UNIVERSITI PUTRA MALAYSIA

PHYTOSOCIOLOGICAL INVESTIGATIONS OF THE SOUTH FACING SLOPE OF GUNUNG LEDANG MONTANE FORESTS, PENINSULAR MALAYSIA

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Thesis Submitted in Fulfillment of the Requirements for the Degree of Master of Science in the Faculty of Forestry, Universiti Pertanian Malaysia

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PHYTOSOCIOLOGICAL INVESTIGATIONS OF THE SOUTH FACING SLOPE OF GUNUNG LEDANG MONTANE FORESTS, PENINSULAR MALAYSIA

By

EKARELAWAN

MAY, 1995

Chairman : Dr. Jamaluddin Basharuddin

Faculty : Forestry

Tree species (≥ 6 cm dbh) in forty 20 x 40 m sampling units (SUs) at the montane forests of Gunung Ledang were individually enumerated in terms of density, frequency, and basal area. Habitat factors (i.e. two of physiographic and six of soil factors) were measured. Physiographic factors measured for altitude and slope while soil factors for soil pH, soil moisture, total N, available P, and exchangeable K. The relationships between vegetation and habitat factors were investigated by canonical correspondence analysis (CCA). Two-way indicator species analysis (TWINSPAN) was used for vegetation classification.

A total of 100 species were recorded. The three most important species (based on importance value) are *Dacrydium beccarii*, *Gluta renghas*, and *Leptospermum flavescens*. Less important species include *Porterandia anisophylla*, *Cephalomappa lepidotula*, and

Fagraea racemosa. The average values of species number, density and basal area were relatively diverse among the SUs.

A gradient analysis of CCA showed that altitude is best correlated with species/SUs distributions. TWINSPAN clustered the forty SUs into two groups which were statistically interpreted by discriminant analysis revealing that species composition was strongly correlated with altitude and soil pH.

Abstrak tesis yang dikemukakan kepada Senat Universiti Pertanian Malaysia sebagai memenuhi keperluan untuk mendapatkan ijazah Master Sains.

KAJIAN FITOSOSIOLOGI HUTAN PEGUNUNGAN BAHAGIAN SELATAN GUNUNG LEDANG, SEMENANJUNG MALAYSIA

Oleh

EKARELAWAN

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Setiap individu pokok (perepang ≥ 6 cm) di dalam 40 unit persampelan berukuran 20 x 40 m hutan pegunungan di Gunung Ledang telah direkodkan padat pokok, kekerapan, dan luas pangkalnya. Faktor-faktor fisiografi dan tanah yang diukur meliputi ketinggian, kemiringan, keasidan tanah, kelembapan tanah, keseluruhan N, ketersediaan P, dan kapasiti dapat ditukar K. Hubung-kait antara vegetasi dan faktor persekitaran diduga dengan kaedah CCA. Kaedah TWINSPAN pula digunakan untuk pengelasan vegetasi.

Seratus spesis telah pun direkodkan. Tiga spesis yang paling penting (berdasarkan nilai penting) adalah *Dacrydium beccarii*, *Gluta renghas*, and *Leptospermum flavescens*. Spesis-spesis yang kurang penting adalah *Porterandia anisophylla*, *Cephalomappa lepidotula*, and *Fagraea racemosa*. Purata nilai jumlah spesis, perepang setinggi dada dan luas pangkal secara relatif bervariasi di antara unit-unit bancian.

Analisis gradient daripada CCA memperlihatkan bahawa ketinggian merupakan faktor yang paling kuat hubung-kaitnya dengan taburan spesis/unit-unit bancian. TWINSPAN mengelaskan empat puluh unit bancian ke dalam dua kelompok yang diinterpretasikan secara statistik dengan analisis diskriminan. Vegetasi pokok ditemui berhubung-kait sangat erat dengan ketinggian dan keasidan tanah.

