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Relation to Soil Animal Populations and Plant Litter Decomposition in a Tropical Region

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Abstract The study was aimed to evaluate effect of soil animals (soil mesofauna and earthworm) on the decomposition of plant litters at different land use areas in Gunung Batin, Lampung Province, South Sumatra, Indonesia. The plant litters were taken from several land use areas, i.e. bushes, cassava, rubber, and cacao plantation lands at Gunung Batin. The decomposition of plant litters were studied by taking soil cores of 100 ml for mesofauna and square box 25 cm ×25 cm for earthworm. The results showed that the number of soil mesofauna were higher in bushes than in other land uses, while the earthworm was in the cacao area. The rate of plant litter decomposition was the highest in the cacao plantation land, and had a correlation to the number of earthworm. Therefore, in the cacao plantation land, earthworm caused decreasing of C/N ratio.

Key words: earthworm, different vegetation, litter decomposition, mesofauna, soil animals

Introduction

The importance of the role and function of soil animals were recognized in the soil formation and litter decomposition (BAL, 1982). Decomposition of plant litter has been studied in various locations from arctic to tropical regions. These detail was introduced by DICKISON and PUGH (1974). On the decomposition of leaf litter in the tropical forest region was studied by ANDERSON *et al.* (1983), MATSUMOTO *et al.* (1999) and NISWATI *et al.* (1998) for mixed leaf litter. There are rather few studies on the decomposition rates for individual tree species and there is rather little information concerning the role and importance of soil animals on the litter decomposition under different land use in tropical region. In the present experiment, we studied the role of soil animals (mesofauna and earthworm) on the litter decomposition under different land use areas in Gunung Batin, Lampung Province, Sumatra, Indonesia.

Study Area and Methods

Location of study area: The study area, Gunung Batin was located at north Lampung (4° 55′ S to 5° 10′ S and 104° 19′ E to 104° 34′ E), Lampung Province, South Sumatra. The elevation of the area ranged from 450 m to 500 m above sea level. Those in the middle terrace area use for the cultivated lands, plantation lands and other lands. The studying sites are the deforested lands, i.e. Bush, Rubber, Cacao and Cassava plantation lands in this location.

Collection of soil animals: Soil animals were collected from a litter and soil layer (0–10 cm). Soil mesofauna were studied by taking soil cores of 100 ml (with a stainless steel tube, 20 cm^2 in area and 5 cm in high) from 5 plots at random in each study sites. Soil mesofauna in soil cores were extracted with Tullgren Funnels during 48 hours and fixed with 75% alchol. Earthworms were collected by hand sorting in quadrates of 25 cm × 25 cm square on soil from 3 plots at random in each study sites every month. The numbers of soil mesofauna and earthworm were surveyed in the study sites during period from April 1998 to August 1998. But data of April were preparation survey. And, we had a consideration about relation to soil animal population and plant litter decomposition.

Measurement of litter decomposition: Plant litter decomposition was studied by measuring the changes of C/N ratio of plant litter in litter bag. Newly fallen leaves of the rubber, bush, cacao and cassava were collected in each study site on April 1998 and were used for the decomposition study. Leaf materials collected were air dried in a room condition for a week. Then, leaf litter sample was put in litter bag (10 cm × 10 cm in nylon mesh) and set on the soil surface. The leaf litter samples were placed in each land use area on April 1998 and then were collected monthly until August 1998. On each sampling occasion, the samples were replicated three times in the locations. The samples were air dried in a room condition for one week and then dry weight was determined at the oven dry base of 105℃. The rate of plant litter decomposition was determined by decreasing of C/N ratio. The C (organic carbon) was determined by Walkey and Black method. Total nitrogen was determined by Kjeldahl method.

