DIVERSITY, ABUNDANCE AND DISTRIBUTION OF GROUND HERBS IN PRIMARY AND SELECTIVELY LOGGED FOREST OF DANUM VALLEY (NORTH EASTERN BORNEO)

DAVID MAGINTAN
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DAVID MAGINTAN
PS97-005-026

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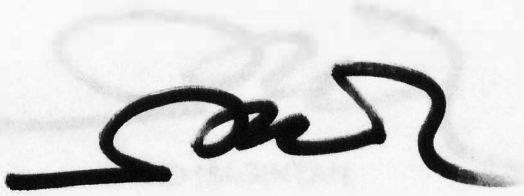

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PERAKUAN

Saya akui bahawa tesis ini adalah hasil kerja saya sendiri kecuali nukilan dan ringkasan yang tiap-tiap satunya telah saya jelaskan sumbernya.

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IBTP, UMS
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ABSTRACT

A research project on ground herbs was carried out in Danum Valley Field Centre (North-East Borneo). Studies on herbaceous plants are still very few, particularly in Sabah. Information on ground herbs is crucially important since destruction of their natural habitat is increasing every year. Such studies may increase the understanding of the ecology of ground herbs, which is also important for conservation purposes.

The present study on ground herbs was conducted in two habitats of lowland mixed dipterocarp forest. The sites were in primary (PF) and selectively logged forest (SLF). Twenty transects of 5 m x 100 m were placed in each area, which pooled totals of one hectare sampled in each habitat. In each transect, all species of ground herbs were recorded as well as the number of individuals. Five environmental factors were measured: level of disturbance, forest structure, canopy openness, degree of slopes and the leaf litter depth. The relationship between number of species and number of individuals and their environmental factors were analyzed using regression analysis.

A total of 187 species were recorded in which 133 were from primary forest and 152 were from selectively logged forest. Nineteen families of angiosperms and 18 families of pteridophytes were found. The percentage of species found in both sites was 59%. The difference in number of species between the two habitats was statistically significant ($F_{1, 38} = 4.140$, P=0.049, ANOVA). A total of 16,859 individuals were recorded from PF and SLF, of which 9588 individuals were from PF and 7271 from SLF. The difference in number of individuals was not statistically significant ($F_{1, 38} = 2.046$, P=0.161, ANOVA).

The regression analysis showed low R^2 value and that no factors had a significant effect on the number of species. The R^2 value for the regression analysis between number of individual and environmental factors was low (0.119).

Selaginella sp. 1 was found to be the most abundant making up 32% of ground herb in both forest types. The most species-rich angiosperm families were the Zingiberaceae with 35 species in total while 56 species of pteridophytes were recorded on both sites. The genus *Piper* had the highest number of species. The grass *Leptaspis cochleata* was the only species that occurred in all transects in SLF; in PF forest this grass of the forest was found in 19 of the 20 transects. Common species included *Mapania palustris*, *Globba pendula*, *Epipremnum falcifolium* and *Selaginella* sp. 1.

The results of this research revealed that selective logging does not destroy the forest completely but, in fact, leads to a more heterogeneous environment and creation of potential new microhabitats for certain species. More intense logging activities could lead to a massive destruction of the forest not just of canopy trees but also of the understorey.

ABSTRAK

Satu kajian tumbuhan herba telah dijalankan di Pusat Luar Lembah Danum (Timur Laut Borneo). Kajian tentang tumbuhan herba masih kurang terutamanya di negeri Sabah. Maklumat tentang tumbuhan herba adalah sangat penting kerana habitat semulajadinya semakin terancam tahun demi tahun. Kajian ini nanti akan membantu meningkatkan lagi kefahaman terhadap tumbuhan herba dan penting untuk tujuan pemuliharaan.

