

A Contribution to the Knowledge of Moss Flora of Koh-Kong and Mondulkiri Provinces, Cambodia

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Abstract The moss flora of Koh-Kong and MondulKiri provinces, Cambodia, was investigated in 2011. The mosses recognized comprise 20 families, 30 genera and 52 species. Among them 24 species are reported as new to the moss flora of Cambodia. For each species recognized here, locality, substrate, specimen number are provided and taxonomic notes are given for some species.

Key words: bryophytes, Cambodia, Koh-Kong Province, MondulKiri Province, mosses.

This study deals with the moss flora of Cambodia (Kampuchea) based on a field trip made by Bakalin in 2011. He made field researches and collected bryophytes mainly from Koh-Kong and Mondulkiri provinces, Cambodia. The main purpose of Bakalin's trip to Cambodia was the collecting of liverworts, whereas mosses were collected only occasionally and, therefore, the present list does not pretend to be exhaustive in any sense. However, taking into account the poorness of data available on Cambodian mosses we think the publication of the list of specimen identifications would be a small contribution to the knowledge of moss taxonomic diversity in this still poorly investigated country.

The field studies took 10 days from the 17th to the 26th of December 2011, in two provinces, both of which belong to the tropical zone. Koh-Kong Province is located in the southwestern flank of the Cambodia and bordered by the Siam Bay of the South China Sea. The mean annual

temperature is 27.1°C with the annual amount of precipitation over 4,000 mm per year with summer maximum (where from April to October almost 3,800 mm are fallen). Mondulkiri Province is located in the northeastern part of the country and borders with southern Vietnam in the East. The mean annual temperature of Senmonorom city (the capital of the province) is 22.9°C and annual precipitation is 2,200 mm, with a distinct summer maximum, when from April to October over 2,000 mm are fallen (<https://en.climate-data.org> for Sen Monorom and Koh-Kong). In the both provinces the annual temperature variations are very low: within 1°C in Koh-Kong Province and 2°C in Mondulkiri Province. Therefore the seasonal variation is evident in moisture conditions but not in temperature regime, this feature shows the tropical character of the climate of the studied areas. The basic habitats for the mosses that were gathered were decaying or living tree trunks and moist cliffs near waterfalls (Figs. 1–3), other habitats were rare.



Figs. 1–3. 1. Tropical forest with dense bamboo thickets in stream valley in Mondulkiri Province (S. S. Choi, 2011). 2. Small waterfall—a habitat for peculiar bryophytes in Koh Kong Province (S. S. Choi, 2011). 3. Small stream valley in Koh Kong Province (S. S. Choi, 2011).

The mosses of Cambodia have been reported by Tixier (1966, 1967, 1975, 1979, 1980). Tan and Iwatsuki (1993) compiled a checklist of Indochinese mosses, and listed 73 genera and 152 species from Cambodia. Later Higuchi (2009) added nine species to the moss flora of Cambodia. The purpose of this study is to investigate the moss flora of Koh-Kong and Mondulhiri provinces and compile it based on the specimens collected.

Materials and Methods

Field studies were carried out in December 2011 and a total of 78 moss specimens were collected. The sites investigated are divided as follows. The collections are preserved in the herbarium of the Botanical Garden-Institute (VBGI) and the duplicates in the herbarium of National Museum of Nature and Science (TNS).

Main collecting sites are as follows.

