On the Biomass of Soil Animals Found in Various Types of Forests in Thailand

Hiroyuki WATANABE
Pairath SAICHUAE
Tsunahide SHIDEI

1 INTRODUCTION

During the period from November, 1963 through January, 1964 a joint party from Kyoto University, Kasetsart University and Chulalongkorn University carried out research on forests and forest soils in Thailand. Our particular area of study was soil animals and our research was carried on in cooperation with the groups on vegetation, forest productivity and soil property.

As is already well known, soil animals play an important role not only in the litter decaying process but also in providing good soil structure. The research on soil animals was carried out in Southeast Asia with two main purposes in mind: to clarify the role of soil animals in the forest ecosystem in the tropical forests which generally have a high productivity and where the decomposition of the leaf litter is rapid and also for comparison with the forests of the temperate regions.

Our first aim was to ascertain the differences in faunistic composition and to make an estimation of individual numbers and the biomasses of animals inhabiting the litter layer and the soil layer in the various kinds of forests, such as the Deciduous Dipterocarpus, the Dry Evergreen, the Tropical Evergreen, the Hill Evergreen, the Mixed Deciduous, the Pine and in land left fallow.

The data shown here will contribute to the basic knowledge on the role of soil animals in the tropical forests. In this paper, the authors have dealt only with the biomasses of soil animals, which have never before been estimated in the tropical region.

Detailed descriptions of the faunistic composition, individual numbers and the biomasses of soil animals in various kinds of forests in Thailand and the relationships between vegetation, soil and soil animals will be reported later to the Center for Southeast Asian Studies of Kyoto University in a more complete form.

2 AREAS STUDIED

The locations where the research was carried out, the length of the research, forest types and

Localities where soil animals were studied

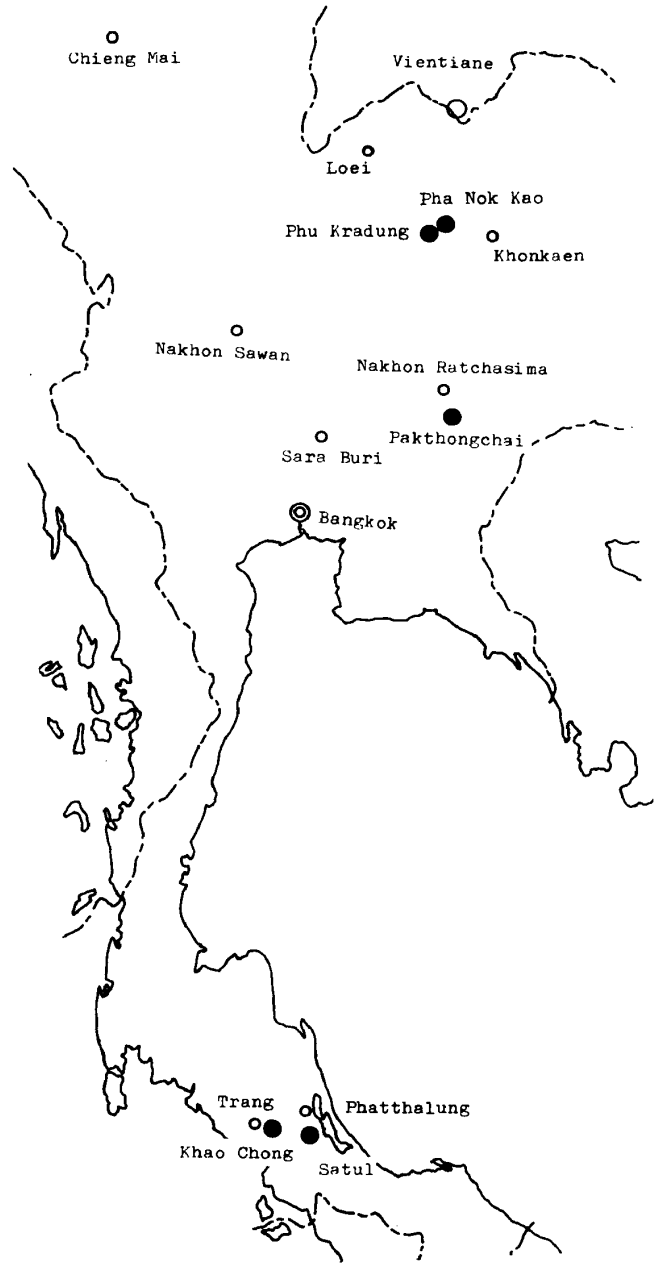
Forest type	Collection site	Term of research	Plot number
Deciduous Dipterocarpus (D. D. F.)	Pakthongchai	24. XI.~10. XII. 63	P. T. C. 5, 7, 8, 9, 10, 11, 15, 16
	Pha Nok Kao	18~19. XII. 63	P. K. D. 7, 8
Dry Evergreen (D. E. F.)	Pakthongchai	24. XI.~10. XII. 63	P. T. C. 1, 2, 3, 4, 12, 17, 18, 20
	Pha Nok Kao	18~19. XII. 63	P. K. D. 9, 10
Fallow Land (F. L.)	Pakthongchai	24. XI.~10. XII. 63	P. T. C. 13, 14
Hill Evergreen (H. E. F.)	Phu Kradung	14~15. XII. 63	P. K. D. 1, 3
Pine (P. F.)	Phu Kradung	14~15. XII. 63	P. K. D. 2, 4
Mixed Deciduous (M. D. F.)	Phu Kradung	16. XII. 63	P. K. D. 6
Tropical Evergreen (T. E. F.)	Khao Chong	28. XII. 63~3. I. 64	K. C. G. 2, 3, 4, 5, 6
	Satul	3. I. 64	S. T. L. 1

