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Effects of Forest Fires on Bryophyte Flora in East Kalimantan, Indonesia

By

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K e y w o r d s : Bio-indicator, bryophyte, forest fires, Kalimantan-Indonesia.

S u m m a r y

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Effects of forest fires on the bryophyte flora were studied in tropical lowland rainforests of Bukit Bangkirai, East Kalimantan in 2001–2003. A total of 110 taxa were found in the study area. Among them, 68 taxa were not mentioned from East Kalimantan in previous check lists reported by TOUW 1978 and MENZEL 1988. While 96 taxa were found in the unburnt forest, only 46 taxa were found in the heavily burnt forest. The bryophytes found in the burnt area are presumed to have emigrated from the unburnt natural forest after the forest fires by dispersal of diaspores. *Trismegistia korthalsii*, *Mizutania riccardioides*, *Zoopsis liukiuensis* and *Arachniopsis major,* which are usually found growing on rotten logs in damp sites, could be indicator plants for the natural lowland tropical rainforest environment.

I n t r o d u c t i o n

The recent big forest fires in Kalimantan (Borneo) were a huge disaster for the nature and human life. To find the recovery way of the burnt forests is an emergent subject for us. As the first step to study the forest recovery, it is necessary to monitor the degree of recovery. Because bryophytes can disperse in long dis-

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tance with small spore, the dispersal rarely becomes the limiting factor for the limiting factor for the establishment of bryophytes on new site. They will soon grow on a new habitat after the area is recovered to be suitable for them. Thus they have the possibility to become a good indicator of forest recovery.

The purpose of the present study was to survey the bryophytes of the region and analyze the impact of forest fires on bryophyte diversity and the recovery of the bryophyte flora during vegetational succession. A second aim was to determine the candidate species if some bryophytes could be used as bio-indicators for evaluating the impact of forest fires.

The study was carried out in Bukit Bangkirai (Fig. 1), East Kalimantan. Bukit Bangkirai (0°58'-0°05'S, 116°47'-16°57'E) is located ca. 25 km northwest of Balikpapan City, East Kalimantan, Indonesia. Bukit Bangkirai area is a nature recreation park with ca. 110m in altitude, and is characterized by natural tropical lowland rainforest, secondary forest, selectively logged areas and agricultural land. The area had been burnt as results of extensive forest fires in 1982-83 and 1997-98. However, some areas escaped the fires.

Kalimantan is one of the richest bryofloral areas in the world. 623 species of Hepaticae and 607 species of Musci are known from Kalimantan (Fig. 1; TOUW 1978, MENZEL 1988). However, most species reported have been from Mt. Kinabalu, and large parts of the island, especially tropical lowland rainforest areas, are almost unexplored bryologically. Contributing to an understanding of the diversity of bryophytes in the tropical rain forest is a further objective of our study.

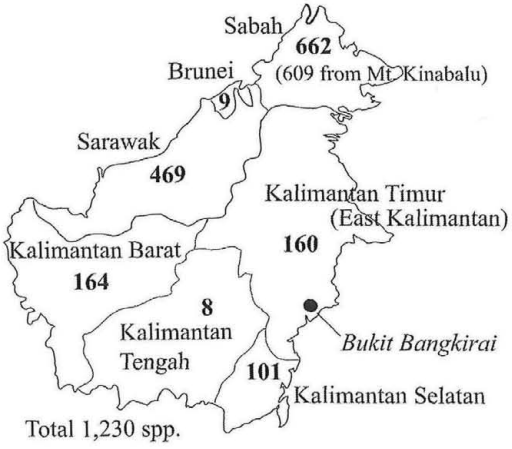

Fig. 1. Map showing the location of the study area, Bukit Bangkirai, and the number of bryophyte species known for the political subdivisions of Kalimantan. Data from MENZEL 1988.

Material and Methods

A general inventory survey of bryophytes was conducted in three permanent plots (Fig. 2): K-plot established in a natural forest escaped the fires, LD-plot in a lightly damaged (burnt) forest and HD-plot in a heavily damaged (burnt) forest. Detailed vegetation of each plot are mentioned by SIMOLON & al. 2005. 15 or 17 permanent sub-plots (10 m x 10 m) in each K-, LD- or HD-plot, were systematically established. All bryophytes on soil, rotten logs, tree trunks and leaves within the sub-plots were noted and voucher specimens collected for further identification. The succession of corticolous bryophyte vegetation on tree trunks was also surveyed in permanent quadrats (20 cm x 20 cm or 10 cm x 40 cm) established on 7-11 selected trees in each plot. The surveys were carried out in Feb. 2001 (3 years after the fire), Sept. 2001, Feb. 2002, July 2002 and Jan. 2003.

