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Effects of Forest Fires on Some Lichen Species in East Kalimantan, Indonesia

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K e y w o r d s : Evaluation, forest fires, Kalimantan-Indonesia, lichens, lowland tropical rain forest.

S u m m a r y

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Developing a simple method for evaluating the damage and recovery from the forest fires in tropical rain forest is required from a forest management standpoint in Indonesia. The purpose of this study is to present a new evaluation method of forest fire damage, especially for field scientists and forest managers. We employed some popular taxonomical groups and their growth forms for evaluation without using any expensive equipment in forests. We surveyed and examined this method in the mixed dipterocarp forest at Bukit Bangkirai, East Kalimantan, Indonesia, in 2002. Results showed that the evaluation score became lower at 0-50 cm height zone at the hardly damaged forest as compared with control (no damaged) forest. In low land of East Kalimantan, lichens grow more at low height zone of tree trunks than higher position, which seemed to depend on the moisture from the ground. Forest fires in this area should spread with burning of dry grasses and fallen leaves on ground surface, and lichens at lower height zone might be severely affected. *Dictyonema* cf. *moorei* with cyanobacteria as photobionts, which apparently prefers the damaged forests, might be a bio-indicator as pioneer lichen for forest fires. While, *Coenogonium* sp. with green algae as photobionts, which was observed only control forest, seemed to be a bio-indicator of good/matured tropical lowland rainforests.

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Introduction

The forest fires occur almost every year in Indonesia due to mainly human activities such as clearing of plantation. Increased CO_2 and other pollutants release from forest fires might one of the causes for the recent abnormal weather. Developing a simple method for evaluating the damage and recovery from the forest fires in tropical rain forests is urgently required from a forest management standpoint in Indonesia. The purpose of this study is to present a new evaluation method of forest fire damage, especially for field scientists and forest managers.

SIPMAN 1993 reported 286 species of lichenized fungi on Mount Kinabalu. However, except for Mount Kinabalu, floristic study of lichen in Kalimantan has not conducted sufficiently. We need more basic data accumulation to understand the effects of forest fire on lichen and its possibility as bio-indicators.

Through the floristic study in the mixed dipterocarp forest, Bukit Bangkirai, East Kalimantan, Indonesia, we found that the trees of *Durio acutifolius* and *Syzygium incarnatum* have resistance for forest fires because of robust barks. Then, we investigated the lichens on those two tree trunks, but just low height zone, as it was very difficult to investigate at the high place like canopy (MCCUNE & al. 2002).

Carrying out the evaluation, preceding studies of lichens as air pollution indicator give us some hints. HAWKSWORTH & ROSE 1970 paid much attention on the selection of tree species as the substratum. GILBERT 1970 reported that the pendent type growth form lichen become short by the influence of air pollution. LEBLANC & DE SLOOVER 1970 reported that the apogamic organ was increased by air pollution. We considered that the forest fires stressed lichen with harmful air pollutants in addition to fire burning and high temperature.

Material and Methods

Except basic floristic study, the present ecological study was carried out from January to February in 2002, at about 110 m above sea level, Bukit Bangkirai tropical rain forest (Fig. 1). Depending on the damage of forest fires, the investigating area was divided into three, a hardly damaged forest (HD-plot: 10000 m^2, 01°02'S/116°52'E), a lightly damaged forest (LD-plot: 10100 m^2, 01°01'S/116°52'E) and no damaged (unburnt) forest (K-plot: 11200 m^2, 01°02'S/116°52'E). The examined trees were restricted only *Durio acutifolius* (n=28) and *Syzygium incarnatum* (n=9). Lichens were recorded depending on the height zone from the ground, as 0-50, 50-100 and 100-150 cm (Fig. 2).

The identification of lichens was sometimes so difficult in the field, especially at HD- and LD-plots, that we developed a simplifying method for damage/recovery evaluation with employing the thallus growth forms such as filamentous lichen (*Dictyonema* cf. *moorei*, *Coenogonium* sp.), crustose lichen (e.g. *Phaeographis* spp., *Thelotrema* spp.), fruticose lichen (*Cladoniaceae*), imperfect lichen (*Lepraria* spp.), and with additional record of activity and presence of apothecia (Fig. 3), followed by BRODO & al. 2001. The evaluation scores were calculated by the sum of each lichen's fire impact index ("Fi") value at each tree and each height (see Table 1). When we found the lichens with apothecia, 0.5 was added to the original "Fi" value. We also considered the activity of lichens as photobionts richness adding 0.2 to "Fi" value, to reflect the influence of forest fires in short span. For example, when 5 individuals of *Lepraria* and 1 individual of *Phaeographis* sp. with apothecia were found at 0-50 cm height of a tree; the evaluation score = $5 \times 0.5 + 1.5 = 4.0$.