plot numbers are shown on the above list.

Paktongchai in the Northeast region, about 60 km south of Nakorn Ratchasima (Khorat). The area was covered by a Dry Evergreen forest and a Deciduous Dipterocarpus forest. There was a small area of fallow land which was once cultivated.

Phu Kradung (at an elevation of 1350 m) in the Northeast is situated between Khonkaen and Loei. The top of this mountain was covered by Hill Evergreen and Pine forests. Two samples were collected from both the Hill Evergreen and the Pine forests at about 1200 m above sea level. A plot was staked out in the Mixed Deciduous forest at about 600 m above sea level. Around the small village of Pha Nok Kao at the foot of Phu Kradung, Dry Evergreen and Deciduous Dipterocarpus forests were found.

Khao Chong in the Peninsular region in the Southern region. Khao Chong National Park, about 25 km east of Trang, and Satul near Phatthalung are located in the Tropical forest area. (Although the Tropical Evergreen forest is often called a Tropical Rain forest, in this paper, the authors have followed that classification used by the Royal Forestry Department of Thailand. Other detailed information on various forest types and vegetation in Thailand are shown in the publication by that department.)



Locations of areas studied

3 METHOD

Collections of the macro soil animals were made within quadrats of a square meter to a depth of 10 cm by the use of forceps. The term soil animals is used for all animals which can be seen by the naked eye; i. e., earthworms, millipedes, ants, spiders, etc. An apparently homogenous area within the forests was selected for sampling and the plots were set to avoid nests of ants and termites and the area around the roots of trees.

We feel that although we did try to take as many samplings as possible, the numbers of plots were not sufficient, especially in those cases where only two plots were taken in one forest type. Unfortunately, the lack of samplings was due to our limited time.

The specimens collected were preserved in a solution of 95% alcohol and then sent to the laboratory of Kyoto University where all specimens were sorted out by groups, their individual numbers counted, and their biomass (wet weight) estimated.

4 RESULTS AND DISCUSSION

i *Faunistic composition*

The faunistic composition may be divided according to two general types of forests, namely the Evergreen forest and the Deciduous forest. We found that although the Dry Evergreen and the Deciduous Dipterocarpus forests whose borders were contiguous with each other and located within areas with the same climatic and soil conditions were distributed around Paktongchai and Pha Nok Kao in the Northeastern region of Thailand, the faunistic compositions of these forests differed to quite a great extent.