Kajian ini telah jalankan di dua habitat hutan iaitu di hutan primer (PF) dan hutan dibalak secara terpilih (SLF). Sebanyak dua puluh transek (5 m x 100 m) telah di letakkan di setiap kawasan kajian yang mana jumlah keluasan bagi setiap plot kajian adalah satu ha. Dalam setiap transek semua spesies tumbuhan herba direkodkan dan bilangan individu untuk setiap spesies juga kira. Lima faktor sekitaran telah di rekodkan iaitu tahap gangguan, struktur hutan, kecerunan, ketebalan sarap hutan dan bukaan kanopi. Kaitan antara bilangan spesies dan bilangan individu dengan faktor-faktor persekitaran dianalisis menggunakan analisis regresi.

Sebanyak 187 spesies telah direkodkan yang mana 133 adalah dari PF dan 152 dari SLF. Sembilan belas famili adalah dari angiosperma dan 18 famili dari kumpulan pteridofita. Peratus pertindihan spesies antara PF dan SLF adalah 59%. Perbezaan bilangan spesies antara dua habitat adalah signifikan secara statistik ($F_{1, 38}$ = 4.140, P=0.049, ANOVA). Sebanyak 16859 individu telah direkodkan dari PF dan SLF, yang mana 9588 individu dari PF dan 7271 dari SLF. Perbezaan bilangan individu di antara dua habitat ini adalah tidak signifikan secara statistik ($F_{1, 38}$ = 2.046, P=0.161, ANOVA).

Analisis regresi menunjukkan nilai R^2 (means of determination) yang rendah dan tidak ada faktor yang mempunyai kesan yang signifikan terhadap bilangan spesies. Nilai R^2 (means of determination) untuk analisis regresi antara bilangan individu dengan faktor sekitaran adalah rendah (0.119).

Selaginella sp. 1 merupakan spesies yang paling melimpah merangkumi 32% daripada jumlah semua individu kedua-dua habitat. Zingiberaceae merupakan famili dari kumpulan angiosperma dengan jumlah sebanyak 35 spesies, manakala, bagi pteridofita sebanyak 56 spesies telah direkodkan. *Piper* merupakan genus yang paling kaya dengan spesies. *Leptaspis cochleata* yang dikenali sebagai rumput hutan merupakan satu-satunya spesies yang dijumpai di dalam kesemua transek di SLF; manakala di PF spesies ini dijumpai di 19 daripada 20 transek kesemuanya. Spesies-spesies yang biasa dijumpai adalah *Mapania palustris*, *Globba pendula*, *Epipremnum falcifolium* dan *Selaginella* sp. 1.

Keputusan kajian ini menunjukkan aktiviti pembalakan secara terpilih tidak semestinya memusnahkan hutan sepenuhnya, tetapi, membentuk persekitaran yang lebih heterogen dan membentuk mikrohabitat spesies tertentu. Pembalakan yang lebih intensif membawa kemusnahan hutan yang bukan sahaja terhadap kanopi pokok tapi juga kepada tumbuhan lantai hutan.

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LIST OF ABBREVIATIONS

ANOVA	means	Analysis of Varians
c	means	circas, approximately
DBH	means	Diameter at Breast Height
DCA	means	Detrended Correspondence Analysis
df	means	Degree of freedom
DVCA	means	Danum Valley Conservation Area
DVFC	means	Danum Valley Field Centre
F	means	Ratio test statistic
ha	means	Hectare
km	means	Kilometer
m	means	meter
mm	means	millimeter
NE	Means	North East
P	means	Probability
PF	means	Primary Forest
R^2	means	Correlation coefficients squared
SLF	means	Selectively Logged Forest
sq	means	Square
U	means	Test statistics of the Mann-Whitney U-test
WWF	means	World Wide Fund for Nature

CHAPTER 1

1.1 INTRODUCTION

For thousands of years, rainforest has been a part of the human environment. At present, sometimes the forest remains intact but often it has been cut. Forests are very important, as they provides resources for the people (foods, materials and water) and are important habitats for wildlife. Tropical rainforests can be extremely rich in plant species. Of the total of approximately 250,000 species of flowering plants in the world, about two-thirds (170,000) occur in the tropics (Whitmore, 1998).