Fig. 1. Location of investigating site at Bukit Bangkirai, East Kalimantan.

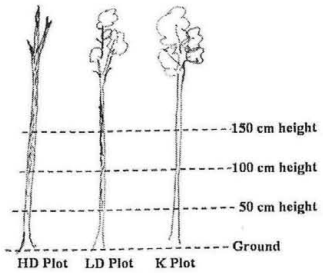

Fig. 2. Explanation of height zone.

Table 1. "Fi" value[1)] by the thallus growth forms[2)] and each epiphytic lichen species.

Thallus growth forms and taxonomical groups	"Fi" value
Fruticose lichen (*Cladoniaceae*) with apothecia	3.5
Fruticose lichen (*Cladoniaceae*), active[3)]	3.2
Fruticose lichen (*Cladoniaceae*), less active[4)]	3.0
Filamentous lichen with green photobionts (*Coenogonium* sp.), active	3.2
Filamentous lichen with green photobionts (*Coenogonium* sp.), less active	3.0
Crustose lichen (e.g. *Phaeographis* spp., *Thelotrema* spp.) with apothecia	1.5
Crustose lichen (e.g. *Phaeographis* spp., *Thelotrema* spp.), active	1.2
Crustose lichen (e.g. *Phaeographis* spp., *Thelotrema* spp.), less active	1.0
Filamentous lichen with cyanobacteria (*Dictyonema* cf. *moorei*)	1.0
Imperfect lichen (*Lepraria* spp.[5)])	0.5

[1)] "Fi" values are estimated from the average of number of the species found in the vicinity of the species at all station. The basic value is according to the value in the study of air pollution (NAKAGAWA & KOBAYASHI 1990).

[2)] The growth forms of foliose and pendent were not observed in this area.

[3)] "Active" means that the individual is vital and it will continue to grow in the future, too.

[4)] "Less active" means that the condition of individual is bad and it will die sooner or later.

[5)] Some *Lepraria* might be difficult to distinguish from burnt crustose lichens in hardly and lightly damaged forests.

Results and Discussion

Although four years have already passed after the forest fires in 1997 and 1998, Fig. 4 in the case of *Durio acutifolius* showed that the lichens were still damaged in HD- and LD-plots. Fig. 4 also showed that the lichens in this area grew more at low height zone (0-50 cm height), especially at K-plot. While in HD-plot, average value was almost same at 0-50 cm and 50-100 cm height zone. These observations also supported that the forest fires in this area should spread with burning of dry grasses and fallen leaves on ground surface and severely destroyed the epiphytes at low height zones of tree trunk. In the case of *Syzygium incarnatum*

(Fig. 5), we observed only nine trees, while we also found the similar tendency that lichens were still affected by forest fires and that lichens preferred the low height zone, which seemed depending on the moisture from the ground.

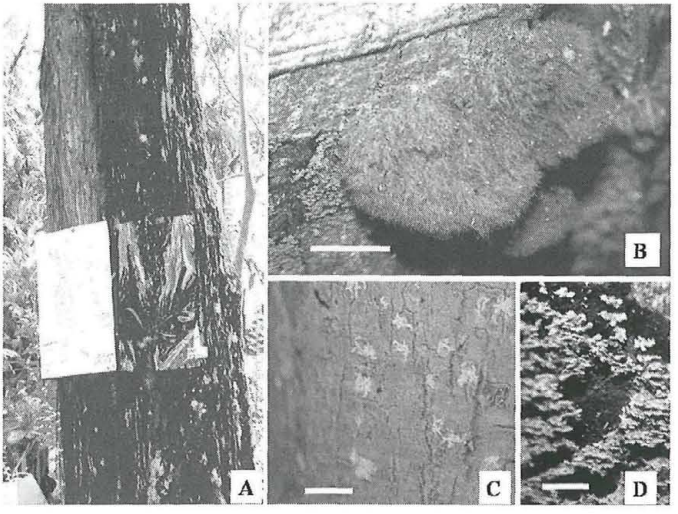

Fig. 3. Some epiphytic lichens observed in the mixed dipterocarp forest. A: Field study at lightly damaged plot (LD-plot). Small amount of *Dictyonema* cf. *moorei* (a filamentous lichen, black part) were observed on this burnt barks. B: *Coenogonium* sp. (a filamentous lichen) at control (no damaged; unburnt) plot (K-plot). C: *Graphics* sp. (a crustose lichen) at K-plot. D: Primary thallus of *Cladonia* sp. (a fruticose lichen) at K-plot. Scale: 1 cm.

