E-3.3 Roles of Animals in Soil Formation

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Abstract Decomposition processes of wood and leaf litter were investigated as a source of nutrients for tree growth in lowland rain forests of penninsular Malaysia. By trapping plant litter in the forest for a few years, seasonal dynamics of plant litter supply to the decomposition process on forest floors were revealed. Amount of soil organic matter was also measured to estimate the amount of litter decomposed. The plant litter supply was almost doubled, but the amount of soil organic matter was low compared with temperate forests. So, the amount decomposed annualy was estimated to be twice as those of temperate forests. It is concluded that abundant supply and rapid decomposition of plant litter is a characteristic of tropical forest ecosystem.

Termites were predominant among soil animals involved in decomposition. On the other hand, collembolans, one of the minor fauna, reflected high activity of decomposing fungi in that they were composed of many fungivores. Termites involved in wood decay were mostly composed of those of Mactotermitinae. Previous studies also show that this group of termites play an important role in leaf-litter decay. It is suggested that they are worth focusing on in the study of decomposition process.

It was revealed that the degree of acceleration by termites in plant litter decomposition would amount to eight times. The immobilization phase of decomposition where nitrogen release is suppressed by fungal growth was terminated earlier in tropical forests compared with in temperate forests. It was also revealed that this earlier mobilization is due to the activity of termites. These findings suggest that termites play an important role in the decomposition process, without which soil formation would be retarded.

Key Words Decomposition, Plant litter, Termite, Soil formation

1.Introduction

Soil is one of the important components in tropical forest ecosystem. Tropical trees grow on it and get nutrient for growth through it. Soil also has a water-reserving capacity, giving water supply to forest itself and surrounding environment. The present study payed a focus on roles of soil animals in formation of soil organic matter, an indispensable element of soil.

The present study intended to evaluate the role of soil animal in soil formation quantitatively. For this purpose, outdoor experiments which treat soil animals were performed in forests. To evaluate activity of soil animals quantitatively, removal treatment was applied in the experiments. Trapping plant litter was also performed to measure the supply of organic matter to the forest floor.

In tropical forests, plant litter contain leaves from a large number of tree species. The leaves are different in size, hardness and chemical constituent. Wood qualities are also different in these traits

with species. Although species identification is a practical problem in sorting the plant litter in tropical forests, selection of sites where scientific researches have been done for a long time may solve this problem.

Tropical soil fauna contains a large number of decomposer animal groups, among which termites are one of the abundant animals. They forage, comminute and transport organic matter originated from plant litter and release nutrients from the litter as available to forest trees. Therefore, the points to reveal are 1) what rate decomposition proceeds at, and 2) how much released nutrients are utilized by trees in the conditions with or without soil animals. The present study was undertaken to reveal the first point.

2.Study area and method

The present study was performed in Peninsular Malaysia. Study areas were selected in lowland tropical rain forests at Bukit Lagong Forest Reserve in Kuala Lumpur and Pasoh Forest Reserve in Negeri Sembilan. In each forest, several sites were selected for trapping plant litter, decay experiment of leaves and wood and census of soil fauna.

Trapping of plant litter was performed with litter traps made of 2-mm mesh with an aperture of 2-m diameter. Collected litter was air-dried and weighed. Debris of plant litter was collected from a given area of ground, air-dried and weighed.

Decomposition rates were measured with litter bags for leaves and with mesh-covered trays for wood. Relatively-intact leaves were sorted from the plant litter collection and enclosed in two types of mesh bag. One bag was made of 0.5-mm stainless-steel mesh and another was made of 2-mm nylon mesh. The former excluded termites. For wood, billets of about 6-cm diameter and 20-cm length were made from a live *Paranephelium macrophyllum* tree and pieces of sawn wood were made from air-dried lumber of *Neobalanocarpus heimii* and *Shorea macroptera*. The wood baits were put in two types of stainless steel tray. They were open-topped and covered with 0.5-mm stainless steel mesh at the bottom and lower sides. One type had completely-covered bottom and sides, but another had openings there. The former excluded termites. Comparison was made between the exclusion treatmet and the control where termites were not excluded to reveal effects of termites on decomposition.

Decay rates were estimated as the loss rates of dry weight or carbon mass. The loss was assumed to fit an exponential curve and the rate was k in the following equation.

$$W_t = W_0 e^{-k t}$$

W_t, weight or mass at retrieval; W_0, weight or mass at start; t, time from start to retrieval.

Soil fauna were collected from soil cores and wood baits in the experiment. From soil cores, soil animals were extracted with heat drying. Termites and collembolans were identified to species level and intestine contents were identified for collembolans.

3.Results

Debris of plant litter in the soil amounted to 4.3 ton /ha at Pasoh and 4.9 ton/ha at Bukit Lagong. Including the amounts recorded by previous reports, the range was 1.5 - 54 ton/ha and more than 70% of the records ranged less than 10 ton/ha in tropical forests. They were lower than the amounts reported from temperate forests. Soil humus did not develop well in tropical forests.

Supply of plant litter amounted to 9.3 - 12.8 ton/ha and was almost composed of leaves.

Seasonal change of the supply showed two peaks per year linked closely with tree phenology. Including the amounts recorded by previous reports, the average supply was 9.1 ton/ha in tropical forests about twice as much as 4 ton/ha in temperate forests.