Up till now, the rainforest has been considered a perpetual resource because of its constant regeneration. However recently, forest destruction has been one of the hot topics and one of the main points of every convention. Relationship between human and the forest is one of the ecological aspects that has been studied in the Far East tropical rainforest particularly the last thirty years (Whitmore, 1991).

1.2 Forest destruction

Rain forest destruction is mainly caused by human activities. These activities can be logging, agriculture, and reclamation of land for various purposes such as airports, highways, and new development areas. Forest disturbance could lead to the reduction in

structural diversity of the forest. The reduction in structural diversity of the forest inevitably follows from human intervention with tropical rain forests as they are progressively simplified by increasing degrees of interference. One of the principal causes of disturbance to the rainforest of South East Asia is commercial timber utilization. Several systems of extracting timber from the forest have been implemented to reduce or to minimize the effects of logging activities to it surrounding. Selective logging is one of those system, which select and cut only large trees. Unfortunately, these trees may be widely spaced and are often situated deep in the forest. Therefore, although only a small proportion of the trees may be cut, the heavy machinery used for felling and transporting is estimated to damage a further 60 to 70 per cent (Howlett, 1989).

In this situation, the eventual effects are destruction of the fragile ecosystem. Streams and rivers will be loaded with silt from the erosion and leached minerals, ultimately, killing the organisms in their natural habitat. Such activities will also disturb the natural habitat of the wildlife and forcing them to move away.

Some native people still depends on the forest as resources for food, material for making houses or place to get their traditional products whether it is to be commercialized or for their own uses. Thus, destruction of the forest will cause loss of many vital ingredients upon which the local people live and depend.

Destruction of the forest would also mean the destruction of the way of life of native communities who depend on the forest. Unlike the old fashioned way of utilizing the forest for agricultural purposes which allowed small scale of regeneration,

nowadays, the destruction is so fast and the area involved so huge, that although regeneration is still possible, it would take many years to achieve.

Large trees take a long time to reach maturity, they may be widely scattered, and they may depend on other plants, insects and animals for their long-term survival. Very little is yet known about this ecological relationship, except that destruction of one organism may affect the whole structure of life within a forest ecosystem.

The expansion of the human population has become one of the reasons of the decline of the rainforest areas. Destruction of the pristine forest and expansion of secondary vegetation is caused by vast prospects of development, for example the railways, roads and farms. According to Whitmore (1997), FAO estimated that in 1990 there were 1,756 million ha of natural tropical forest, with the largest forest area (52%) located in the America and lesser amounts in Africa (30%) and Asia (18%). Furthermore, the total loss of all natural tropical forest, during the decade from 1981 to 1990 was 154 million ha, representing an annual loss of 0.81% of the 1980 total (Whitmore, 1997). Malaysia is one of the most productive tropical timber producers in the world especially for dipterocarps. As a result, Sabah state has almost depleted the virgin forest outside conservation areas, and Peninsular Malaysia is approaching this condition.

The forest depletion has been affecting the fauna of forest and some of the species are likely to have gone extinct. The habitat of many species of flora and fauna may become too small for them to survive in the long term, and numerous species occuring in that portion are becoming susceptible to extinction. Forest loss will result in

the extinction of species, and some of these could be of yet unknown or unutilized economic value (Whitmore, 1997), hitherto, research is badly needed to understand the many aspects of how plants interact with environment and learn how to manage the species that are going to be destined to extinction.

1.3 Research on ground herbs

The herbaceous ground flora of the rain forest, as well as the climbers, epiphytes, saprophytes and parasites, depend on other plants for mechanical support, or for nutrition and live under specialized condition (Richards, 1996). Some of the epiphytes have been much studied, due to their conspicuous adaptations to their environment, but there has less interest in the understorey plants. Interaction between the animal communities and some of the plants, creates great interest to the scientists to conduct research on them.

Research has been carried out on herbaceous plants which has underlined the importance to the people in terms of food resources, medicinal and now one of the most valuable for ornamental purposes. Herbaceous plants provide food and also shelter to particular animals or insects.