- A. Mondulhiri Province, broad-leaved evergreen forest, 285 m alt., 12°11'04"N, 106°59'28"E, December 17, 2011.
- B. Mondulhiri Province, broad-leaved evergreen forest on slope, 880 m alt., 12°22'19"N, 107°18'33"E, December 18, 2011.
- C. Mondulhiri Province, broad-leaved evergreen forest on slope, 860 m alt., 12°21'22"N, 107°18'54"E, December 18, 2011.
- D. Mondulhiri Province, broad-leaved evergreen forest near waterfall, 800 m alt., 12°24'35"N, 107°18'46"E, December 18, 2011.
- E. Mondulhiri Province, broad-leaved evergreen forest on slope, 900 m alt., 12°32'40"N, 107°30'31"E, December 19, 2011.
- F. Mondulhiri Province, broad-leaved evergreen forest near waterfall, 530 m alt., 12°26'31"N, 107°09'37"E, December 20, 2011.
- G. Koh-Kong Province, broad-leaved evergreen forest on slope, 700 m alt., 11°48'19"N, 103°30'39"E, December 22, 2011.
- H. Koh-Kong Province, agricultural land near village, 430 m alt., 11°41'06"N, 103°26'23"E, December 23, 2011.
- I. Koh-Kong Province, broad-leaved evergreen forest on slope to waterfall, 360 m alt., 11°39'43"N, 103°23'55"E, December 23, 2011.
- J. Koh-Kong Province, broad-leaved evergreen forest on slope, 400 m alt., 11°41'15"N, 103°25'38"E, December 23, 2011.
- K. Koh-Kong Province, broad-leaved evergreen forest on slope, 200 m alt., 11°37'33"N, 103°16'07"E, December 24, 2011.
- L. Koh-Kong Province, broad-leaved evergreen forest on slope, 200 m alt., 11°35'15"N, 103°11'29"E, December 24, 2011.
- M. Koh-Kong Province, wet broad-leaved evergreen forest at the edge of grass land, 380 m alt., 11°35'49"N, 103°13'32"E, December 24, 2011.
- N. Koh-Kong Province, broad-leaved evergreen forest on slope, 700 m alt., 11°48'56"N, 103°28'34"E, December 25, 2011.
- O. Koh-Kong Province, area near waterfall in evergreen forest, 43 m alt., 11°35'11"N, 103°05'47"E, December 26, 2011.

Results and Discussion

The mosses recognized in this study comprise 20 families, 30 genera and 52 species. Twenty four species are new additions to the moss flora of Cambodia. Among them ten taxa, *Fissidens albolimbatus*, *F. autoicus*, *F. axilliflorus*, *F. crispulus* var. *crispulus*, *F. crispulus* var. *robinsonii*, *F. firmus*, *F. kalimpongensis*, *F. kamiyamae*, *F. pellucidus* and *F. pseudoceylonensis*, are new to Indochina including Cambodia, Laos, Myanmar, Thailand and Vietnam.

Enumeration of Species

The families, genera and species are arranged alphabetically. The generic position follows Goffinet *et al.* (2009). In the following enumeration an asterisk (*) preceding a species indicates "new to Cambodia." Each species is referred by collecting site (A–O), substrate and specimen num-

ber of Bakalin, and some species taxonomic notes.

Bartramiaceae (by Higuchi)

***Philonotis roylei** (Hook. f.) Mitt.

Specimen examined. D, on wet cliff, splashed with water near waterfall (#78-11-11).

Note. This species is reported from Myanmar (Tanaka *et al.*, 2003) and Thailand (cf. Tan and Iwatsuki, 1993) in Indochina.

Calymperaceae (by Higuchi)

Calymperes semiliber Mitt.

Specimen examined. I, on decaying wood (#83-4-11).

Leucophanes octoblepharoides Brid.

Specimen examined. G, on tree trunk (#81-23-11).

Octoblepharum albidum Hedw.

Specimen examined. B, on tree trunk (#76-40-11).

Syrrhopodon confertus Sande Lac.

Specimen examined. K, on decaying wood (#85-16-11).

Syrrhopodon muelleri (Dozy & Molk.) Sande Lac.

Specimen examined. K, on tree trunk (#85-7-11).

Syrrhopodon trachyphyllus Mont.

Specimen examined. G, on tree trunk (#81-25-11).

Dicranaceae (by Higuchi)

***Campylopus comosus** (Reinw. & Hornsch.) Bosch & Lac.

Specimens examined. J, on forest floor (#84-1-11); M, on forest floor (#87-6-11).

Note. This species is reported from Thailand and Vietnam in Indochina (cf. Tan and Iwatsuki, 1993).