For the Dry Evergreen forests, the fauna found was the richest, but earthworms were found to be scanty. The important components encountered were snails, isopods, millipedes, spiders, cockroaches, grasshoppers, termites, caterpillars, ants, Dipteran larvae and many different beetles. Scorpions were found only in this forest type.

The Tropical Evergreen forests that are situated in the Peninsular region (South) were not as rich when compared with the Dry Evergreen forest, but earthworms and millipedes were abundant. The important components encountered were earthworms, snails, isopods, millipedes, centipedes, cockroaches, caterpillars, ants, termites and many different beetles.

For the Hill Evergreen forests, located about 200 m above sea level, the fauna found were also abundant; earthworms, snails, isopods, caterpillars, ants and many different beetles were collected but there was an absence of millipedes and termites.

The Pine forest whose borders were contiguous with this Hill Evergreen was found to be scarce in fauna. Spiders and ants were dominant in this Pine forest but in one plot we recorded a great incidence of earthworms.

On the other hand, in the Deciduous Dipterocarpus forest the faunistic composition was less in volume than in those of the Evergreen forests, and here, fauna such as ant lions, false scorpions, and earwigs, which were absent or scanty in the Evergreen forests were found. There was also quite a number of spiders, ants and termites. In the fallow land and the Mixed Deciduous forests, the faunistic compositions were similar to that of the Deciduous Dipterocarpus forests just mentioned.

It appears that the fauna is richer in the Evergreen forests than in the Deciduous forests.

ii *Individual numbers of macro animals*

Total individual numbers per square meter including both the litter layer and the soil layer to a depth of 10 cm are shown in Fig. 1. Total num-

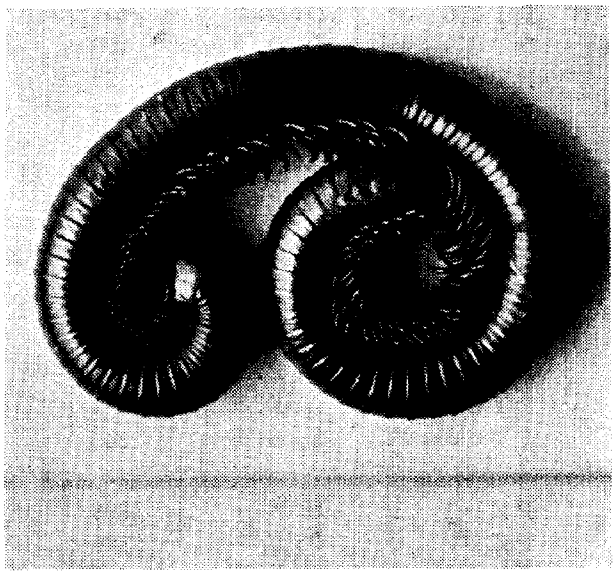


Photo 1 A big millipede collected at Khao Chong

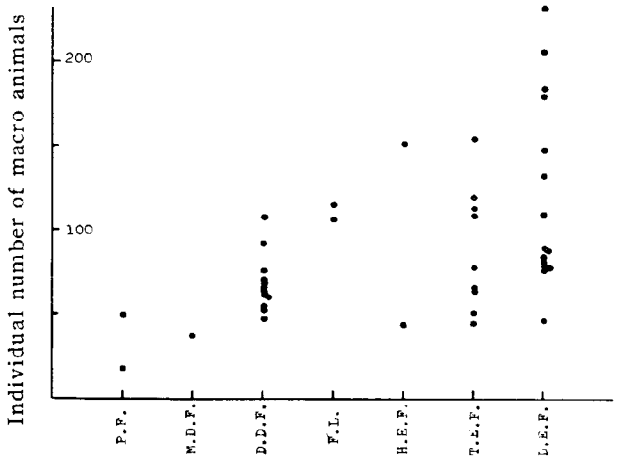


Fig. 1 Individual numbers of macro animals

Table 1 Total numbers and total biomass of macro soil animals in the litter layer and soil to depth of 10cm/m²