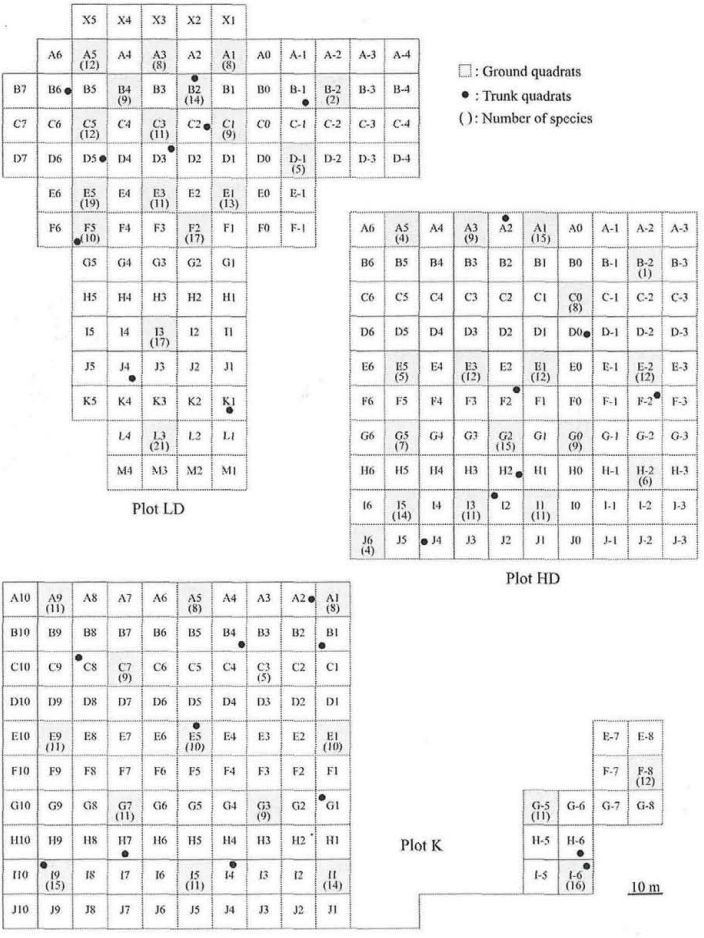

Fig. 2. Plots and quadrats. Plot HD: heavily burnt forest site, LD: lightly burnt forest site, K: unburnt natural forest site.

Table 1. A general overview of all bryophytes found in the study area. Numerals show the number of specimens found in each plot area. Numerals in parentheses show the number of specimens found in the adjacent area of the plot. Numerals in square brackets show the number of specimens found in the plot and its adjacent area. *: species not reported by TOUW 1978 and MENZEL 1988 from East Kalimantan. Plot HD: heavily burnt forest site, LD: lightly burnt forest site, K: unburnt natural forest site.