Results and Discussions

The soil of the study sites is called "Red Acid Soil" that formed with large area of the forests in South East Asia. The soils lose rapidly the potentiality of sustaining 'fertile' vegetation, after they are opened to cultivated lands. Annual precipitation in Indonesia is more than 1500 mm and seems to be enough for plant growth and habitat of soil animals. But, the climate is clearly divided into dry and wet seasons, and heavy rain is concentrated in the very short period in the wet season. So that, the water contents and organic carbon of the soil is very

Table 1. Some characters of the study sites in Gunung Batin area.

Sampling site	Soil temp. (℃)	Soil water contents (%)	Soil pH (H_2O)	Organic-C (%)	Total-N (%)
Bush	29–32	20–32	5.0	1.89	0.05
Rubber	28–30	19–20	5.0	2.91	0.14
Cacao	26–30	26–30	4.5	3.14	0.18
Cassava	31–36	11–19	4.7	2.33	0.10

low in dry season. The other character of soil environments in this study sites were shown in Table 1. The volume of rain fall are 5.0–9.8 mm/day and the range of soil temperature is relatively constant (26℃ cacao site, 36℃ cassava site) irrespectively of wet or dry season in this area. Soil pH is low, too.

We surveyed population of soil animals under the different vegetation and environment in this area. The results were shown in Table 2. Soil mesofauna and earthworm were surveyed during the litter decomposition period from April (for reparation survey time) to August 1998 (dry season). The soil mesofauna collected during the period were classified into three group of mesofauna, i.e. Acari, Collembola and others. The population densities of mesofauna and earthworm are little changed with different vegetation and soil environments. Acari were predominant in bush area, and population densities of soil mesofauna are significantly higher in the bush area, among the other land use areas. Densities of earthworm were the highest in cacao plantation land. This might be caused by the higher biomass of litter fall, lower temperature and wetter than the other land areas.

Table 2. The population of soil mesofaun and earthworm in study sites during the period from May '98 to Aug. '98.

Sampling site	Month	Soil mesofauna (ind/100 ml soil)				Earthworms (ind/m²)
		Acari	Collembola	Others	Total No.	
Bush	May	179.90	53.33	44.37	278.04	58.66
	Jun	35.05	9.32	32.74	77.11	48.00
	July	28.04	67.79	70.10	165.93	48.00
	Aug.	44.37	18.72	46.76	109.85	26.66
Rubber	May	42.06	25.73	9.32	77.11	32.00
	Jun	44.37	11.71	4.69	60.77	16.00
	July	53.77	11.71	11.71	77.19	32.00
	Aug.	18.72	21.03	46.76	86.51	80.00
Cacao	May	46.76	11.71	4.69	63.16	101.30
	Jun	51.38	11.71	28.04	91.13	96.00
	July	30.35	9.32	11.71	51.38	74.67
	Aug.	86.43	11.01	11.71	109.15	106.70
Cassava	May	23.34	14.02	4.69	42.05	21.33
	Jun	30.35	21.03	2.31	53.69	-
	July	60.78	63.09	95.83	219.70	-
	Aug.	11.71	44.37	39.75	95.83	16.00

Table 3. The mass of fallen litter per month in this area.

Site and litter	April '98 (g/m²/month)	May '98 (g/m²/month)	June '98 (g/m²/month)	July '98 (g/m²/month)	August '98 (g/m²/month)
Bush	100.80	89.60	75.04	86.40	97.28
Rubber	498.56	579.20	596.48	561.60	576.00
Cacao	963.36	648.96	654.40	1116.80	638.40
Cassava	96.00	97.60	80.32	83.20	95.68

The results of the measurement of a mass of fallen litter and the quality of litter during the studying period (dry season) in this area were shown in Table 3 and 4. The large mass of litter fall is rubber and cacao during the period. Quality of leaf litter may be related to the susceptibility of each tree species to the soil organisms such as fungi, bacteria and soil animals. Especially, the breakdown of leaf litter was decomposed by the earthworm's eating action (MATSUMOTO, 1990). The structural properties of leaves reflect the qualities of leaf litter as food resources for soil organisms and may be related to the palatability of leaf litter to soil animals. The results showed that the raw material of cacao leaves had a good quality such as low C/N ratio, low lignin and high protein content than the others. In this case, soil animals preferred to the sources with lower C/N ratio of the litter components. The changes in C/N ratio through decomposition of leaf litter were shown in Table 5.