Plot		Forest type	Litter weight (oven dried)	Earthworms		Millipedes		Total No. of macro animals	Total biomass of macro animals
				No.	Weight	No.	Weight		
			g		mg		mg		mg
PTC 1	1	D. E. F	422	3	80	1	11	131	1668
PTC 1	2	D. E. F	699	1	30	2	45	46	879
PTC 2	3	D. E. F	460	2	81	4	226	147	4681
PTC 2	4	D. E. F	428	1	2210			76	4000
PTC 3	5	D. E. F	429	1	8			179	1398
PTC 4	6	D. E. F	1105			4	49	183	2495
PTC 5	7	D. D. F	257	4	1315	1	11	107	2827
PTC 5	8	D. D. F	83					61	635
PTC 7	9	D. D. F	38					68	414
PTC 7	10	D. D. F	62					67	1303
PTC 8	11	D. D. F	104					70	1140
PTC 9	12	D. D. F	150					47	1092
PTC10	13	D. D. F	18					52	499
PTC11	14	D. D. F	73					62	2697
PTC12	15	D. E. F	378			3	378	89	3678
PTC13	16	F. L	193	1	55	5	182	106	1765
PTC14	17	F. L	162			1	64	115	888
PTC15	18	D. D. F	126					76	620
PTC16	19	D. D. F	126			10	476	60	1531
PTC17	20	D. E. F	531	1	26	1	155	231	3378
PTC18	21	D. E. F	322			4	120	78	1781
PTC 3	22	D. E. F	397			1	25	88	2700
PTC20	23	D. E. F	398					81	3588
PTC20	24	D. E. F	340					84	3318
PKD 1	1	H. E. F	598	16	2464			43	3422
PKD 2	2	P. F	166	17	11420			49	11851
PKD 3	3	H. E. F	678	27	3421	1	4	151	4593
PKD 4	4	P. F	169	4	455			18	655
PKD 6	5	M. D. F	191					38	1714
PKD 7	6	D. D. F	205					92	1518
PKD 8	7	D. D. F	122					53	1739
PKD 9	8	D. E. F	454					109	3631
PKD10	9	D. E. F	262			1	23	205	2315
KCG 2	1	T. E. F	419	6	2840			119	4620
KCG 3	2	T. E. F	302	21	8120	2	36	154	14484
KCG 4	3	T. E. F	328	23	8070	2	3633	44	13704
KCG 5	4	T. E. F	451	18	8540	5	8476	50	19032
KCG 4	5	T. E. F	274	42	19380			108	20778
KCG 4	6	T. E. F	270	39	18320			113	19733
KCG 5	7	T. E. F	362	8	2930	2	3627	78	9350
KCG 6	8	T. E. F	399	15	3775	1	59	63	7277
STL 1	9	T. E. F	360	20	6840	2	1940	65	10766

bers of macro animals ranged the highest in the Dry Evergreen forests from 46 to 231/m^2. The figure shows that the individual numbers varied greatly among the Evergreen forest types, with of course, several plots showing small numbers. The Mixed Deciduous and the Pine forests indicated very small totals.

According to K. W. Dammerman (1925, 37), the data ranged from 6 to 1167/m^2 in about 200 plots of surface fauna taken in Indonesia. He mentioned that the fauna was more numerous in the various kinds of forests than in the grass land. E. A. Williams (1941) estimated individuals at 294/m^2 in the Tropical Rain forests in Panama and C. J. Goodnight et al. (1956) estimated 170 to 870/m^2 in the Tropical Rain forests in Mexico.

iii *Biomass*

First of all, it must be emphasized that only one study by F. Golley et al. (1962) on the biomasses of soil animals has hitherto been reported, so far as the authors know, on tropical forests.

Our estimation of the biomasses of soil animals in various kinds of forests in Thailand are shown in Table 1.

It is clear from our estimation that the biomasses of soil animals of the Evergreen forests are greater than those of the Deciduous forests. The biomasses from the Dry Evergreen, the Hill Evergreen and several plots of the Deciduous Dipterocarpus forests showed more than 4 g per square meter. Almost all the Deciduous Dipterocarpus, the Mixed Deciduous forests and the fallow land plots showed less than 3 g. The biomass value of 0.5 g/m^2 of soil animals in some plots of the Deciduous Dipterocarpus forests seem to have been remarkably small when compared with the results obtained from the other types.