Family	Species	Plot HD	LD	K
	BRYOPSIDA			
Polytrichaceae	* *Racelopus pilifer* Dozy & Molk.	.	.	1
Fissidentaceae	* *Fissidens crassinervis* Sande Lac.	4	6	24(1)
	* *Fissidens ganguleei* Nork. ex Gang.	8	.	.
	* *Fissidens hollianus* Dozy & Molk.	.	.	1
	* *Fissidens pellucidus* Hornsch.	1	5	3(1)
	* *Fissidens robinsonii* Broth.	1	.	1
	Fissidens sp.	.	1	1
Leucobryaceae	*Leucobryum aduncum* Dozy & Molk.	11	10	1(1)
	* var. *scalare* (*Müll.*Hal.) A.Eddy	12	3	(1)
	* var. *teysmannianum* (Dozy & Molk.) T.Yamag.	34	25(4)	8(8)
	* *Leucobryum chlorophyllosum* Müll.Hal.	3	6	9(1)
	Leucobryum sanctum (Brid.) Hampe	31	42	68(7)
Calymperaceae	*Arthrocormus shimperi* (Dozy & Molk.) Dozy & Molk.	42	96(1)	142(4)
	* *Calymperes erosum* Müll.Hal.	.	.	(1)
	* *Calymperes fasciculatum* Dozy & Molk.	.	.	1
	* *Calymperes lonchophyllum* Schwägr.	.	2	.
	* *Calymperes palisotii* Schwägr.	.	3	1(1)
	* *Calymperes serratum* A.Braun ex Müll.Hal.	.	1	.
	Calymperes sp.	1	1	.
	* *Exostratum blumii* (Nees ex Hampe) T.L.Ellis	.	(1)	1(1)
	Leucophanes candidum (Schwägr.) Lindb.	4	3	5
	* *Leucophanes glaucum* (Schwägr.) Mitt.	3	.	.
	* *Leucophanes octoblepharioides* Brid.	24	20(2)	20(5)
	* *Mitthyridium fasciculatum* (Hook. & Grev.) H.Rob.	1	2	.
	* *Mitthyridium repens* (Harv.) H.Rob.	20	37	9(3)
	* *Mitthyridium undulatum* (Dozy & Molk.) H.Rob.	1	10(1)	9(1)
	* *Mitthyridium wallisii* (Müll.Hal.) H.Rob.	2	8	2(2)
	Mitthyridium sp.	.	1	(1)
	* *Octoblepharum albidum* Hedw.	23	16	5
	* *Syrrhopodon albovaginatus* Schwägr.	56	72	102(3)
	* *Syrrhopodon aristifolius* Mitt.	3	11	6(1)
	* *Syrrhopodon armatus* Mitt.	6	12	10
	* *Syrrhopodon ciliatus* (Hook.) Schwägr.	36	4(1)	6(1)
	* *Syrrhopodon confertus* Sande Lac.	1	2	9
	Syrrhopodon croceus Mitt.	9	24(2)	7(2)
	* *Syrrhopodon gardneri* (Hook.) Schwägr.	2	8	5
	* *Syrrhopodon hispidissimus* Dixon	1	4	7
	* *Syrrhopodon involutus* Schwägr.	9	3	(3)
	* *Syrrhopodon loreus* (Sande Lac.) Reese	4	4(1)	10(3)
	Syrrhopodon muelleri (Dozy & Molk.) Sande Lac.	.	.	8
	* *Syrrhopodon rufescens* Hook. & Grev.	1	2	.
	* *Syrrhopodon sarawakense* (Dixon) W.D.Reese	.	.	4
	Syrrhopodon spiculosus Hook. & Grev.	115(1)	108(1)	193(2)
	* *Syrrhopodon trachyphyllus* Mont.	1	5	(1)
	Syrrhopodon sp.	1	1	.
Rhizogoniaceae	* *Pyrrhobryum spiniforme* (Hedw.) Mitt.	9	51	113(3)
Sematophyllaceae	*Acanthorrhynchium papillatum* (Harv.) M.Fleisch.	35	118(1)	162(7)
	Acroporium convolutum (Sande Lac.) Fleisch.			
	* var. *elatum* (Dixon) B.C.Tan	.	2	.
	Acroporium diminutum (Brid.) M.Fleisch.	8	15	78
	* *Acroporium lamprophyllum* Mitt.	9	10	13(2)
	Acroporium sp.	.	.	1
	* *Papillidiopsis ramulina* (Thawites & Mitt.) W.R.Buck & B.C.Tan	(1)	4	1
	* *Taxithelium kerianum* (Broth.) Broth.	.	.	1
	* *Taxithelium vernieri* (Duby) Besch.	.	.	1
	Taxithelium sp. 1	.	1	1
	Taxithelium sp. 2	.	1	9

Table 1. A general overview of all bryophytes found in the study area (continued).

