Comparing the Lichen and Bryophyte Composition between Mid-trunk and Basal Regions on Trees in Bornean Lowland Dipterocarp Forest

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ABSTRACT

The trees supporting the SkyBridge canopy walkway in Maliau Basin, Sabah, Malaysia were studied to determine if lichen and bryophyte composition differs between the mid-trunk (~20 m above ground level) and basal (~2 m above ground level) regions of trees. A circumferential line intersect transect method was used to determine the percent coverage of each bryophyte and lichen morphotype. Multivariate composition analysis revealed that mid-trunk regions clustered separately from basal regions in terms of lichen and bryophyte abundance. In general, bryophyte coverage dominates over lichen in basal regions while crustose lichen dominates in mid-trunk regions. Overhead cover was also significantly positively correlated (p -value = 0.012) with bryophyte abundance. It is proposed that breakage of continuous canopy cover from natural causes or human interference may change the trunk microclimate in a way which favors lichen cover. Further research is necessary to elucidate the effects of other factors on trunk epiphyte communities.

Key words: Lichens, bryophytes, composition, lowland rain-forest, bioindicators, Borneo.

INTRODUCTION

Bornean rain-forest, as a locus of incredible biological diversity, has long been an object of scientific curiosity and investigation (Wallace 1869). Since the pioneering work of the 19th century, many studies have explored the patterns and processes influencing the composition and diversity of tropical flora and fauna in Borneo and elsewhere (e.g. Connell 1978, Novotny 2006, Beck and Vun Khen 2007). Even a single large tree offers a wide range of microclimates and niches, with variations in such conditions as brightness, temperature, humidity, and wind speed at different levels along its height (Wolseley and Aguirre-Hudson 1997). Two groups frequently found on large trees are the lichens, which are mutualistic associations of fungi and algae, and the bryophytes, which are a group of primitive non-vascular plants that includes mosses and liverworts. Due to the vertical variability described, and due to the clear responsiveness of lichens to bottom-up factors (Dyer and Letourneau 2007), one might expect microclimate specialization such that different species of lichens and bryophytes predominate at different heights. Because lichens have been labelled as bio-indicators for levels of air pollution and microclimatic change from forest disturbance (Wolseley and Aguirre-Hudson 1997), and because bryophytes are sensitive to levels of desiccation, gaining an understanding of the drivers determining the composition of these groups would contribute to the disciplines of ecology, global change biology, and forestry.

In this study, we sought to discover how the composition of bryophytes and lichens might differ between the mid-trunk (~20 m) and basal (~2 m) regions of rain-forest trees. Due to large differences particularly in moisture, light availability, and exposure between tree regions, our expectation was that hardier forms with less three-dimensional structure and tighter adhesion, like crustose lichen, might be more prevalent in the mid-trunk and canopy areas. At the same time, we expected that more leafy or structured forms like foliose lichen and moss, which are more exposed, might be more prevalent towards tree bases.

METHODS

This study was conducted in Maliau Basin, Sabah, Malaysia during August 2008. The Skybridge canopy walkway provides direct access to the mid-trunk regions of the seven trees that support it. Six of these trees were used for data collection; one was eliminated because its basal region was inaccessible.

Data collection was carried out using a circumferential line intersect transect method. From a given starting point, the length of the transect line intersecting either bare bark or different bryophyte and lichen morphotypes was recorded around the tree. General lichen growth form was also recorded. Morphotyping was accomplished by visual assessment and recognition alone, using obvious visual characters such as color, size, shape, and so on – an admittedly dubious method. This composition data was recorded at knee and breast height (separation of 1 m) for both study regions (mid-trunk and base) of each tree, with two additional data points collected on the first tree, for a total of 26 line transects.

In addition to compositional data, environmental data was also collected at each site. Bark type and sample location height were recorded, and a spherical densiometer was used to determine overhead vegetation cover (as a proxy for long term light levels) around the tree.

The statistical programming platform R and the third-party analysis package Vegan were used to perform

multivariate compositional analyses such as multidimensional scaling and hierarchical clustering, as well as pairwise Wilcoxon tests to compare the Shannon's Diversity Indices between the mid-trunk and basal regions. The Shannon's Index was computed as:

$$H = \Sigma\ [(\%\ \text{cover})_i * \ln (\%\ \text{cover})_i]$$ where i is each morphotype found on the transects.

