
Research Article

The mosses of Kangkawat Research Station, Imbak Canyon Conservation Area, Sabah, Malaysia

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Abstract

A total of 65 species, two subspecies and one variety of mosses in 32 genera and 17 families from 102 individuals were collected during the Borneo Geographic Expedition at Kangkawat Research Station from 29th September to 3rd October 2018. This number represents ca. 10% of the taxa of mosses reported for Sabah and ca. 9% of the taxa reported for Borneo. The largest moss family recorded in this area was Calymperaceae with 18 species and one subspecies which is ca. 28% of the total taxa collected, followed by Sematophyllaceae with eight species (ca. 12%). Out of the 68 taxa of mosses from the study area, ten are new to Imbak Canyon Conservation Area including one new to Sabah, which is *Chaetomitrium weberi* Broth. By and large, the moss species richness of Kangkawat Research Station is typical of the conservation area.

Keywords: Borneo Geographic Expedition, ICCA, new records.

Introduction

Imbak Canyon Conservation Area (ICCA) is a Class 1 (Protection) Forest Reserve with a total area of 30,000 ha. It is one of the five conservation areas that are managed by Yayasan Sabah Group, in addition to Danum Valley, Maliau Basin, Silam Coast and Taliwas River. This area comprises of habitat ranging from lowland dipterocarp forests to lower montane heath forests.

The mosses of ICCA have been explored since 2000 when the area was still largely inaccessible (Suleiman & Gisil, 2015). A milestone in bryological exploration in ICCA was in 2010 during a scientific expedition to Mount Kuli Research Station organized by the Academy Sciences of Malaysia. During the expedition, Suleiman et al. (2011a) reported 119 taxa of mosses with one new record to Borneo and two to Sabah.

The richness of mosses of ICCA led to a floristic study of this conservation area by Chua & Suleiman (2015) from 2011 to 2012. They added 62 new records to ICCA with three new records to Sabah and five to Borneo. Thus, the total number of mosses in ICCA is 191 taxa in 68 genera and 19 families.

A scientific expedition organized by the Institute of Tropical Biology and Conservation, Universiti Malaysia Sabah was held from 28th September to 9th October 2018 in Kangkawat Research Station, ICCA. The expedition site covered both primary and secondary forests ranging from elevation 250 m to 500 m a.s.l. This area was only recently accessible, and it was not covered by Chua & Suleiman (2015). Thus, the objective of this study is to carry out an inventory of mosses from Kangkawat Research Station and adjacent areas to fill in the gaps of knowledge of the moss richness in ICCA.

Methodology

Mosses were collected along the Kawang, South Rim, Nepenthes and Palajau trails (Table 1). Common substrates of mosses were surveyed extensively, such as on rotten logs, tree roots, tree trunks, lianas, branches, soils, termite mounts, rocks and boulders. Special attention was given to substrates near rivers and streams, as this habitat is very conducive for the growth of mosses. The collected specimens were curated, identified and deposited at the BORNEENSIS Herbarium (BORH) of Universiti Malaysia Sabah with duplicates in Sandakan Herbarium (SAN) of Sabah Forestry Department.

Table 1. Collection details of mosses collected from Kangkawat Research Station

Collection No.	Collection detail
MS 6458–6510	Kawang Trail; primary forest, N 5°04'41.3", E117°03'17.2", 29 September 2018.
MS 6511–6544	South Rim Trail; primary forest, N 5°04'41.3", E117°03'17.2" to N 5°03'41.8", E117°01'53.2", 30 September 2018.
MS 6545–6558	Nepenthes Trail; primary forest, N 5°04'39.4", E117°07'57", 1 October 2018.
MS 6559–6560	Palajau Trail; secondary forest, N 05°04'48", E117°03'18" to N 05°05'60.5", E117°03'41.7", 2 October 2018.

Note: MS - M. Suleiman

Results and Discussion

A total of 102 specimens of mosses were collected during the Borneo Geographic Expedition at Kangkawat Research Station, ICCA (Appendix 1). It comprises of 65 species, two subspecies and one variety of mosses in 32 genera and 17 families (Table 2). This number represents ca. 10% of the total 651 taxa of mosses reported for Sabah and ca. 9% of the 771 taxa reported for Borneo (Akiyama, 2012; Akiyama & Suleiman, 2015; Andi & Suleiman, 2005; Andi et al., 2015; Chua & Suleiman, 2015; Ellis, 2016; Ellis et al., 2010, 2016a, 2016b, 2018, 2019; Higuchi et al., 2008; Ho et al., 2010; Mohamed et al. 2010; Suleiman & Akiyama, 2007; Suleiman & Andi, 2019; Suleiman & Jotan, 2015; Suleiman et al., 2006, 2009, 2011a, 2011b, 2017a, 2017b). Calymperaceae is the dominant family from this area with 19 taxa, followed by Sematophyllaceae with eight taxa. These families are common in the lowland areas of Borneo.