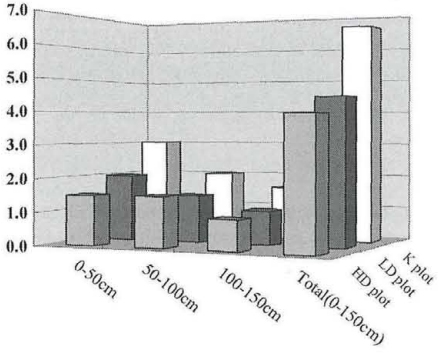

Fig. 4. The average evaluation score of each height zone on *Durio acutifolius* at HD-, LD- and K-plots. Number of trees examined were; HD-plot: 10, LD-plot: 10 and K-plot: 8.

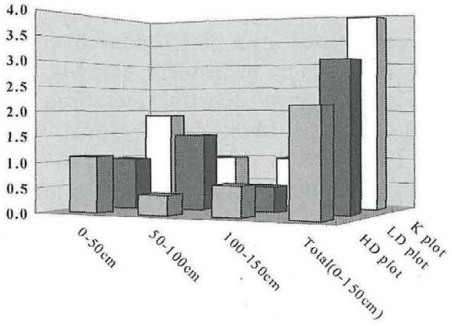

Fig. 5. The average evaluation score of each height zone on *Syzygium incarnatum* at HD-, LD- and K-plots. Number of trees examined were; HD-plot: 6, LD-plot: 1 and K-plot: 2.

Table 2. Total number of epiphytic lichen individuals grown on *Durio acutifolius* examined at HD-, LD- and K-plots.

Plot	Genus name	0-50 cm height	50-100 cm height	100-150 cm height	Total
HD-plot*	*Dictyonema* cf. *moorei*	10	7	3	20
	Coenogonium sp.	0	0	0	0
	other lichen species	7	12	11	20
	Total	17	19	14	50
LD-plot*	*Dictyonema* cf. *moorei*	9	3	0	12
	Coenogonium sp.	0	0	0	0
	other lichen species	12	13	12	37
	Total	21	16	12	49
K-plot*	*Dictyonema* cf. *moorei*	0	0	0	0
	Coenogonium sp.	2	1	0	3
	other lichen species	15	13	12	40
	Total	17	14	12	43

* Number of the tree examined; HD-plot: 10, LD-plot: 10, K-plot: 8.

Dictyonema sp. *moorei* and *Coenogonium* sp. with filamentous growth form are popular in tropical forests (FARKAS & SIPMAN 1993, SIPMAN 1993). But *Dictyonema* cf. *moorei* that has cyanobacteria as photobionts apparently preferred HD- and LD-plots as compared with K-plot (Table 2). *Dictyonema* cf. *moorei* might be one candidate species of bio-indicator as pioneer lichen from forest fires. On the other hand, *Coenogonium* sp. that has green algae as photobionts was observed at only K-plot (Table 2). Because K-plot was control (unburnt, no damaged by fire) and normal mixed dipterocarp forest, *Coenogonium* sp. seemed to be another candidate as bio-indicator of good conditioned matured tropical lowland rain forests.

The difference of photobionts might be reflecting the pH or some chemical factors. Lichens with cyanobacteria usually have ability to fix atmospheric nitrogen.

This reaction is highly pH-sensitive with an optimum at pH 7 for isolated *Nostoc* (GRIES 1996). Ash by the forest fires might affect lichen symbiosis. In MIYAWAKI & al. 1987, the lichens directly growing on limestone were containing cyanobacteria as a symbiosis partner. In the study in British Columbia, Canada, GOWARD & ARSENAULT 2000 reported that nutrient-rich leachates from the upper branch of *Populus* increased the pH of conifer trunk closely grown, which was benefit of cyanolichen colonization. Further study might be needed to clarify these phenomena. We are now expanding the investigating area and examine the other growth forms.

However, we found that some popular taxonomical lichen groups and their growth forms are useful for evaluating the damage and recovery from forest fires without using any expensive equipment in forests. This simple evaluation method should be used for monitoring and checked/proved by field scientists and forest managers, and should be modified to more practical way for evaluating the damage and recovery from the forest fires.

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