Family	Species	Plot	HD	LD	K
	* *Trichosteleum boschii* (Dozy & Molk.) A.Jaeger		.	.	(1)
	Trichosteleum sp.		.	1	3
	* *Trismegistia korthalsii* (Dozy & Molk.) Broth.		.	.	(3)
	Trismegistia sp.		.	1	.
Hypnaceae	* *Ctenidium malacobolum* (Müll.Hal..) Broth.		.	.	1
	* *Isopterygium minutirameum* (Müll.Hal.) A.Jaeger		2	1	.
	Isopterygium sp.		.	2	1
	* *Pseudotaxiphyllum pohliaecarpum* (Sull. & Lesq.) Z.Iwats.		.	.	1
	* *Vesicularia kurzii* (Sande Lac.) Broth.		2	3	3
	* *Vesicularia miquellii (Sande Lac.) Feisch.*		4	4	6
	HEPATICOPSIDA				
Pseudolepicoleaceae	* *Blepharostoma tricophyllum* (L). Dumort.		.	.	1
Lepidoziaceae	*Acromastigum divaricatum* (Gottsche, Lindenb. & Nees) A.Evans.		.	1	1
	Acromastigum inaequilaterum (Lehm. & Lindenb.) A.Evans		.	20	48(1)
	* *Arachniopsis major* Herzog		.	.	1(6)
	* *Bazzania tridens* (Reinw., Blume & Nees) Trevis.		.	.	1
	Bazzania sp. 1		.	.	1
	Bazzania sp. 2		.	1(1)	.
	Bazzania sp. 3		.	1	5
	Bazzania sp. 4		.	1	1
	Kurzia sp.		.	.	1
	Zoopsis liukiuensis Horik.		.	.	1(5)
Calypogeiaceae	* *Calypogeia arguta* Nees & Mont.		.	.	3
	Calypogeia sp.		.	.	2
Cephaloziaceae	*Cephalozia* sp. 1		.	1	1
	Cephalozia sp. 2		.	1	4
Geocalycaceae	*Heteroscyphus* sp.		.	.	1
	Lophocolea sp.		.	.	1
Radulaceae	* *Radula javanica* Gottsche		.	.	2
	Radula sp. 1		.	.	1
	Radula sp. 2		.	.	1
Frullaniaceae	* *Frullania neosheana* S.Hatt.		.	.	3
	Frullania sp.		.	.	(1)
Lejeuneaceae	* *Archilejeunea planiuscula* (Mitt.) Steph.		.	.	2
	Cheilolejeunea ceylanica (Gottsche) R.M.Schust. & Kachroo		1	1	2(5)
	* *Cheilolejeunea falsinervis* (Sande Lac.) Kachroo & R.M.Schust.		.	1	1
	* *Cheilolejeunea intertexta* (Lindenb.) Steph.		.	.	3
	* *Cheilolejeunea trifaria* (Reinw., Blume & Nees) Mizut.		.	1	1(1)
	Colura sp.		.	.	(1)
	* *Drepanolejeunea teysmannii* (Steph.) Steph.		.	1	1
	* *Lejeunea anisophylla* Mont.		.	.	4
	* *Lejeunea patens* Lindb.		.	.	2
	* *Leptolejeunea elliptica* (Lehm. & Lindenb.) Schiffner		.	.	1
	Lopholejeunea latialata Mizut.		1	1(1)	1
	* *Lopholejeunea horticola* Schiffn.		.	1	1(2)
	Stictolejeunea sp.		.	.	1
	* *Thysananthus spathulistipus* (Reinw., Blume & Nees) Lindenb.		.	.	2
Pallaviciniaceae	*Pallavicinia lyellii* (Hook.) Carruth.		.	(1)	3
Aneuraceae	* *Aneura maxima* (Schiffn.) Steph.		.	.	(1)
	* *Riccardia baumannii* Huerl.		.	(1)	.
	* *Riccardia graeffei* (Steph.) Hewson		2	.	(1)
	* *Riccardia spongiosa* Furuki		2	.	1(1)
	* *Riccardia tenuicostata* Schiffn.		1	.	2
	Riccardia sp. 1		.	1	1
	Riccardia sp. 2		.	.	3
	Total number of species		45(2) [46]	63(14) [66]	86(40) [97]

Results and Discussion

We found 110 taxa of bryophytes in the study area (Table 1). Among them, 68 taxa were not mentioned from East Kalimantan in previous check lists reported by Touw 1978 and Menzel 1988. Since our research was restricted in a small lowland site, a large number of species may be newly found in East Kalimantan area.

The Bukit Bangkirai area abounds in Calymperaceae (33 taxa), Sematophyllaceae (14 taxa), Leucobryaceae (5 taxa) and Lejeuneaceae (14 taxa), a composition typical of the tropical lowland bryoflora. Some species of Calymperaceae, which have a high vegetative reproductive capacity since they produce numerous tiny gemmae at the leaf tips, are adapted to the dry and sunny conditions.