Table 2. Summary of the mosses collected from Kangkawat Research Station.

No.	Families	Genera	Species
1	Calymperaceae	6	18 + 1 subsp.
2	Fissidentaceae	1	5
3	Garovagliaceae	1	2
4	Hypnaceae	3	5
5	Hypnodendraceae	1	1 + 1 subsp.
6	Hypopterygiaceae	1	1
7	Leucobryaceae	2	4 + 1 var.
8	Meteoriaceae	1	1
9	Neckearaceae	2	2
10	Orthotrichaceae	1	2
11	Pilotrichaceae	1	1
12	Polytrichaceae	1	2
13	Pylaisiadelphaceae	3	4
14	Rhizogoniaceae	1	1
15	Sematophyllaceae	4	8
16	Symphodontaceae	2	7
17	Thuidiaceae	1	1
	Total	32	65 + 1 var. + 2 subsp.

Among the 102 specimens of mosses collected during the expedition, one species, *Chaetomitrium weberi*, has contributed to the richness of mosses of Sabah. This species was previously known as a Philippine endemic but later reported for Borneo by Tan et al. (1997) based on a specimen from Kalimantan Tengah Province of Indonesia. In addition, ten species are reported for the first time from this conservation area (Table 3). Thus, the current number of mosses for ICCA is 201 taxa in 68 genera and 27 families (Chua & Suleiman, 2015). This

represent ca. 26% of the taxa reported for Borneo and ca.31% of the taxa reported for Sabah.

Several other mosses found from Kangkawat Research Station are rarely reported from Borneo. For example, *Macromitrium falcatulum*, which was found on fallen branch, is the third record for Borneo after it was reported by Brotherus (1912) and Dixon (1916) more than a century ago. Similarly, *Fissidens autocius* was only reported twice in Borneo, based on its type specimen from Sandakan (Dixon, 1916) and a recent collection from Pulau Gaya (Suleiman & Rimi, 2016). While, *Chaetomitrium lancifolium* which was previously reported as new to Borneo from Crocker Range Park (Suleiman et al., 2017b), was also found from this area. This species has a finely acuminate leaf apices and twisted tip, with filamentous gemmae found at its leaf axil. It can be confused with small *Acroporium* in the field, such as *Acroporium diminutum*, from its lax leaves.

Table 3. List of mosses reported as new to Imbak Canyon Conservation Area.

No.	Families	Species
1.	Calymperaceae	<i>Calymperes strictifolium</i> (Mitt.) G. Roth
2.	Calymperaceae	<i>Mitthyridium flavum</i> (Müll. Hal.) H. Rob.
3.	Calymperaceae	<i>Mitthyridium jungquilianum</i> (Mitt.) H. Rob.
4.	Calymperaceae	<i>Syrrhopodon albidus</i> Thwaites & Mitt.
5.	Fissidentaceae	<i>Fissidens autocius</i> Thér. & Dixon
6.	Hypnaceae	<i>Ectropothecium zollingeri</i> (Müll. Hal.) A. Jaeger
7.	Hypnodendraceae	<i>Hypnodendron subspininervium</i> subsp. <i>subspininervium</i> (Müll. Hal.) A. Jaeger
8.	Orthotrichaceae	<i>Macromitrium falcatulum</i> Müll. Hal.
9.	Symphyodontaceae	<i>Chaetomitrium lancifolium</i> Mitt.
10.	Symphyodontaceae	<i>Chaetomitrium weberi</i> Broth.

The endemic mosses of Borneo are relatively low. However, two Bornean endemics were found from the study area. The first one is *Chaetomitrium maryatii* which was described from Maliau Basin Conservation Area in 2001 (Akiyama & Suleiman, 2001). The second endemic species is *Pogonatum iwatsukii* which was found growing on rocks near the river along the Nepenthes Trail. The latter is fairly common throughout the lowland forests in Sabah.

It is worth to note that, *Fissidens laxitextus* which was previously reported as new to Borneo (Chua & Suleiman, 2015), was collected in the study area. This shows the diminutive moss is common in ICCA. Previously, this species was only found growing on termite mounds (Chua & Suleiman, 2015; Suleiman & Rimi, 2016). However, it was also found growing on thin layer of soil on tree trunks in Kangkawat Research Station.

Conclusion

Overall, ICCA has a relatively rich moss flora in terms of number of taxa, compared to other large conservation areas in Sabah such as Maliau Basin Conservation Area. More explorations, especially to less accessible areas, will definitely increase the number of mosses from this conservation area.

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Appendix 1. Checklist of mosses of Kangkawat Research Station

Species marked with an asterisk (*) are new to Imbak Canyon Conservation Area and double asterisk (**) are new to Sabah. The arrangement of families follows that of Buck & Goffinet (2010). MS denotes for M. Suleiman.