Decomposition of leaves were measured for those of *Dipterocarpus baudii* at Bukit Lagong. The leaves were treated with termite exclusion. In first two months, decomposition rates did not differ between the termite exclusion and the control. This means that the first phase of decomposition proceeded by leaching and microbial activity. In four and six months, weight decrease was signigicantly higher in the termite exclusion than in the control. Nitrogen mass also followed the same pattern. In both the termite exclusion and the control, rapid decrease by leaching and the following slow decrease by immobilization occurred for nitrogen, firstly. After that, mobilization occurred in the control, but it did not occur in the exclusion. This result shows that termites stopped immobilization and released nitrogen.

Decomposition of leaves of eight tree species were measured at Pasoh. The decay rates were listed in Table 1. They ranged 0.825 for *Shorea multiflora* to 2.532 for *Endospermum malaccense.* The average for eight species was 1.367, higher than the average 0.929 reported for temperate trees (Takeda et al. 1984, 1987). These rates correlated positively with the frequency of termite attack, showing that rapid decomposition was due to termite foraging.

Decomposition of wood was measured for *Paranephelium macrophyllum* billets at Bukit Lagong and Pasoh. The decay rates were not significantly different between the termite exclusion and the control at both sites for three years of the experiment, although termite attacked all control billets (Table 1). This indicates that termite did not affect the decay rate of this wood. This wood had a wood density of about 1 g/m^3. Since it is widely accepted that hard wood is durable to termite attack, no effect of termite foraging may be due to the high wood density.

The second experiment of wood decomposition was performed with wood of different wood densities. The hard wood of *Neobalanocarpus heimii* (around 1.0 g/cm^3) did not show different decay rates with presence of termite foraging (Table 1). On the other hand, the soft wood of *Shorea macroptera* (around 1.0 g/cm^3) did show different decay rates with presence of termite foraging (Table 1). The difference was 8-folds at maximum. In absence of termites, the decay rates were similar between the two kinds of wood.

Species identification of soil fauna revealed that four species appeared in the experiments of wood decomposition, among which three species were those of Macrotermitinae. This group of termites have been reported to play a high activity of decomposing leaves (Matsumoto and Abe 1979). Termites of Macrotermitinae may play a significant role in decomposition of plant litter. Soil-core sampling showed that the collembolan community was predominated by underground species which had the cosmopolitan distribution and foraged on organic debris. A minor portion was composed by ground surface species which were endemic and foraged on fungi. The fact that humus-feeding species which are commom in the temperate were rare reflected the rapid decomposition of plant litter.

4.Discussion

The present study showed clearly that termites enhanced the decomposition of leaves and wood drastically. If termites are absent at decomposing stage of plant litters, decomposition will be retarded, giving detrimental effects on tropical forest ecosystem. They may also play a role of releasing nutrients assimilated by fungi.

Termites did not affect decomposition of hard wood and foraged infrequently on leaves of some species. Part of this inpalatability for termites may come from hardness of them. A well-known

Table 1. Annual decay rates of leaves and wood from tropical forests. The rates were measured in presence of termites, otherwise mentioned especially.

Species	Rate
Leaves	
Dipterocarpus baudii	1.935
D. baudii (no termite)	0.969
Heritiera javanica	0.928
Shorea macroptera	1.136
Blumeodendron calophyllum	1.284
Dipterocarpus crinitus	2.364
Endospermum malaccense	2.532
Shorea multiflora	0.825
Xerospermum noronhianum	0.887
Baccaurea reticulata	0.984
Wood	
Paranephelium macrophyllum	0.456, 0.522
P. macrophyllum (no termite)	0.307, 0.404
Shorea macroptera	0.244, 0.398
S. macroptera (no termite)	0.050
Neobalanocarpus heimii	0.032, 0.053
N. heimii (no termite)	0.041, 0.041

example is the wood of *Neobalanocarpus heimii* used for outdoor wooden works without chemical treatment. In fact, decomposition of this wood was not affected by termites in the present study. Such kind of wood may exist longer even in presence of termites.

In presence of termites, however, the decay rate of billets of hard *P. macrophyllum* was higher than that of sawn wood of soft *S. macroptera*. This reversed result may pose some difficulty on the interpretation of the present results. One of the probable causes of these results is that the billet was so fresh that it still contained highly-degradable matter, which might be lost in the sawn wood. It

may attract higher activity of decomposer animals and microorganisms irrespective of the hardness of the wood. Therefore, the wood of *S. macroptera* would show higher decay rate in the fresh condition. Abe (1980) reports that the decay rate of billets of *Shorea parvifolia*, another soft-wood tree, are 0.63 in diameter of 6 -13 cm and 1.13 in diameter of 3 - 6 cm.

Importance of termites, especially those of Macrotermitinae, in decomposition of plant litter is indicated by the present study. Some studies, however, have reported the minor role of this group of termites in decomposition process of tropical forests. The minor role may be ascribed to that wet environment suppresses the distribution of these termites in wetter tropical rain forests (Anderson and Swift 1983, Collins 1983). On the other hand, activity of termites controls the decomposing process of wood litter almostly in an African savanna (Collins 1981). As an intermediate stage of these tropical environments, in relatively-dried rain forest of Pasoh, termites play an unnegligible role in decomposition of plant litter and may contribute to nutrient cycling to tree growth.

5.References

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