Leucoloma molle (Müll.Hal.) Mitt.

Specimens examined. G, on tree trunk (#81-3-11, #81-54-11).

Fissidentaceae (by Suzuki)

***Fissidens albolimbatus** Dixon

Specimen examined. F, on more or less wet fine-grained ground (Cam-80-24-11).

Note. This species is new to Indochina.

***F. autoicus** Thér. & Dixon

Specimen examined. G, on stone in forest (Cam-81-100-11).

Note. This species is new to Indochina.

***F. axilliflorus** Thwaites & Mitt.

Specimens examined. D, on wet stone near waterfall in the spray zone (Cam-78-32-11); on wet cliff, splashed with water near waterfall (Cam-78-15-11).

Note. This species is new to Indochina.

F. ceylonensis Dozy & Molk.

Specimen examined. B, on bare soil on slope in grass land near forest (Cam-76-6-11).

***F. crispulus** Brid. var. **crispulus**

Specimens examined. D, on wet cliff, splashed with water near waterfall (Cam-78-10-11); O, on crevice behind waterfall (Cam-89-3-11).

Note. This species is new to Indochina.

***F. crispulus** Brid. var. **robinsonii** (Broth.) Z. Iwats. & Z.H.Li

Specimen examined. I, on wet cliff near waterfall (Cam-83-35-11).

Note. This species is new to Indochina.

***F. firmus** Mitt.

Specimen examined. N, on stone in streambed (Cam-88-2-11).

Note. This species is new to Indochina.

***F. geminiflorus** Dozy & Molk.

Specimen examined. F, on wet cave in the cliff behind waterfall (Cam-80-49-11).

Note. This species is reported from Vietnam in Indochina (cf. Tan and Iwatsuki, 1993).

F. hollianus Dozy & Molk.

Specimen examined. F, on roadside in part shade (Cam-80-4-11).

***F. javanicus** Dozy & Molk.

Specimens examined. G, on stone in forest (Cam-81-86-11, Cam-81-98-11).

Note. This species is reported from Myanmar, Thailand and Vietnam in Indochina (cf. Tan and

Iwatsuki, 1993).

***F. kalimpongensis** Gangulee

Specimen examined. F, on more or less wet fine-grained ground in steep slope to watercourse (Cam-80-6-11).

Note. This species is new to Indochina.

***F. kamiyamae** Tad.Suzuki & Z.Iwats.

Specimen examined. A, on bark of tree (Cam-75-8-11).

Note. This species is new to Indochina.

F. nobilis Griff.

Specimens examined. F, on wet cave in the cliff behind waterfall (Cam-80-46-11, Cam-80-48-11).

***F. pellucidus** Hornsch.

Specimen examined. L, on stone side (Cam-86-6-11).

Note. This species is new to Indochina.

***F. pseudoceylonensis** B.C.Tan & M.S.Choy

Specimen examined. C, on soil in open place (Cam-77-4-11).

Note. This species is new to Indochina.

***F. virens** Thwaites & Mitt.

Specimen examined. B, on bare soil in grass land near forest (Cam-76-5-11).

Note. This species is reported from Thailand in Indochina (cf. Tan and Iwatsuki, 1993).

Hypnaceae (by Higuchi)

Pseudotaxiphyllum pohliaecarpum (Sull. & Lesq.) Z.Iwats.

Specimen examined. G, on fine-grained soil on slope (#81-119-11).

Hypopterygiaceae (by Higuchi)

Lopidium struthiopteris (Brid.) M.Fleisch.

Specimen examined. E, on tree base (#79-30-11).

Leucobryaceae (by Higuchi)

Leucobryum aduncum Dozy & Molk. var. **scalare** (M.Fleisch.) A.Eddy

Specimens examined. B, on forest floor (#76-

7-11); E, on decaying wood (#79-8-11), on stone in part to full shade (#79-47-11); I, on more or less dry cliff near waterfall (#83-66-11); K, on decaying wood (#85-19-11).