ABBREVIATIONS AND GLOSSARY

Abbreviations

CCA	: Canonical correspondence analysis
DBH	: Diameter at breast height
IVI	: Importance value index
SU(s)	: Sampling unit(s)
TWINSPAN	: Two-way indicator species analysis
VJR	: Virgin jungle reserve

Glossary

Basal Area	: The area of cross section of a tree at height of 1.3 m above ground
Beta Diversity	: A measure to express the relative diversities among the communities
Biplot	: An ordination diagram of two kinds of entities (e.g. species and environment)
Classification	: An attempt for recognising and defining plant communities which subject to group together a set of sampling units on the basis of their floristic composition
Density	: Number of individuals in relation to the space in which they occur
Discriminant Analysis	: A statistical technique which involves deriving the linear combination of independent variables that will discriminate best between a priori defined groups
Dominant Species	: Species which characterise the community in its larger importance value
Eigen Value(s)	: Value(s) that represent(s) the relative contribution of each component/variable to the explanation of the total variation in the data
Floristic Composition	: The kinds of plant species, in aggregate, that occur in a community or in an area
Flora	: The plant life of an area
Frequency	: Probability of finding the species in any one sampling unit
(General) Diversity	: Relative rich ss in number of species

Importance Value : Sum of relative density, relative dominance and relative frequency for a species in the community

Ordination : An attempt for ordering of sampling units in relation to each other in terms of their similarity of species composition and/or their associated environmental factors

Sampling Unit : Unit (quadrat) where vegetation and habitat measurements are undertaken

Structure : An expression of the life forms of community together with their spatial relationship

Unimodal Model : Model of relationships between species occurrences and values of a quantitative environmental variable conform to bell-shaped curves

Vegetation : Plants in general, the total aggregation of plants

CHAPTER I

INTRODUCTION

There are three great regions of tropical rainforest in the world: the American Rainforest, African Rainforest and Indo-Malayan Rainforest. The structure of various kinds of rainforest and the physiognomy of the species are similar throughout the world, in all three regions. Despite this similarity there are important differences. The Indo-Malayan region has a larger mountainous region compared to the American and African Rainforest (Richards, 1952).

A large part of the Peninsular Malaysia area is mountainous and papers have been published concerning the malayan mountain forests. Many of these works however are mainly short descriptive accounts based on the qualitative analysis of floristic data.

In Peninsular Malaysia undisturbed or minimally-disturbed montane rainforest communities are few and scattered in isolated areas. On all major mountains, at least two formations develop: lowland forest and upper montane forest. The upper montane forest differs from lowland forest in having a lower canopy, with fewer, smaller emergent trees, and is characterised by microphyll-dominated trees, with a low, flattish canopy surface, usually with gnarled limbs, and very dense subcrowns (Whitmore, 1984). One such montane rainforest exists on Gunung Ledang (1276 m) in northwest Johore.

A thorough understanding of the ecological processes involved in maintaining the existence of the forest at Gunung Ledang and a knowledge of the plant communities that occur there is required as a basis for the formulation of management strategies necessary for its conservation. The study focuses on the upper montane forest, using the techniques of phytosociological studies, which subject floristic data of communities to classification and ordination procedures.

The present study was developed in response to an obvious lack of phytosociological information on tropical montane forests. Gunung Ledang was chosen because of its unique plant communities and because of the area has virgin jungle reserve (VJR) status.

Obviously, there are many situations where vegetation merits study. The results of this study hopefully provide the basic data for biological conservation and management. The objectives of this study, therefore, are:

1) to find out what tree species occur;
2) to investigate the horizontal structure of plant communities;
3) to attempt to classify and ordinate the tree species and plant communities observed;
3) to identify some physiographic and soil factors that may play a role in determining the tree species distributions and plant communities in the study area.

CHAPTER II

LITERATURE REVIEW

General Phytosociological Studies

The term 'phytosociology' is practically synonymous with `vegetation science' (van der Maarel, 1979; Westhoff, 1979; Jahn, 1982). It has been defined by Braun-Blanquet (1932) as a science of plant communities or a knowledge of vegetation in the widest sense, including all phenomena which touch upon the life of plants in social units. More usually however, the term is taken to mean the study of sets of species forming communities (Lambert and Dale, 1964). It can be divided into the following subdivisions (Westhoff, 1979): (1) Symmorphology, (2) Synecology, (3) Syndynamics, (4) Synepiontology, (5) Synchronology, and (6) Syntaxonomy or Synsystematics.

Phytosociology is useful for describing vegetation (Poore, 1962). Lambert and Dale (1964) thought of phytosociology as a scientific investigation rather than a description of vegetational relationships. Later, Pignatti (1980) identified three approaches to phytosociological studies: (i) the autecological approach, (ii) the synecological approach, and (iii) operational deductions. The first two approaches correspond with finding out the information on the ecology of site by an individual species and an assemblage species, respectively. The third approach is based on the assumption that each species has common ecological space and an assemblage of species can be recognised in nature and individual sites with corresponding ecology.

