E-1. Analysis of the Environment and Structure of the Ecosystem of Tropical Forest

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Abstract
(1) Population structure and dynamics of trees in hill forest: A study plot was established in the Semangkok Forest Reserve. Trees larger than 5 cm DBH (diameter-at-breast height) were tagged and measured. Saplings of *Shorea curtisii*, *Teijsmanniodendron coriaceum* and *Diospyros venosa* were abundant. Small sized saplings of *Lithocarpus wallichianus*, *D. latisepara*, *Antidesma cuspidatum*, and *Vatica odorata* were not found. While no large sized saplings of *D. latisepara*, *Eurycoma longifolia*, *Scaphium macropodum*, and *Xanthphyllum griffitii* could be observed. There were marked differences in soil resistances at different topographical conditions. On the ridge, the soil resistance was large while on the lower slope resistance was small. There was no apparent difference in the vertical changes of resistance between the directions of slope.
(2) Structure of insect communities: Five plots along the gradient from the forest edge to the core were set in the Pasoh Forest Reserve. In every plot, 18 black collision traps were set at 1.5 m high and at about 10 m intervals in a line. Collected ambrosia scolytids were sorted and identified. Forty-five morpho-species of the ambrosia scolytids were caught; *Xyleborus* (32 spp.), *Arixyleborus* (5), *Xylosandrus* (4), *Webbia* (2), *Cnestus* (1) and *Eccoptop~erus* (1). There was no marked difference in species richness between plots, though the similarity value changed gradually along the gradient. Species composition and richness of the ambrosia scolytids were essentially unchanged from the edge to the core. *X. crassiusculus* increased gradually from the core to the peripheral area. Catches of *X. crassiusculus* decreased exponentially with minimum distance from the forest edge.

Key Words Hill Forest, Vegetation, Species Composition, Ambrosia Scolytids, Insect Community

1. Introduction

The knowledge on the structure and function of tropical forest is required to initiate the study on the effects of deforestation and/or reforestation on the environment. Based on this concept, the following basic surveys were done in this study: (1) determination of population structure and dynamics of major tree species in hill Dipterocarp forest, (2) description of the insect fauna.

(1) Population structure and dynamics of trees in hill forest

It is well known that there is no remarkable difference of species richness between lowland and hill Dipterocarp forests, though the hill forest is often characterised by the dominant species[7]. Several major tree species have an important role in community organization and matter production in the hill forest. The purpose of this study is to clarify the population structure and dynamics of such major tree species. For this purpose, we surveyed the regeneration process from seed production and seedling establishment to accumulation of saplings. We also tried to clarify the influence of soil properties to the population structure and dynamics of major tree species. Spatial distribution of each species would be strongly affected by topography of the site. To determine the relationship between vegetation and topography in the Semangkok plot a floristic component analysis was carried out.

(2) Structure of insect communities

Fragmentation of forests often threatens the persistence of some species and natural ecological systems. It will have greater effects in the tropics than elsewhere, but adequate empirical data are lacking[8]. In order to understand and assess the artificial impacts on organic communities of tropical rain forests, we should clarify the functions and community structure of the invertebrates that are expected to be playing important ecological roles. In this study, we focus our attention on the wood-boring beetles (early wood-decomposers), flower-visiting beetles (pollinators) and parasitic Hymenoptera (predators of insect grazers and decomposers). In this report, we describe the community structure of a group of early wood borers, "ambrosia beetles", which usually bore into weakened or freshly dead parts of trees and saplings; they transmit symbiotic fungi and cultivate them in wood for the progeny[4]. To assess the edge effects on the community of ambrosia beetles inhabiting a virtually isolated natural forest, we surveyed the diversity of trapped ambrosia scolytids along the gradient from the forest edge of the Pasoh Forest Reserve to its core area.

2. Materials and Method

(1) Population structure and dynamics of trees in hill forest

A study plot was established in the Semangkok Forest Reserve (N 3°36'21.8", E 101°44'29.3"). It covers an area of 28 ha Seraya ridge forest with an elevation of 300m to 520m [11]. All trees larger than 5 cm DBH (diameter-at-breast height) were tagged and DBH were measured on March, 1993. Seed production, seedling establishment, and Sapling 1 (lower than 30 cm height) were examined in the 2 ha core area, Sapling 2 (30 cm-200 cm in height) and Sapling 3 (larger than 2m in height, smaller than 5 cm in DBH) were tagged and measured in 600 sub-quadrats (1 x 4 m) in the 6 ha plot at every 10 m.