Forest understorey vegetation has been studied less than the woody component in the forest and there are lots more to learn from the forest floor particularly the herbaceous plants. Fewer researchers have focused on the forest floor vegetation than for example the canopy where in fact it has an equal role in term of some aspects of ecology. Consequently, attention should be made to the exploration of these rather

insignificant plants in order to comprehend the function of their presence to the forest ecosystem.

1.4 The objectives of the study

The objectives of this study are as follows:

i) To compare species richness, diversity and composition of ground herbs in primary and Selective logged forest.

ii) To relate the occurrence of species of ground herbs to environmental factors such as light intensity, forest component, level of disturbance, topography and the leaf litter depth.

iii) To make an inventory of ground herbs in the area around Danum Valley Field Center.

This study has several aspects. It is well known that herbaceous plants have been neglected both in taxonomy treatments as well as in ecological studies. Inventories are important to carry out in this area particularly on ground herbs since very few studies have been done on this group of plant. The documentation of the ground herbs in Danum Valley will provides general knowledge for scientists and others.

Species composition in primary and secondary forests might become different in many aspects after disturbance. Hence, a study on this group of plant is in fact needed. This study may help to understand how certain species are affected by the human activities. Apart from that, it could also illustrate how disturbance creates new habitats

where new comers of plant may eventually invade and perhaps drive some rare species to extinction.

CHAPTER II

LITERATURE REVIEW

2.1 What is a ground herb?

A tropical rainforest has many life forms, ranging from the trees of the lowland mixed dipterocarp forest to smaller herbs that are rooted in the ground. Ground herbs were discussed by Richards (1996) but not specifically defined. He concluded that the synusia of ground herbs is not synonymous with the ground flora or lowest (E) stratum of the forest. This is because the majority of the plants in the lower stratum (E) layer are young trees, shrubs and woody climbers. Whitmore (1984), has also revealed that the so-called 'herb layer' is actually mainly a synusia of tree seedlings. Kiew (1988b), tried to define ground herbs as small non-woody plants but is still inconsistant because longer living herbaceous plants in the tropics will may become woody with age. Hence, the distinction between herbaceous and woody plants is not clear-cut. Poulsen and Balslev (1991) discussed in more detail the life form strategy of ground herbs. In their study they use the term 'ground herbs' for a plant that at some stage during its life cycle may have individuals or stem part at ground level, rooted in the ground. Obligate terrestrial species are those, which found at ground level only and facultative terrestrials those which may have climbing part or be epiphytic at some stage in their life cycle.

2.2 Non-woody climbers and epiphytes

The present study includes, climbers that are non-woody which adhere to the tree trunks by specialized roots and may completely hide the bark beneath. They are called bole climbers. These climbers normally grow togather with epiphytes and hemi-epiphytes (Whitmore, 1998). Mostly, the bole climbers consists of species of Araceae and Piperaceae. They are humidity demanding, therefore, these families have less abundance in light zones. Occasionally, especially in deep shade, some shade-loving plant or skiophytes growing on the rocky areas or on tree buttresses. The numbers of epiphyte species increase with wetness of climate (Whitmore, 1998).

2.3 Ground herb morphology

Ground herbs have a varied morphology. Plants of compact habit, such as rosette plants, are rare and as might be expected from the uniformity of microclimatic conditions throughout the year, there are very few plants that form resting buds on or just below the soil surfaces. Many of the herbs elongated aerial stems will live for several years (Kiew, 1986). Plants with underground rhizomes or stolons are frequent, but the rhizome is adapted for multiplication and migration rather than perennation (Richards, 1996). According to Burtt (1977), some ground herbs are linked by areal shoots, which become prostrate and buried in the soil. In the Malayan forest, various Melastomaceae and many Zingiberaceae species form dense patches several square metre in extent. Adventitious root system is always found in many monocotyledons and this root system is successful, such as the ginger stems which sometimes can grow up to 5 meter as well as the leaves