The earliest methods used in phytosociological studies were based on sorting floristic data tables by hand and have often been described as `subjective'. Since the advent of computers in the late 1950s and early 1960s various numerical methods based on mathematics and statistics have been devised, and these are described as `objective' (Kent and Coker, 1992). Numerical (objective) methods are categorised as either `classification' or `ordination' methods (van der Maarel, 1979).

Classification may be taken as indicating the similarities and differences among the individuals actually studied (MacNaughton-Smith, 1965). It involves ordering or arranging objects into groups or sets on the basis of their relationships, that is, of their associations by contiguity, similarity, or both (Sokal & Sneath, 1963; Cormack, 1971). In plant community ecology the aims of classification are: 1) to give information on the concurrence of species, 2) to establish community types, and 3) to detect community variation with respect to environmental variables (van Tongeren, 1987).

Classification involves the following stages: the definition of sampling units (SUs), from which various types of data are obtained, a computation of the ecological resemblance between all pairs of SUs, in order to quantify their similarity or dissimilarity, and the grouping of SUs according to their resemblances (Ludwig &

Reynolds, 1988). These groups are then interpreted and used to define a set of plant communities for the area under study (Kent and Coker, 1992).

In general, classification of ecological communities often provide a useful way of summarising (large) data structure (Digby and Kempton, 1987; van Tongeren, 1987), particularly when complemented by the process of ordination (Digby and Kempton, 1987).

Ordination is broadly referred as to an `ordering', in any number of dimensions (preferably not too many), that approximates some pattern of responses of the set of objects (Digby and Kempton, 1987). For vegetation data the objective of ordination is normally to generate hypotheses about the relationships between the species composition and underlying environmental factors (Greig-Smith, 1983; Digby and Kempton, 1987).

Two distinct approaches to ordination can be recognised: 1) *Direct gradient analysis*, and 2) *Indirect gradient analysis* (Whittaker, 1967; Gauch, 1982). Direct gradient analysis is used to display the variation of vegetation in relation to environmental factors by using environmental data to order the vegetation samples. The environmental data are used directly to organise the information on vegetation. The term indirect gradient analysis is applied to techniques which operate on a set of vegetation data by first examining the variation within it. The environmental data are then compared and correlated with the summarised vegetation data in order to detect possible environmental gradients (Kent and Coker, 1992).

Ordination is useful for recognizing orderly patterns in vegetation. It must then be combined with environmental information and classification techniques to gain a more complete description and understanding of the community (Kelmann, 1980; Krebs, 1989). Ordination is sometimes considered an alternative to classification. This is because grouping stands into classes may result in an apparent discreteness that does not really exist in nature. An ordination of sample stands will expose the relative continuity or discontinuity among them (Mueller-Dombois & Ellenberg, 1974).

Researchers often face a problem in choosing between classification or ordination. Whittaker (1956) stated that classification and ordination are mutually complementary. To Goodal (1963) the idea of ordination is not consistent with that of classification. Greig-Smith et al. (1967) asserted that theoretical considerations suggest that the choice between classification and ordination should rest on the level of vegetation variation in the set of stands being analysed and this is confirmed in practice. Orlóci (1978) added that both classification and ordination should not be regarded as preferential strategies associated with rigid assumptions, but rather, as techniques which, among the many available different techniques of data analysis, can help the user to accomplish certain objectives.

There are currently a large number of different numerical methods available in the form of computer programmes for analysis of vegetation data. In Britain and North America TWINSPAN (Two-Way Indicator Species Analysis) is currently the popular method for community classification, while DCA (Detrended Correspondence Analysis) and CCA (Canonical Correspondence Analysis) are the most widely applied methods for ordination (Kent and Coker, 1992).

TWINSPAN is based on the basic idea of phytosociology that various groups of sites can each be characterised by a group of different species. This method employs Reciprocal Averaging Ordination. Based on information provided by ordination axis, TWINSPAN program by Hill (1979) not only classifies the sites but also constructs an ordered two-way table from a sites-by-species matrix. These features in TWINSPAN have made it one of the most widely used programs in community ecology (van Tongeren, 1987; Causton, 1988).

TWINSPAN is a divisive polythetic method - the most popular classification method at present time. This type of classification is superior to an agglomerative method because one is starting with the entire data set and successively fragmenting it, while in the latter one start with fragments and have to build up the whole. Further, a polythetic method also uses the information carried by several attributes (species) compared to monothetic method which utilizes the information from one attribute (Causton, 1988) .