Vertical changes in soil resistance to penetration from soil surface to 100 cm depth were measured with Hasegawa-type penetration meter at 176 points at the red pegs set every 20 m in March 1993. The soil resistance to penetration was calculated from penetrated depth of a core with 3.14 cm^2 in section area by 0.5 kg in penetration energy.

The two hectare core plot was divided into fifty 20 x 20 m quadrats, quadrats 0 to 49, and vegetation similarity indices were calculated among every quadrat by Similarity Ratio (SR[6]) for the most abundant 200 species. Based on SR matrix a special cluster analysis that restrict cluster fusion to spatially adjacent blocks was performed. By this process, we tried to get mosaic structure in the plot.

(2) Structure of insect communities

In the Pasoh Forest Reserve, we fixed 5 plots along the gradient from the forest edge to the core (Fig. 1). In every plot, 18 black collision traps ("Sankei Type") contained 25 ml of 99 % ethanol were set at 1.5 m high at about 10 m

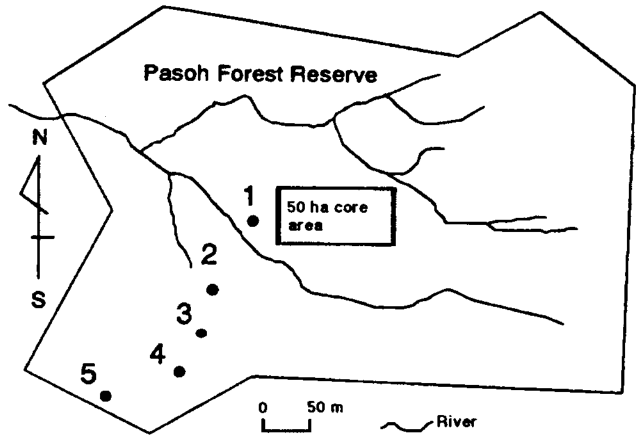

Fig. 1. Map of study site

intervals in a line. Trapping was conducted for three weeks from March to April, 1983. All catches of ambrosia scolytids (Scolytidae: Xyleborini and Eccoptopterini) were sorted into morpho-species and identified. Species richness at every plot was measured by the number of species and the Q statistic[6]. The dominant component of diversity (unevenness of relative species abundance) was estimated by the Berger-Parker index (the proportion of the most abundant species)[2] and the Simpson's index[9]. The Sorensen index based on quantitative data[3] was used as a similarity measure between plots.

3. Results and Discussion

(1) Population structure and dynamics of trees in hill forest

Shorea curtisii, Teijsmanniodendron coriaceum and *Diospyros venosa* had abundant sapling populations which means a successive regeneration in the plot. *Lithocarpus wallichianus, Diospyros latisepara, Antidesma cuspidatum*, and *Vatica odorata* had not Sapling 1. Lack of Sapling 1 population mean that these species could not regenerate recently or their seedlings quickly grew out this stage. *Diospyros latisepara, Eurycoma longifolia, Scaphium macropodum*, and *Xanthphyllum griffitii* lacked Sapling 3 stage. Individuals of this stage compete with Bertam palm (*Eugeissona triste*), because foliage of the palm overlapped with that of Sapling 3 stage. Bertam palm, which is very abundant in the hill forest, has an important role to the structure and dynamics of the tree populations.

There were apparent differences in the soil resistance according to the topographical conditions. On the ridge, the soil resistance was very large even in the top soil from the surface to 20 cm depth. On the other hand, the lower slope soil resistance was very small even in the subsoil under 100 cm depth, and showed small vertical change with depth. On the mid-slope, the soil resistance became larger gradually from sub-soil under 20 cm depth. There was not apparent difference in the vertical change between on the eastern slope and on the western slope.

The thickness of the soft soil showed the clear corresponding to the topography, namely the soft soil was thin on the ridge and on convex slope, and thick on the lower slope and on concave slope. On the concave slope, the soft soil was thick whether near the ridge or near the bottom.

The soil resistance to penetration influences to the root growth of seedlings. Then the thickness of the soft soil probably affects the depth of the rooting zone of seedlings and the survival rate of current-year seedlings in the dry season.