The species richness increased in order of HD-plot (46 taxa), LD-plot (66 taxa) and K-plot (97 taxa). Calymperaceous taxa dominated in HD-plot (24 taxa, 52%) and LD-plot (28 taxa, 42%), while 26 taxa (27%) were found in K-plot. The richness of calymperaceous taxa seems to be one characteristic of bryoflora in disturbed tropical lowland forests. In K-plot and its surrounding natural forest, we found many large sized mosses (e.g. *Trismegistia*, *Trichosteleum*), epiphyllous hepatics (e.g. *Colura*, *Cololejeunea*), and delicate hepatics (e.g. *Arachniopsis*, *Zoopsis*).

In spite of the difference of the species richness among the plots, the average number of taxa found in permanent sub-plots was not so different among the three plots: 9.1 taxa in HD-plot, 11.6 in LD-plot and 11.1 in K-plot (Fig. 2). This means that considerable habitat diversity has been formed in K-plot.

Most of the species found in HD- and LD-plots were also found in K-plot. The bryophytes found in burnt areas are presumed to have emigrated from the unburnt natural forested areas after forest fires by dispersal of the diaspores.

In natural forests, we often found large moist rotten logs under big trees. We consider that *Trismegistia korthalsii* (Fig. 3A), *Mizutania riccardioides* (Fig. 3B), *Zoopsis liukiuensis* (Fig. 3C) and *Arachniopsis major* (Fig. 3D), which are usually found growing on rotten logs in damp sites, could be the candidates of indicator plants for the natural forest environment.

The successional sequence and regeneration time of the bryophyte vegetation could not be determined in our initial survey but will be monitored over time in the permanent plots established.

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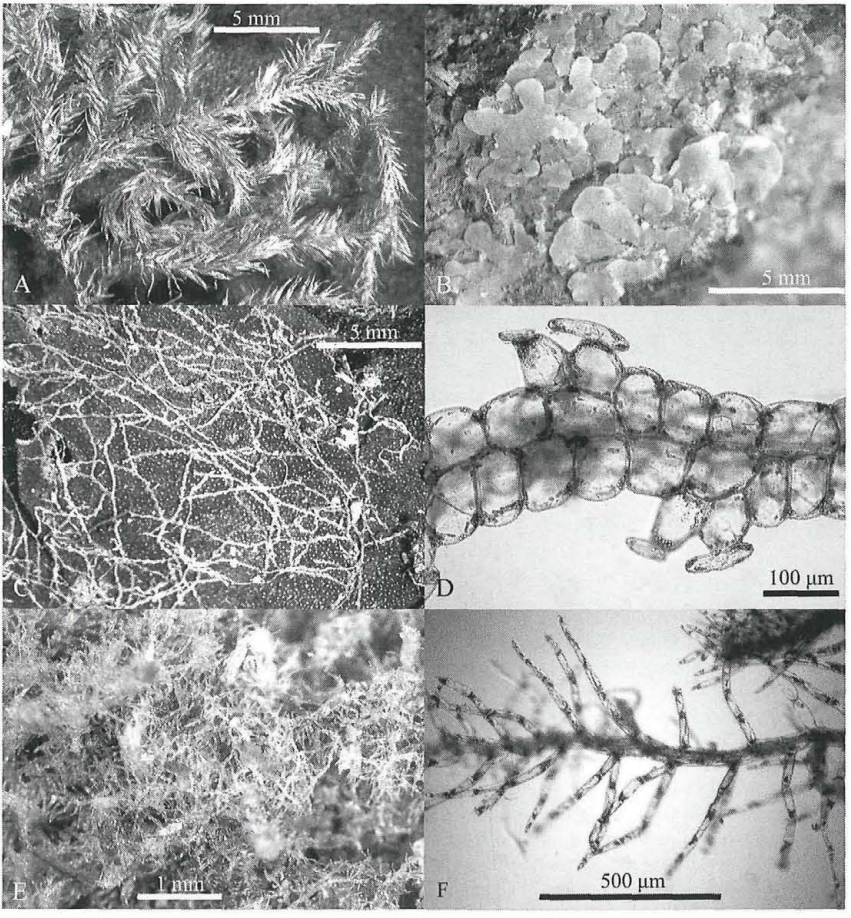

Fig. 3. The candidates of indicator bryophytes for the natural tropical lowland rainforest environment. A, *Trismegistia korthalsii.* B, *Mizutania riccardioides.* C, D, *Zoopsis liukiuensis.* E, F, *Arachniopsis major.*

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