E-3.3 Roles of Plant Communities and Soil Organisms in Soil Formation

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Abstract Soil formation was investigated by revealing the supply of plant litter and the organization of soil animal communities on the forest floors of two forests of Peninsular Malaysia. One of the study sites was the Kepong campus of Forest Research Institute of Malaysia at Kuala Lumpur and another was the Pasoh Forest Reserve at Negeri Sembilan. Supply of plant litter at Kepong changed seasonally. The highest monthly litter fall was 2.3 t/ha and the annual total was 12.0 t/ha. The standing stock of soil organic matter was 4.9 t/ha, thus the annual turnover rate was 2.4. This value indicated the rapid decomposition of plant litter on the forest floor, although it was situated in the lower range of turnover rates reported about lowland tropical forests. Soil animal communities were composed of various groups. In number, Collembola and Oribatid mites were predominant. In weight, termites and ants were predominant. Collembolans were separated into the soil-dwelling species and the surface-dwelling species. The former took organic debris mainly and the latter took fungi mainly. Decomposition of wood pieces in 5 cm diameter showed that the decay constant was about 0.2, suggesting the very slow process. Based on the present results, further researches would proceed to evaluating the importance of each factor such as termites, collembolans, tree species, etc. in the process of soil formation.

Key Words Litter, Termite, Collembolan, Decomposition, Dipterocarpacae

Soil formation in tropical rain forests has been studied by measuring the supply and disappearance rate of plant litter on the forest floor. These studies have revealed that the decomposition of plant litter is very rapid. That is why the soil layer is poorly developed in tropical rain forests, although the litter supply is also high.

Plant litter is supplied from trees as in the form of leaves, twigs, branches and trunks. The supply rate has been measured in some of tropical rain forests. There are seasonal variations in weight and nutrient contents.

Soil animals decomposing plant litter have been listed and revealed about their general ecology. Soil animals involved in litter decomposition are termites, earth worms, collembolans and vice versa. The role of termites has been regarded as important in the rapid decomposition of plant litter, thus in the poor development of soil layer.

The general view of soil formation in tropical rain forests has been well described in the previous researches. Many factors, however, concerning the soil formation have not been well analyzed separately. We have much floral knowledge of the forests, but we have poor accurate data about in which species leaves are rapidly decomposed, and, on the other hand, in which species they are slowly decomposed for. As mentioned above, termites are one of the important decomposers, but it is not known accurately which type of plant litter they are most effective to. Since the general view has been established by measuring the litter supply and decomposition as a total mass, the dynamics of each factor working in the process of soil formation and their interactions are poorly known.

To solve this problem, experimental procedures are one of the most effective measures. Before, however, proceeding to the experimental procedure, it is necessary to reveal the overall aspect of soil formation by measuring the supply of plant litter and collecting the soil fauna.

Study Sites and Methods

The present study was conducted at two sites in Peninsular Malaysia. One was located at the Kepong campus of Forest Research Institute of Malaysia (FRIM) in Kuala Lumpur. The forest was artificially planted and is mainly composed of trees of Dipterocarpacae. Another site was located at the Pasoh Forest Reserve in Negeri Sembilan State. This forest is the mixture of primary and secondary forests and one of the major components of tree flora is also Dipterocarpacae, but the species diversity of trees including many non-dipterocarps is much more diverse than at Kepong site.

Climatic conditions of two sites are not clearly different from each other, but it is drier at Pasoh than at Kepong. Peak rainfalls are generally recorded in around April and November. The annual rainfalls range 1,500 - 2,500 mm.

Both at Kepong and Pasoh, a 25 x 10 m plot was established for sampling plant litter and soil animals. Ten litter fall traps were set in the plot. The trap was cone-shaped and had the mouth of 0.5 m^2. The litter was collected at monthly intervals. Soil animals were sampled also at monthly intervals. Fifteen core samples of soil were collected among 20 subplots in the plot on each occasion. The sampling schedule began from July 1991.

Soil animals were extracted using a Tullgren funnel extractor in the Entomological Laboratory of FRIM, Kepong. Extraction was carried out at 40 ℃ over five days. The soil sample was put into a funnel and dried with a heater and an electric bulb. Animals in the soil escaped from it and fell into an ethanol solution in a glass vial place below through the outlet of the funnel. The animals were identified into some taxa. Collembolans were identified to the species level. Counting and identification were done in the Forest Ecology Laboratory of Kyoto Unversity.

Feeding habits of collembolans were studied by the gut contents analysis. Collembolan specimens collected from the core samples were used for the analysis of gut contents. Gut contents of individual specimens were examined under a microscope with a grid eye piece having 100 squares.

Several pieces of small tree trunk were set at two sites for measuring the decomposition rate of wood litter. At Kepong, a young tree of *Dryobalanops aromatica* in a diameter of 5 cm was cut and separated into 20-cm long pieces. At Pasoh, a young tree of *Quercus gemelliflora* was cut and separated into 20-cm long pieces. They were tied with iron angles and, at Kepong, half of them were hanged above the ground. The setting place was in a nearly-pure *D. aromatica* forest at Kepong and in a mixed secondary forest at Pasoh. This work began from March 1990. The wood pieces were weighed at intervals of three or four months.

Results

Soil Structure

Soil organic layer is an important food and habitat resources for the organization of soil animal communities. In the two study sites, the accumulation of organic matter was studied over one year period from July 1991 to June 1992. The amounts of soil

Table 1. Accumulation of soil organic layers in the study sites.