Cluster fusion continued until maximum SR became less than 0.1 and 50 quadrats were fused into 11 blocks. Each block was named by smallest number of quadrate contained. These blocks have fairly good correspondence with topography; block no. 4 corresponds to the major ridge, no. 5 to a minor ridge and no. 17 to a valley.

S. curtisii was detected in every block but mainly in the block 4. Densities of *Scaphium macropodum* and *T. coriaceum* were high in the block 0. That of *V. odorata* was high in block 4. *Vitex quinata* occured almost completely in block 17. Mean soil thicknesses in blocks 0, 4 and 17 were 40, 33 and 89 cm, respectively and this might have a direct effect to determine distribution of each species through the effect of seedling establishment and survivorship.

(2) Structure of insect communities

Forty-five morpho-species (1583 individuals) of the ambrosia scolytids which belong to the genera *Xyleborus* (32 spp.), *Arixyleborus (5)*, *Xylosandrus* (4), *Webbia (2)*, *Cnestus (1)* and *Eccoptop~erus (1)*, were caught in the survey.

Table 1 Diversity of ambrosia scolytids (*Xyleborini* and *Eccoptopterini*) caught in ethanol traps in the Pasoh Forest Reserve, March - April, 1993. The plot numbers see Fig.1.

	P1	P2	P3	P4	P5
(A) Species richness					
Number of species	22	23	23	23	22
Q statistic	8.0	8.4	7.2	8.4	6.7
(B) Species dominance					
Berger-Parker index	0.20	0.36	0.54	0.71	0.86
Simpson's index	0.11	0.25	0.32	0.51	0.74
(C) Species dominance (exc. *X. crassiusculus)*					
Berger-Parker index	0.23	0.53	0.31	0.24	0.29
Simpson's index	0.16	0.62	0.14	0.10	0.13
(D) Proportion of *X. crassiusculus*	0.16	0.36	0.54	0.71	0.86

As shown in Table 1 (A), there was no marked difference in species richness (the number of species and the Q statistic) between plots. Although the similarity value changes gradually along the gradient from Plot 1 to Plot 5, it was virtually constant between plots when a predominant species *Xylosandrus crassiusculus* was excluded (Table 2). These indicate that species composition and richness of the ambrosia scolytids are essentially unchanged from the forest edge to its core.

The Berger-Parker and Simpson's dominance indexes obviously increased along a gradient from Plot 1 to Plot 5 (Table 1 (B)). This was largely due to the gradual increase of X. *crassiusculus* from the core area to the peripheral area of the forest because the dominance measures did not changed along the gradient if this species was omitted (Table 1 (C)). Catches of X. *crassiusculus* decreased exponentially with minimum distance from the forest edge.

No edge effect was noted on species richness of the ambrosia scolytids, but the species abundance distribution was obviously affected mainly by the gradual increase of the predominant species X. *crassiusuclus*. The Pasoh Forest Reserve is largely surrounded by oil palm plantations where we have observed the reproduction of X. *crassiusculus* in fallen leafstalks of oil palms. The species may also propagate in the surrounding copsy areas which are often disturbed by farmers. It is thus most likely that the vast flux of X. *crassiusculus* exists from artifcially disturbed bordering areas into the reserved forest.

According to Browne[4], *X. crassiusculus* (as *Xyleborus semiopacus)* extends from Japan through Malaysia and across trop

Table 2 Similarity of ambrosia scolytids in the Sorensen index using quantitative data between Plot 1 and other plots and between Plot 5 and others.

	P1	P2	P3	P4	P5
(A) All species					
P1	1.00	0.57	0.55	0.39	0.24
P5	0.24	0.28	0.34	0.57	1.00
(B) Excluding X. *crassiusculus*					
P1	1.00	0.59	0.62	0.61	0.68
P5	0.68	0.46	0.61	0.63	1.00

ical Africa, and this ambrosia scolytid is fairly polyphagous and breeds in more than 30 families of woody species. The ambrosia scolytid most usually infests cut small stems and fallen branches, but it also attacks living young trees. It is generally known that ambrosia beetles are associated with not only symbiotic fungi but also other miscellaneous fungi and bacteria [1]. Thus influx of the ambrosia beetles with associated microorganisms may cause unpredictable deterioration of the natural ecosystem in isolated forests. Further intensive researches are necessary on ecological functions and behavior of the ambrosia beetles in tropical forests.

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