CALYMPERACEAE

Arthrocormus schimperi (Dozy & Molk.) Dozy & Molk.

On tree trunk, 300 m, MS 6471.

Calymperes fasciculatum Dozy & Molk.

On tree trunk by river, 250 m, MS 6556.

Calymperes porrectum Mitt.

On tree trunk by stream, 500 m, MS 6535.

**Calymperes strictifolium* (Mitt.) G. Roth

On tree trunk by river, 300 m, MS 6459.

Calymperes taitense (Sull.) Mitt.

On treelet and tree trunk, 300 m, MS 6463, 6468.

Exostratum blumei (Nees ex Hampe) L.T. Ellis.

On tree root and bases by river and waterfall, 300–450 m, MS 6461, 6527.

Leucophanes angustifolium Renauld & Cardot

On tree buttress by river, 300 m, MS 6460.

Leucophanes octoblepharioides Brid.

On tree trunk, 300 m, MS 6470.

Mitthyridium fasciculatum (Hook. & Grev.) H. Rob. subsp. *fasciculatum*

On rotten root, 400 m, MS 6537.

Mitthyridium fasciculatum subsp. *cardotii* (M.Fleisch.) B.C. Tan & L.T. Ellis

On fallen branch, 250 m, MS 6555.

**Mitthyridium flavum* (Müll. Hal.) H. Rob.

On fallen branch, 300 m, MS 6475.

**Mitthyridium jungquilianum* (Mitt.) H. Rob.

On rotten log, 300 m, MS 6544.

Mitthyridium undulatum (Dozy & Molk.) H. Rob.

On treelet trunk and shrub branches, 300 m, MS 6469, 6485, 6486, 6501.

Mitthyridium wallisii (Müll.Hal.) H. Rob.

On fallen bark and branches 250–300 m, MS 6512, 6547, 6557.

**Syrrhopodon albidus* Thwaites & Mitt.

On soil in open area, 450 m, MS 6523.

Syrrhopodon albo-vaginatus Schwägr.

Growing on soil and rotten logs in open and partial shade by river, 300–450 m, MS 6490, 6493, 6525.

Syrrhopodon confertus Sande Lac.

On rotten log and tree buttress, 300–500 m, MS 6491, 6536.

Syrrhopodon loreus (Sande Lac.) W. D. Reese

On tree trunk, 300 m, MS 6481.

Syrrhopodon muelleri (Dozy & Molk.) Sande Lac.

On tree trunk, 300 m, MS 6476.

FISSIDENTACEAE

**Fissidens autocious* Thér. & Dixon

On rock by streambed, 300 m, MS6497.

Fissidens crispulus Brid.

On rocks and tree trunk by streambed and waterfall, 300–450 m, MS 6480, 6498, 6515, 6522.

Fissidens hollianus Dozy & Molk.

On shrub trunk and tree buttress, 250–300 m, MS 6472, 6554.

Fissidens laxitextus Broth. ex Gangulee

On termite mounts and tree trunk, 300–450 m, MS 6502, 6506, 6533.

Fissidens pellucidus Hornsch.

Growing on wet rock by waterfall, 450 m, MS 6519.

GAROVAGLIACEAE

Garovaglia compressa Mitt.

On treelet trunk and liana by stream, 300 m, MS 6489, 6499.

Garovaglia elegans (Dozy & Molk.) Hampe ex Bosch & Sande Lac.

On treelet branch, 300 m, MS 6551.

HYPNACEAE

Ectropotheciella distichophylla (Hampe ex Dozy & Molk.) M. Fleisch.

On tree trunk, 300 m, MS 6464.

Ectropothecium eleganti-pinnatum (Müll.Hal.) A. Jaeger

On twigs, 300 m, MS 6508.

Ectropothecium striatulum Dixon ex E.B. Bartram

Growing in open area, on wet rotten log by waterfall, 450 m, MS 6517.

Recorded as new to Borneo from ICCA (Ellis et al., 2015).

**Ectropothecium zollingeri* (Müll.Hal.) A. Jaeger

Growing in open area, on wet rock by waterfall, 450 m, MS 6516.

Vesicularia miquelii (Sande Lac.) M. Fleisch.

On rotten logs, 300 m, MS 6474, 6494.

HYPNODENDRACEAE

Hypnodendron subspininervium subsp. *arborescens* (Mitt.) A.Touw

On tree trunk, 300 m, MS 6507.

**Hypnodendron subspininervium* subsp. *subspininervium* (Müll. Hal.) A. Jaeger

On tree trunk by waterfall, 450 m, MS 6529.

HYOPTERYGIACEAE

Hypopterygium vriesei Bosch & Sande Lac.

On liana, 300 m, MS 6462.

