906, Arikawa 5241. IV: on boulder, Higuchi 44965. VIII: on rock-cliff, Higuchi 45243.

VI: on concrete, Higuchi 45124; on basal part of tree, Higuchi 45093.

**Weissia controversa** Hedw., Spec. Musc. 67 (1801).
VIII: on soil at trail bank, Higuchi 45305 (+ *Philonitis calomica*).

**Racocarpaceae**

III: on rock, Higuchi 44928, 44930.

**Sphagnum sericeum** Müll. Hal., Bot. Zeit. 5: 481, 484 (1847).
IV: on stump and root, Arikawa 5317.

II: on rock-cliff, Higuchi 44869.

Notes. Hattori (1963a, b) firstly reported *Takakia lepidozioides* from Borneo Island based on the collections from Mt. Kinabalu, from a gorge near Paka Cave and above the cave between ca. 3000 m alt. and 3200 m alt. Subsequently Akiyama (1999) in his genetic study of *Takakia lepidozioides* described the habitat of the species at Mt. Kinabalu as “Beside a stream in tropical montane *Quercus* forest, ca. 3000 m alt. Partially shaded, or at rather sunny site.” We observed the species growing on the basal part of the rock-cliff at basin of a small waterfall near Paka Cave (Fig. 1: 3). It grows sporadically in small populations. Higuchi and Lin (2005) pointed out in the first record of *Takakia lepidozioides* in Taiwan that the size and growth form of plants were different between sheltered places and exposed ones. *Takakia lepidozioides* observed in
this study are larger plants and loose mats as compared to the population of sheltered places.

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References