Study site	Forest type	Humus type	Amounts (t/ha)
Kepong	Dipterocarpacae forest (*Dipterocarpus baudii* plantation)	Mull	4.9
Pasoh	Dipterocarpacae forest (mixed)	Mull	4.3

organic layer accumulation are shown in Table 1.

The amounts of soil organic layer were 4.9 and 4.3 t/ha at Kepong and Pasoh, respectively. At both sites, the soil organic layer showed a mull types humus accumulation and consisted mainly of leaf and branch litters. The developments of F and H layers were very poor. The results showed that the accumulation of soil organic matter was very poor in the study sites.

The poor development of soil organic layers may have been characterized by the rapid decomposititon of litter by the microbial organisms. These characteristics of soil structure may be reflected on the organization of soil animal communities.

Litter fall

Litter fall pattern is summarized about Kepong site in the present report. It showed a large seasonal change. Monthly litter fall exceeded 0.5 t/ha except in August. Peak litter fall was recorded in October and June. The highest peak was 2.3 t/ha in June. The annual litter fall was 12.0 t/ha.

The comparison of litter fall and soil organic layer showed a rapid turnover of organic matter on the forest floor in the study site. The annual turnover rate of organic matter was calculated by the following formula,

Annual turnover rate = [Annual average standing stock of soil organic matter]/[Annual litter fall]

The annual turnover rate was 0.5. The result showed the rapid decomposition of soil organic matter supplied to the soil in the forest.

Soil animal communities

Abundances and composition of soil animals at Pasoh site is reported in the present report. Abundances of soil animals ranged from 12,300 to 16,800 individuals per 1 m^2 with a mean of 14,000 individuals per 1 m^2.

Soil animal communities consisted of various animal groups. The dominant animal groups were Collembola, Oribatid mites, ants, Mesostigmata, Prostigmata and termites. Among these soil animals, Collembola and Oribatid mites were predominant and accounted for about 45 to 60% of total soil animals. In the biomass, termites and ants were predominant in the soil animal communities.

The abundance of soil animal have been estimated in various soils in the tropical forests. The abundances of soil animals are generally lower in the tropical forest where there are poorly developed soil organic layer. At Pasoh, the accumulation of soil organic layer were about 4.3 t/ha. The amounts of soil organic layer were related to the low abundances of soil animals at Pasoh.

Collembolan communities

Collembola was a predominant soil animal group at Pasoh. Twenty-nine species were recorded from our collection.The community was characterized by a dominance of a few abundant species. Two cosmopolitan species, *Isotomiella minor* and *Folsomina onychiurina*were predominant and accounted for about 33% (1,708 indiv./m^2) and 13% (657 indiv./m^2)of total abundance, respectively. The genus *Lepidocyrtus* was high in species number and these species were all endemic or Asian tropical species. Collembola community at Pasoh was consisted of two groups, i.e. the abundant cosmopolitan species, *Isotomiella minor, Folsomina onychiurina* and *Folsomides purvus;* and the diverse endemic species, *Lepidocyrtus* spp. and *Pseudosinella* spp.

Feeding habits of Collembola

Gut contents of collembolans were mainly classified into fungi or organic debris. Other food items were negligible in their contents.

Comparing gut contents between the soil dwelling species (*I. minor, F. purvus, F. onychiurina*, etc.) and the surface dwelling species (*Lepidocyrtus* spp., *Pseudosinella* sp., etc.), there were remarkable differences. The soil dwelling species took organic debris mainly and the suface dwelling species took fungal components mainly.

Wood decomposition

Wood pieces were gradually decomposed in appearance. Decay constant (k) was determined from wet weight changes in the following formula,

$$W_t = W_0 * e^{-kt}.$$

where W_t is the remaining weight of wood piece at time t and W_0 is the weight at the start (t = 0).

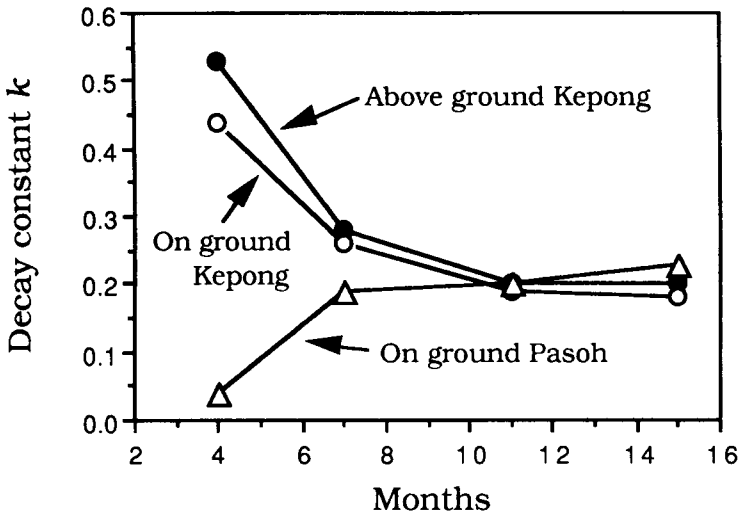

Fig. 1. Changes in decay constant k in relation with months passing after decomposition began.

Changes in decay constants were shown in Fig. 1. There was a big difference of decay constants between Kepong and Pasoh four months after the decomposition began. Seven or more months after, however, the constants showed little difference.

At Kepong, the pieces hanged above the ground were not attacked not only by termites, but by detrivorous beetles, while those put on the ground were all attacked by termites. The decay constants after 15 months were 0.20 above the ground and 0.18 on the ground. It seems that drying and leaching processes were important in weight loss of wood pieces in the present study.