DCA and CCA were developed from the idea that the species show unimodal relationships with environmental variables (ter Braak, 1987). CCA, however, is more powerful in detecting relationships between species composition and environment (ter Braak and Prentice, 1988). Unlike DCA, CCA is a direct gradient analysis technique. Direct gradient analysis differs from indirect gradient analysis in that species composition is directly related to measured environmental variables (Palmer, 1993). However, CCA may only performed effectively if a good set of environmental data has been collected for the samples in the analysis (Kent & Coker, 1992).

Phytosociological studies can be categorised as either academic or applied. In the former case vegetation is described and analysed largely for its own sake, whereas applied studies have the aim of providing information of relevance to some ecological problem (Kent and Cooker, 1992). The recent studies of Hill (1991), Heikkinen (1991), Zobel (1993), and Diamantopoulos (1994) are examples of a primarily academic survey of vegetation and its variation in relation to environmental factors. Sairanen's (1990) and Nakashizuka et. al.'s (1991) studies are examples of applied studies.

Phytosociological data have yielded considerable information on community-environment relationships of the community in temperate regions, as well as adding considerably to knowledge about the autecology of many species. In tropical forests phytosociological studies have faced problems in the extraction of ecological information from a long list of species each of which is poorly known autecologically (Knight, 1975). Within rainforests the assemblage of species apparently shows little response to environmental factors (Greig-Smith, 1971). This has led to idea that within rainforest there is little control by environment, which, in turn, has strongly influenced thinking on speciation (Fedorov, 1966, Greig-Smith, 1971).

Notwithstanding it is possible to define site indicator species from rainforest data (Ashton, 1964), although high species diversity makes it difficult to identify indicator species (Poore, 1964; William and Webb, 1969). In general, phytosociological studies in tropical rain forest have mostly focused on identification and causes of floristic patterns in relation to succession and site (Knight, 1975).

Studies of Tropical Montane Rainforest

Montane rainforest of the tropical regions, particularly in South East Asia, has been studied scientifically since the middle 19th and the early 20th centuries. Wallace (1854), and Ridley (1901) explored the flora of Mount Ophir (Gunung Ledang) in northwest Johore, Malaysia. Gibbs (1917) contributed to the phytogeography and flora of the Arfak mountains, Irian Jaya, Indonesia. Brown (1919) studied extensively the environment and physical characteristics of vegetation at different altitudes on Mount Maquiling and Mount Banahao, Luzon, Philippines.

It is known that in montane forest there is a continuous change in the vegetation formation in relation to environmental gradients (Richards, 1952; Grubb et al., 1963), which conveniently regarded as altitudinal zonation. The vegetation formation types recognized on the tropical mountains and the characters used in their classification are summarized in Table 1 (Grubb, 1974). In Peninsular Malaysia, there are three important altitudinal vegetation zones: Lowland Rainforest, Lower Montane Forest and Upper Montane Forest (Whitmore, 1984). These vegetational zones, however, do not show conspicuous demarcation (Soepadmo, 1971; van Steenis, 1984).

The altitudinal zonation of tropical rain forests has been the subject of numerous studies. Many classifications, with varying terminologies, have been proposed and several factors affecting the

Table 1

The Vegetation Formation Types on Tropical Mountains and the Characters Used in Their Classification

Formation type	Lowland rain forest	Lower montane rain forest	Upper montane rain forest	Subalpine rain forest
Height of forest[a] (m)	24-45(-67)	15-33(-45)	1.5-18(-26)	1.5-9(-15)
Dominant leaf-size class of trees and shrubs	mesophyll	notophyll or mesophyll	microphyll	nanophyll
Buttresses on trees	usually frequent and large	infrequent or small or both rare	usually none	none
Cauliflorous tree	frequent	rare	none	none
Compound leaves on trees	abundant	occasional	few	none
Drip tips on leaves	abundant	frequent or occasional	few or none	none
Climbers	thick-stemmed woody species frequent	thick-stemmed woody species usually none; other species often frequent	usually very few	very few
Vascular epiphytes	frequent	abundant	frequent	occasional

[a] emergents in parentheses

Source: Grubb, 1974

altitudinal zonation have been reported (Grubb et al., 1963; Holdridge et al., 1971; Grubb, 1974).

Some authors regard air temperature as the main factor determining the gradual change in forest formation in tropical mountains