Leucobryum javense (Brid.) Mitt.

Specimen examined. G, on decaying wood (#81-130-11).

Leucobryum sanctum (Brid.) Hampe

Specimen examined. I, on more or less dry cliff near waterfall (#83-77-11).

Note. Cambodia is not listed in this species by Tan and Iwatsuki (1993), but Yamaguchi (1993) reported the species from Cambodia.

Meteoriaceae (by Higuchi)

***Trachycladiella sparsa** (Mitt.) M.Menzel

Specimen examined. E, hanging down from shrub branch (#79-6-11).

Note. This species is reported from Myanmar and Thailand in Indochina (cf. Tan and Iwatsuki, 1993).

Mniaceae (by Higuchi)

***Orthomnion bryoides** (Griff.) Norkett

Specimen examined. E, on tree trunk (#79-69-11).

Note. This species is reported from Myanmar and Thailand in Indochina (cf. Tan and Iwatsuki, 1993).

Neckeraceae (by Higuchi)

Himantocladium plumula (Nees) M.Fleisch.

Specimen examined. G, on tree trunk (#81-39-11).

***Homaliodendron exiguum** (Bosch & Sande Lac.) M.Fleisch.

Specimen examined. E, on stone in part to full shade (#79-55-11).

Note. This species is reported from Myanmar and Thailand in Indochina (cf. Tan and Iwatsuki, 1993).

***Homaliodendron flabellatum** (Sm.) M. Fleisch.

Specimens examined. G, on tree trunk (#81-24-11, #81-32-11, #81-56-11).

Note. This species is reported from Laos, Myanmar, Thailand and Vietnam in Indochina (cf. Tan and Iwatsuki, 1993).

***Neckeropsis exserta** (Hook. ex Schwägr.) Broth.

Specimens examined. I, on tree trunk (#83-14-11, #83-19-11); on more or less dry cliff near waterfall (#83-72-11).

Note. This species is reported from Myanmar and Thailand in Indochina (cf. Tan and Iwatsuki, 1993).

***Neckeropsis semperiana** (Hampe ex Müll. Hal.) Touw

Specimen examined. K, on thin branches (#85-34-11).

Note. This species is reported from Thailand and Vietnam in Indochina (cf. Tan and Iwatsuki, 1993).

Orthotrichaceae (by Higuchi)

***Macromitrium fasciculare** Mitt.

Specimen examined. C, on tree trunk (#77-31-11).

Note. This species is reported from Vietnam in Indochina (cf. Tan and Iwatsuki, 1993).

Polytrichaceae (by Higuchi)

***Pogonatum camusii** (Thér.) Touw

Specimen examined. G, on fine-grained soil on slope (#81-113-11).

Note. This species is reported from Thailand in Indochina (cf. Tan and Iwatsuki, 1993).

Pottiaceae (by Higuchi)

Barbula subcomosa Broth.

Specimen examined. H, on stone in part shade in agricultural land near village (#82-2-11).

Hyophila involuta (Hook.) A.Jaeger

Specimen examined. D, on wet cliff, splashed with water near waterfall (#78-11-11).

***Timmiella anomala** (Bruch & Schimp.) Limpr.

Specimens examined. D, on wet stone near waterfall in the spray zone (#78-30-11); F, on wet cave in the cliff behind waterfall (#80-31-11).

Note. This species is reported from Myanmar, Thailand and Vietnam in Indochina (cf. Tan and Iwatsuki, 1993).

Pterobryaceae (by Higuchi)

Pterobryopsis crassicaulis (Müll.Hal.) M. Fleisch.

Specimen examined. G, on tree trunk (#81-2-11).

Racopilaceae (by Higuchi)

Racopilum cuspidigerum (Schwägr.) Ångstr.

Specimen examined. D, on stone in forest (#78-3-11).

Rhizogoniaceae (by Higuchi)

Pyrrhobryum spiniforme (Hedw.) Mitt.