RESULTS

A total of 35 crustose lichen, 7 foliose lichen and 11 bryophytes morphotypes were identified on a total of 26 transects. Hierarchical clustering of all 26 transects (Figure 1a) matches up extremely well (nearly 1:1) with the overall clustering of each tree's measurement regions (Figure 1b). This suggests that each transect and each transect pair represents its respective tree region strongly and cohesively. We thus combined the transects to give 6 mid-trunk samples and 6 basal samples for the following analyses.

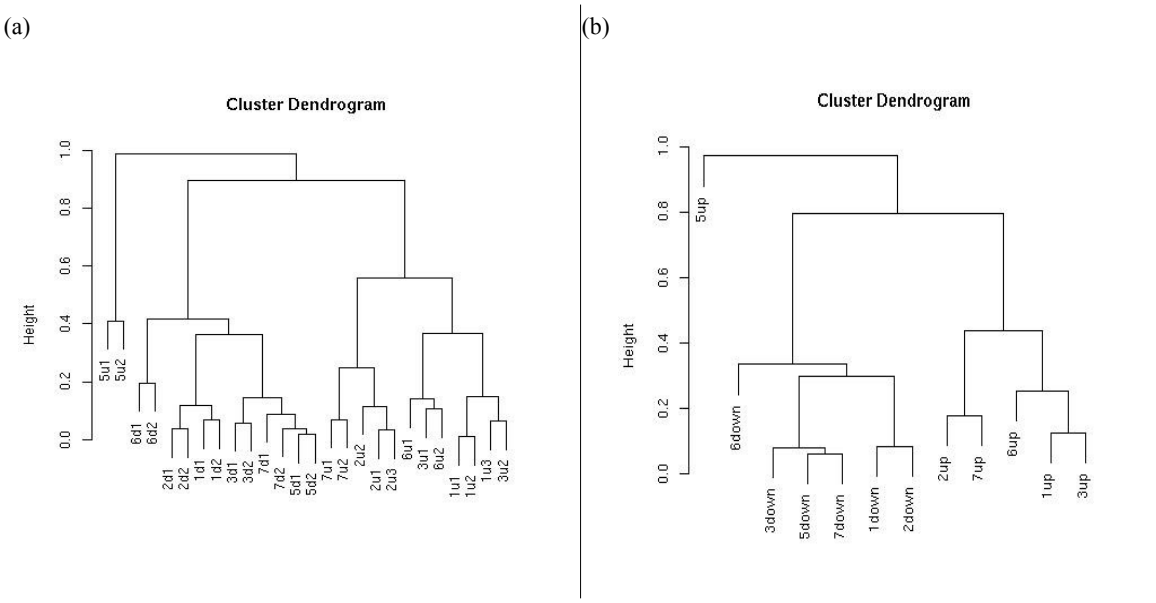

FIGURE 1: Hierarchical clustering of (a) all transects and (b) pooled samples. For all annotations, tree 4 is absent as it was the tree excluded from measurements.

Values for Shannon's diversity index for each mid-trunk and basal regions on the six trees sampled are given in Table 1. The pairwise Wilcoxon test yielded a p-value of 0.2188. The Shannon's Index was not significantly different between the mid-trunk and basal regions of the trees. Similarly, morphotype richness and diversity was compared between the mid-trunk and basal regions using a pairwise Wilcoxon test, but no significant difference was found.

Table 1. Shannon's Index computed for each sample.

Tree	Region	Index
1	high	1.911
	low	1.588
2	high	1.387
	low	1.379
3	high	1.565
	low	0.971
5	high	0.064
	low	0.903
6	high	0.954
	low	0.751
7	high	0.939
	low	0.617

Due to lack of robust methods of identifying species, morphotypes were grouped together as crustose

lichen, foliose lichen or bryophyte for our multidimensional scaling (Figure 2). The mid-trunk samples cluster well together and were distinctly separate from the basal samples of the same trees. Fitting of environmental variables of overhead cover showed significant positive correlation with bryophyte dominance (p-value = 0.012). Basal samples were generally dominated by bryophytes while mid-trunk samples were dominated by crustose lichens.