In the Tropical Evergreen forest situated in the Peninsular region, it was remarkable that the biomass of soil animals ranged the highest, from 5 to 21 g/m^2. These high values were attributed to the abundance of big millipedes in the litter layer and earthworms in the soil layer.

Incidentally, the biomasses from the few plots of the Pine forest showed values of 12 g and 0.7 g/m^2.

Our findings showed that the biomasses mainly depended on earthworms, snails, centipedes, millipedes, big beetles, cockroaches, grasshoppers and the nymphs of cicades, all of which are heavy, compared to soil animals in the forests of the temperate or warm zone of Japan, where it is a characteristic that cockroaches, ants and termites are commonly found in the forest floor. A most noteworthy feature was that big millipedes in the litter layer and earthworms in the soil layer were found to be abundant in the Tropical Evergreen forests, and thus they must play an important role in the soil formation.

These biomass values were found not to be great, except in the Tropical Evergreen forest, when compared with those of the various kinds of forests in Japan. This is, perhaps, due to the fact that the collections were made from November through January, the dry season. Referring to our former research done in Saraburi Province in Central Thailand, the minimum population of soil fauna occurs in the period from August to March. Research should be carried out on biomasses throughout the whole year in order to confirm seasonal changes of biomass.

F. Golley et al. (1962) showed biomasses of 67

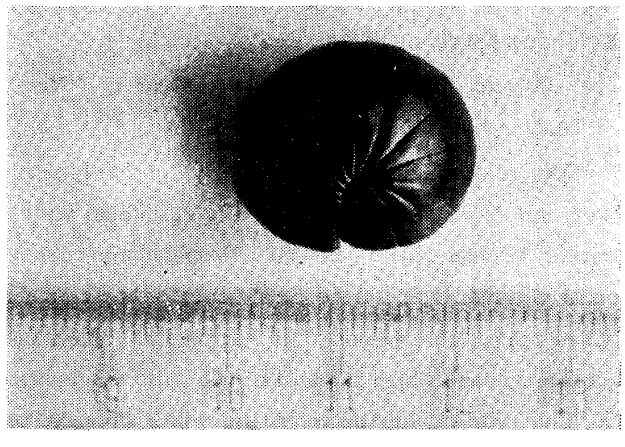


Photo 2 A big isopod collected at Khao Chong

individuals /m², 6.4 g (dry weight), whose components were crabs and shrimps in a mangrove forest in Puerto Rico.

Comparing these with results from the temperate regions, we find that Stockli et al. (1963) estimated 400 g/m² in a Swiss meadow; A. Macfadyen (1963) showed 189.5 g in grass lands, 191.1 in upland limestone grass lands, 78 g in upland Juncus moors; the Hokkaido Development Board Japan showed 186.8, 141.1 g from meadows; K. P. Barley (1956) measured 152, 121 g from meadows in Australia. This data cited above is known to have been composed mostly by earthworms. It is well known that grasslands and meadows show higher biomasses than those of forests.

C. H. Bornebusch (1932) showed 76.8/m² from oak, 70.7 and 5.3 from beech, 122.2 and 9.8 from spruce forests. C. A. Edwards & G. W. Heath (1963) showed 36.7 from oak, 39.1 from oak and beech forests. These values are remarkably high when compared with results found in Japan. Y. Kitazawa et al. (1960) showed biomasses of 15～30 g/m² in the summer from an Evergreen forest on the coast of the Osumi Peninsula in Kyushu. Our research showed 0.9～5.7 g in winter in Kyushu and 2.0～11.5g/m² in Nara Prefecture.

Unfortunately we can not find any data, except that of Golley concerning the biomass of soil animals of tropical forests in order to compare with our data. However, it is clear that the Evergreen forest will always show a greater biomass than the Deciduous forests.

iv *Relationship between water content of litter and soil and biomass*

The relationship between the water content of litter and biomass is shown in Fig. 2. The water content of the litter in the Tropical Evergreen forest ranged from 40 to 60% where the biomass values ranged the highest. It seems that biomass increases as the water content of the litter increases.