Specimens examined. B, on tree trunk (#76-46-11, #76-54-11); E, on decaying wood (#79-15-11), on stone in part to full shade (#79-34-11); I, on more or less dry cliff near waterfall (#83-65-11).

Sematophyllaceae (by Higuchi)

Acanthorrhynchium papillatum (Harv.) M. Fleisch.

Specimens examined. B, on tree trunk on slope (#76-60-11); I on more or less dry cliff near water fall on slope to waterfall (#83-65-11).

Papillidiopsis macrosticta (Broth. & Paris) W.R.Buck & B.C.Tan

Specimen examined. I, on more or less dry cliff near water fall (#83-68-5-11).

Sphagnaceae (by Buck)

Sphagnum perichaetiale Hampe

Specimens examined. M, on forest floor (#87-

7-11, #87-12-11, #87-13-11, #87-16-11, #87-18-11, #87-19-11).

Stereophyllaceae (by Higuchi)

Entodontopsis nitens (Mitt.) W.R. Buck & Ireland

Specimen examined. E, on stone in part to full shade (#79-42-11).

Thuidiaceae (by Higuchi)

***Herpetineuron tocoae** (Sull. & Lesq.) Cardot

Specimens examined. I, on more or less dry cliff near waterfall (#83-73-11); N, on stone side (#88-25-11).

Note. This species is reported from Laos, Thailand and Vietnam in Indochina (cf. Tan and Iwatsuki, 1993).

Pelekium investe (Mitt.) Touw

Specimen examined. A, on stone in part shade (#75-1-11).

Thuidium plumulosum (Dozy & Molk.) Dozy & Molk.

Specimens examined. D, on wet stone near waterfall in the spray zone (#78-23-11); G, on stone in forest (#81-94-11).

Thuidium pristocalyx (Müll. Hal.) A. Jaeger var. **samoanum** (Mitt.) Touw

Specimens examined. G, on tree trunk (#81-16-11); L, on stone side (#86-11-11).

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References

- Goffinet, B., Buck, W. R. and Shaw, A. J. 2009. Morphology, anatomy, and classification of the Bryophyta. In: Goffinet, B. and Shaw, A. J. (eds.), *Bryophyte Biology*. 2nd ed., pp. 55–138. Cambridge University Press, New York.
- Higuchi, M. 2009. Moss flora of Angkor, Cambodia. *Bulletin of the National Museum of Nature and Science, Series B (Botany)* 35: 141–150.
- Tan, B. C. and Iwatsuki, Z. 1993. A checklist of Indochinese mosses. *Journal of Hattori Botanical Laboratory* 74: 325–405.
- Tanaka, A., Zaw, K. M., Ngai, S. G. and Akiyama, H. 2003. Mosses of Natma Taung (Mt. Victoria) National Park, Myanmar. *Makinoa* 3: 1–84.
- Tixier, P. 1966. Bryophytae Indosinicae. A preliminary contribution to the bryoflora of Angkor (Cambodia). *Natural History Bulletin of the Siam Society* 21: 129–133.
- Tixier, P. 1967. Bryophytae Indosinicae. *Inventory bryologique de massif de Kirirom (Cambodge)*. *Annales de la Faculté des Sciences, Université de Phnom Penh* 1: 41–68.
- Tixier, P. 1975. Bryophytae Indosinicae.—XXIII. A preliminary contribution to the knowledge of the coastal southern bryoflora of Cambodia. *Natural History Bulletin of the Siam Society* 26: 11–24.
- Tixier, P. 1979. Bryogéographie du Mont Bokor (Cambodge) (Bryophyta Indosinicae XXIV). *Bryophytorum Bibliotheca* 18: 1–113.
- Tixier, P. 1980. Bryophytae Indosinicae.—XXVI. Cambodian bryoflora. Collections from Phnom Kulen. *Nova Hedwigia* 32: 369–376.
- Yamaguchi, T. 1993. A revision of the genus *Leucobryum* (Musci) in Asia. *Journal of Hattori Botanical Laboratory* 73: 1–123.