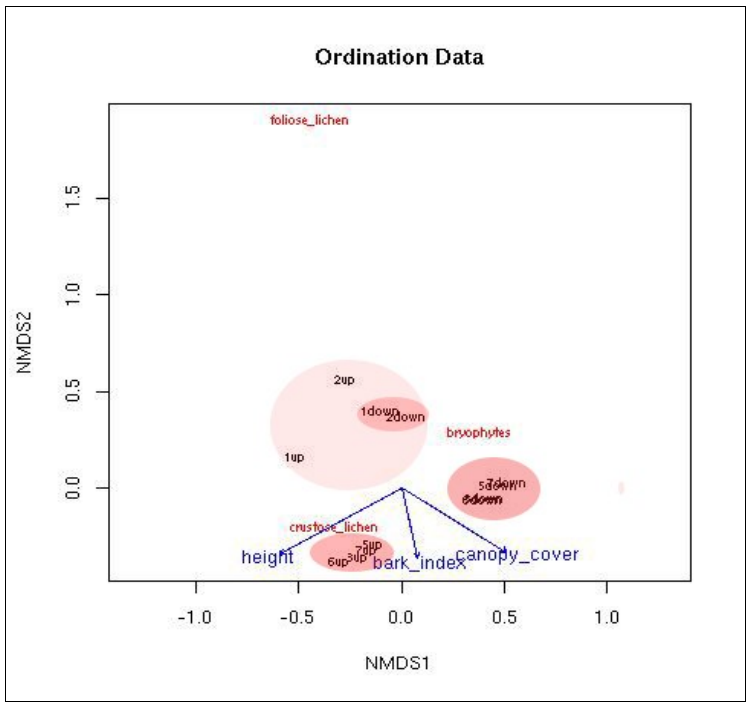

FIGURE 2: Multidimensional scaling of composition data, with red circles indicating clusters. Note that the 'bark_index' is an ex post facto scale we devised wherein higher values represent higher bark roughness and unevenness. This scale is admittedly an unnatural scale that is not an exceptionally strong tool for tree classification, but we analyzed it because general bark character was an attribute we wanted to investigate at least elementarily. The lack of any significant correlation with this index confirms our suspicions and also lends more to the strength of the data's correlations with height and canopy cover. Beyond these functions, the bark index is not particularly significant.

DISCUSSION

These results show a clear distinction between basal and mid-trunk communities of lichen and bryophytes. This was to be expected, as the microclimatic conditions in a forest are often very different between the ground level and mid-story. Our measurements showed a large difference in overhead cover, which is strongly related to light levels, between the two height regions. Other variable factors which may be involved in the observed community differences include temperature, moisture levels, wind speed, and presence of herbivorous insects (Wolseley and Aguirre-Hudson 1997). Additionally, a marked difference in community composition was sometimes noted on different sides of a single tree. However, our sampling methods did not allow examination of this phenomenon, and our sample size was limited by the number of trees that support the SkyBridge canopy walk. Further investigation will be necessary to analyze the roles that these factors play.

Our results suggest that natural or human-caused decreases in canopy coverage could result in a shift towards lichen in trunk epiphyte communities. However, rapid growth of dense understory shrubs may be able to re-establish microclimatic conditions favorable for bryophyte re-colonization. Perhaps long-term monitoring of freshly logged forests can support these claims and help further establish lichens as tools for managing Reduced Impact Logging and sustainable forestry.

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LITERATURE CITED

Beck, J. & Vun Khen, C. (2007), 'Beta-diversity of geometrid moths from northern Borneo: effects of habitat, time and space', *Journal of Animal Ecology* **76**, 230-237.

Connell, J. H. (1978), 'Diversity in tropical rain forests and coral reefs', *Science* **199**, 1302-1310.

Dyer, L. A. & Letourneau, D. K. (2007), 'Determinants of lichen diversity in a rain forest understory', *Biotropica* **39**(4), 525-529.

Novotny, Vojtech; Drozd, Pavel; Miller, Scott E.; Kulfan, Miroslav; Janda, Milan; Basset, Yves & Weiblen, George D. (2006), 'Why are there so many species of herbivorous insects in tropical rainforests?', *Science* **313,** 1115-1118.

Wallace, A. R. (2000), *The Malay Archipelago*, Periplus Editions.

Wolseley, P. & Aguirre-Hudson, B. (1997), 'The ecology and distribution of lichens in tropical deciduous and evergreen forests of northern Thailand', *Journal of Biogeography* **24**(3), 327-343.