The relationship between the water content of the soil and the biomasses is shown in Fig. 3. The

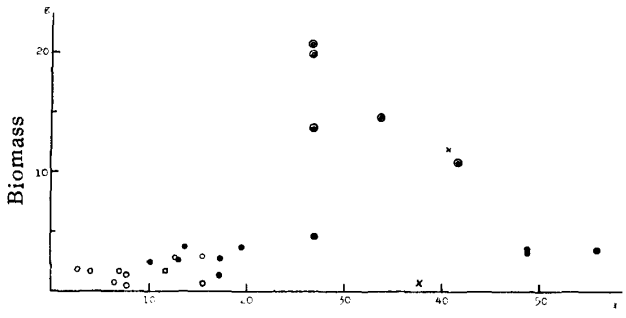


Fig. 2 Biomass and water content of leaf litter

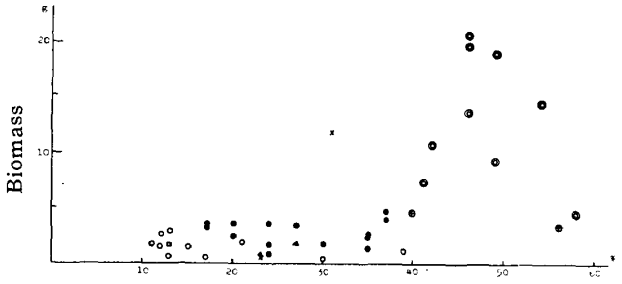


Fig. 3 Biomass and water content of surface soil

biomasses from the Tropical Evergreen forests, where the water content in the soil ranged 25～40%, were the highest. But the relationship between the biomasses and the water content of the surface soil was not so evident.

v *Relationship between litter weight and biomass*

Fallen leaves, so called litter, are important both for food and for the habitat of soil animals. The weight of the litter (Ao) layer ranged only 18～260 g/m² on soil surface in the Deciduous Dipterocarpus forests and in Mixed Deciduous forests while in the Dry Evergreen forests ranged 300～500 g and more, the floor was covered by freshly fallen leaves.

But the biomass was the highest in the Tropical Evergreen forests where the litter weight ranged 250～400 g/m². Although the biomasses increased in proportion to the increase of the litter weight in the Deciduous Dipterocarpus and the Dry Evergreen forests, biomasses of soil animals in the Tropical Evergreen forests decreased with the increasing litter weight.

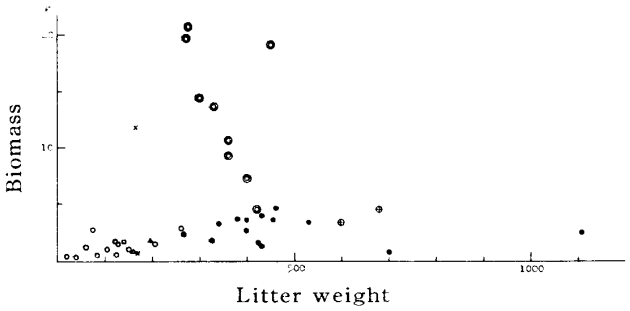


Fig. 4 Relationship between biomass and litter weight

5 SUMMARY

The estimations of biomasses of soil animals in various kinds of forests were taken in Thailand during the period from November, 1963 to January, 1964. The biomasses ranged the highest in value from 5.6 to 21.6 g/m^2 in the Tropical Evergreen forest situated in the Peninsular region (south) of Thailand.

These high values were attributed to the abundance of big millipedes in the litter layer and earthworms in the soil layers. It, however, appears that the biomasses of soil animals of the three Evergreen forest types, the Dry, the Hill and the Tropical, are higher than those of the Deciduous forests, i. e., the Mixed Deciduous, the Deciduous Dipterocarpus forests and the fallow land.

The biomasses show a high correlation with the water content of the leaf litter while corresponding relationships between the biomass and the litter weight as well as the water content of the soil were not so clearly defined.

6 ACKNOWLEDGEMENTS

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