LEUCOBRYACEAE

Cladopodanthus heterophyllus (M. Fleisch.) E.B. Bartram

On fallen branches, 250–400 m, MS 6539, 6553.

Leucobryum aduncum var. *aduncum* Dozy & Molk.

On rotten log and termite mount on the ridge, 300–500 m, MS 6492, 6513, 6526b, 6560.

Leucobryum aduncum var. *scalare* (Müll. Hal. ex M. Fleisch.) A. Eddy

On rotten log, 500 m, MS 6514.

Leucobryum chlorophyllosum Müll. Hal.

Growing in open area on tree root by waterfall, 450 m, MS 6526a.

Leucobryum sanctum (Nees ex Schwägr.) Hampe

Growing on wet rotten log and rock in open area by waterfall, 3000–450 m, MS 6482, 6520.

METEORACEAE

Aerobryopsis wallichii (Brid.) M. Fleisch.

On shrub branches and tree trunk by waterfall, 300–450 m, MS 6500, 6530, 6540.

NECKERACEAE

Himantocladium cyclophyllum Enroth

On tree buttress by river, 300 m, MS 6458.

Pinnatella mucronata (Bosch & Sande Lac.) M. Fleisch.

On tree trunk and boulder by waterfall, 300–450 m, MS 6465, 6521.

ORTHOTRICHACEAE

**Macromitrium falcatulum* Müll. Hal.

On fallen bark on ridge, 450 m, MS 6538a.

Macromitrium fuscescens Schwägr.

On fallen bark on ridge, 450 m, MS 6538b.

PILOTRICHACEAE

Callicostella papillata (Mont.) Mitt. var. *papillata*

On liana, 300 m, MS 6473.

POLYTRICHACEAE

Pogonatum iwatsukii A. Touw

On rock by river, 250 m, MS 6552.

Pogonatum piliferum (Dozy & Molke.) A. Touw

On rock by waterfall, 450 m, MS 6528.

PYLAIADIACEAE

Mastopoma pulchellum (Herzog) H. Akiy.

On tree trunk, 300 m, MS 6509.

Taxithelium instratum (Brid.) Broth.

On rotten logs by stream, 300 m, MS 6477, 6545.

Taxithelium kerianum (Broth.) Broth.

On treelet branch, 300 m, MS 6548.

Trismegistia lancifolia var. *lancifolia* (Harv.) Broth.

On boulder, rotten log and root by waterfall, 300–450 m, MS 6483, 6524, 6532.

RHIZOGONIACEAE

Pyrrhobryum latifolium (Bosch & Sande Lac.) Mitt.

On rotten log and tree trunk, 300–450 m, MS 6484, 6534.

SEMATOPHYLLACEAE

Acanthorrhynchium papillatum (Harv.) M. Fleisch.

On liana and rotten log, 300 m, MS 6505, 6549.

Acroporium adpersum (Hampe) Broth.

On treelet branch, 300 m, MS 6487.

Acroporium convolutum var. *convolutum* (Sande Lac.) M. Fleisch.

On rotten logs, 300 m, MS 6495, 6496.

Papillidiopsis aquatica (Dixon) B.C. Ho & B.C. Tan
 Growing on rock in open area by waterfall, 450 m, MS 6518.
Papillidiopsis bruchii (Dozy & Molk.) W.R. Buck & B.C. Tan
 On shrub branch, 300 m, MS 6546.

Papillidiopsis complanata (Dixon) W.R. Buck & B.C. Tan
 On liana, 300 m, MS 6504.
 This species was reported as new to Borneo from ICCA (Chua & Suleiman, 2015).

Trichosteleum boschii (Dozy & Molk.) A. Jaeger
 On tree trunk, 300 m, MS 6510.

Trichosteleum saproxylophilum (Müll.Hal.) B.C. Tan, W.B. Schofield & H.P. Ramsay
 On rattan node, 300 m, MS 6541.

SYMPHYDONTACEAE

**Chaetomitrium lancifolium* Mitt.
 On fallen branch, 300 m, MS 6478

Chaetomitrium maryatii H. Akiy. & Suleiman
 On treelet trunk, 300 m, MS 6550.

Chaetomitrium orthorrhynchum (Dozy & Molk.) Bosch & Sande Lac.
 On treelet branch, 300 m, MS 6479.

Chaetomitrium cf. *orthorrhynchum* (Dozy & Molk.) Bosch & Sande Lac.
 On treelet branch, 300 m, MS 6488.

Chaetomitrium setosum Broth. ex Dixon
 On shrub branches, 300 m, MS 6503, 6542.

***Chaetomitrium weberi* Broth.
 On treelet trunk, 450 m, MS 6531.

Dimorphocladon bornense Dixon
 On liana, 300 m, MS 6543.

THUIDIACEAE

Pelekium velatum Mitt.
 On rotten log and liana, 300 m, MS 6466, 6467.