Changes of C/N ratio varied greatly among the four kinds of leaf litter. The decreasing in C/N ratio was higher in cacao leaves than the others. It might be caused by qualities of raw material of cacao leaf. The decomposition of leaf litter is a complex process regulated by the interactions between soil organisms, physical environmental factors (soil temperature and moisture) and resource quality (MILLAR, 1974; TAKEDA, 1984). As shown in Table 6, there was no significant relationship between the decreasing of C/N ratio of litter and the number of soil mesofauna and earthworm in this sampling sites, except the number of earthworm in cacao and bush lands. In the present study, high densities of earthworm in cacao and bush significantly decreased the C/N ratio of leaf litter in decomposition processes. The decreased rate of C/N ratio can be used as indicator of the rate of decomposition. On the contrary in the temperate forest soil, collembola and acari were numerically abundant and might contribute to the plant litter decomposition (MALAISSE, 1975). Therefore, the decreasing of C/N ratio of cacao and bush lands were caused by earthworm action, and in the other lands were none.

The lowest decomposition rate in these sites were cassava fields. These results might be related to the low population densities of earthworm. High soil temperature and lower water content might cause the lowest of earthworm densities. And there were lower mass of fallen litter and pour quality of leaf litter. So that, we can be observed as the poor growth and small

Table 4. The quality of leaf litter in study sites.

Leaf litter	Lignin (%)	Fats (%)	Protein (%)	Ash (%)	C/N
Bush	43.07	7.38	4.94	15.15	50.13
Rubber	11.57	8.99	6.12	0.90	29.60
Cacao	21.10	2.47	7.12	6.80	41.91
Cassava	28.19	12.31	6.44	5.70	29.54

Table 5. The changes of C/N ratio in leaf litter during the decomposition process.

Leaf litter	April '98 C/N	May '98 C/N	June '98 C/N	July '98 C/N	August '98 C/N
Bush	50.13	44.16	37.93	37.30	36.38
Rubber	29.60	22.90	20.06	19.15	18.04
Cacao	41.91	29.39	27.76	26.61	19.91
Cassava	29.54	29.00	28.32	19.15	18.04

Table 6. Correlation coefficient of soil animals with the decreasing of leaf litter C/N ratio.

Leaf litter C/N ratio	No. of earthworms	No. of soil mesofauna
Bush	0.69**	0.03
Rubber	0.37	0.29
Cacao	0.90**	0.07
Cassava	0.26	0.58

**Significance at 1 % level.

of body size.

Conclusion: The rate of leaf litter decomposition was high in cacao plantation lands and due to the highest in population densities of earthworm. The number of mesofauna was not related to decreasing of C/N ratio in all of the study ares in a tropical region, Gunung Batin, Sumatra.

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摘　要

松本貞義・Sri YUSNAINI*・Ainin NISWATI*（近畿大学農学部　〒631-8505　奈良市中町3327-204, *ランポン大学農学部　バンダルランポン市, 35145, インドネシア）：熱帯における土壌動物と植物遺体の分解について.

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インドネシア・スマトラ島の東南域の中位段丘にある土地利用の異なる土壌環境に生息する，主にミミズ・ダニ・トビムシ類の生息数と植物遺体分解との関係について調べた．調査は1998年4月から8月にかけて行われた。その結果，ミミズは土地利用形態により生息数は異なったが，ダニ・トビムシ類では大きな差異はなかった。ミミズは植物遺体の分解に深く関わっており，それは植物遺体の種類とその成分組成に密接な関係にあることが示唆された。

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