THE ROLE OF SOIL NUTRIENTS AND TERMITES IN DECOMPOSITION OF BRANCH-WOOD LITTER OF *SHOREA ROBUSTA* IN A SUB-TROPICAL FOREST

Le rôle des substances nutritives et des termites dans la composition des branches de *Shorea robusta* dans une forêt subtropicale.

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RESUME

La décomposition des branches de Shorea robusta *dans la litière a été suivie. La population, la respiration et la densité des termites ont été estimées. Après 2 ans de décomposition le poids sec moyen des branches avait diminué de 89 %. Le rapport C/N dans le sol plus bas en hiver et pendant la saison des pluies, montre l'influence de l'action microbienne, tandis que le rapport plus élevé de l'été montre celle de la faune et plus spécialement celle des termites.*

Le taux de décomposition plus rapide observé pendant la saison des pluies est dû aux plus grandes quantités de matières organiques et en azote disponibles pour la colonisation microbienne pendant la décomposition.

ABSTRACT

Branch wood litter decomposition was performed for Shorea robusta *branches in a sub tropical sal forest. Termite population, respiration and density was estimated for this site. After 2 years of decomposition mean dry weight of branch wood decreased by 89 %. Lower C/N ratio in soil in winter and rainy seasons signify the positive influence of microbes, and greater ratio in summer supported the faunal activity especially termites. Faster decay rate, observed in rainy season, was due to greater availability of organic matter and N from soil for microbial colonization for decomposition.*

INTRODUCTION

Termites play a significant role in soil and nutrient turnover by fragmenting and chemically changing the complex organic matter into simpler one. DICKINSON (1974) discussed the effect of soil structure, soil water, soil water relations, soil atmosphere and soil physical and chemical properties on the activity of soil organisms. Soil structure affects the movement of soil animals as most animals avoid regions of low O_2

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concentrations, thus affecting the rate of decomposition. Soil temperature, N-content and the biological interactions occuring in the soil affect the growth of soil organisms and decomposition. The present study was aimed at elucidating the rate of litter decomposition in relation to termite activity and chemical and physical properties of soil in a subtropical forest located in foothills of Kumaun Himalaya.

Study site, climate vegetation, geology and soil.

The study site is located at 330 m altitude (29°08' N and 79°38' E) in sal (*Shorea robusta* Gaertn. f.) forest at Chorgalia in the foothills of Kumaun Himalaya. The climate is greatly influenced by monsoon and can be referred as monsoon sub-tropical. The average monthly rainfall ranges from 3 mm (November) to 607 mm (July) and the mean daily temperature ranges from 13° C (January) to 31.9° C (June). The year can be broadly divided into three distinct seasons viz : summer, rainy and winter.

The site is situated on the Siwalik ranges of the Himalaya. The rocks, exposed at the site and termed as lower Siwalik formation consists of mainly grey sandstone with considerable shearing. The essential constituents of Siwalik sediments are quartz, feldspar, mica and calcareous cement. The soil is deep and alluvial. Soil texture is loamy sand and colour is dark brown. Sand content was higher in top soil (79 %) compared to sub-soil (76 %). Silt and clay showed the reverse trend. Bulk density for the top soil was 1.16 g cm^{-3} and for the sub-soil 1.32 g cm^{-3}. Water holding capacity, moisture and soil porosity were higher for the top soil. Phytosociological analysis of the site indicated the strong dominance of *Shorea robusta* having mean basal area 0.068 m^2 ha^{-i}. *Mallotus philippensis* was the important under canopy species. Other associated species of the site were *Syzygium jambolana* and *Ehertia laevis*.

MATERIALS AND METHODS

Litter decomposition

Live branches of *Shorea robusta* were collected in August, 1981. It was not possible to obtain all replicate samples with exactly the same diameter, however, the overall variation in the diameter of branches was only 4.63 - 4.84 cm (mean 4.73 cm). Length of the branches was similar i.e. 23 cm. The fresh and dry weight of branches of sizes approximately similar to the above were determined. The preweighed fresh samples were placed on the forest floor in permanents plots on August 7, 1981. Three samples were recovered at 4-months interval. The samples, thus obtained from periodical samplings were oven-dried at 70° C and weighed to determine the rate of decay and the changes in moisture content. The study was continued for a 2-yr-period.

Termite study

The total number of monds and carton nests were marked in a 5 ha plot. 25 quadrats of 20 m x 20 m size were laid out to determine the density of mounds and carton nest. Termite population of *Odontotermes obesus* on per mound basis was estimated by destructive sampling and the values of different castes of termites were multiplied by the total weight of termites and the fungus combs (BANERJEE, 1966, SINGH & SINGH, 1981). Population of *Microcerotermes championii* on per next basis was estimated following SEN-SHARMA and MISRA (1969).

Termite respiration

The CO_2 evolution of the entire mounds and nests was measured by alkali absorption. The mound was covered with air tight polyethylene tent and the nest by a sealed aluminium cylinder for a period of 24 hrs. Inside these 0.25 N NaOH solution was kept. After 24 hrs the alkali was titrated with HCl of the same normality, using phenophthaline as an indicator.

Physical and chemical analysis of soil

For physico-chemical analysis, the soil samples from top-soil (0-10 cm depth) and sub-soil (10-30 cm depth) were excavated with the help of soil cores. Water holding capacity and texture of soil samples were estimated following PIPER (1944) and BUOYOUCOS (1951), respectively. Organic carbon was determined by Walkley and Black's method; total N by microjeldahl method (PIPER, 1944); P by spectrophometer (JACKSON 1958); Na and K by flame photometer and Ca and Mg by atomic absorption spectro-photometer (ISSAC & KERBER, 1971).

RESULTS

Wood litter decomposition

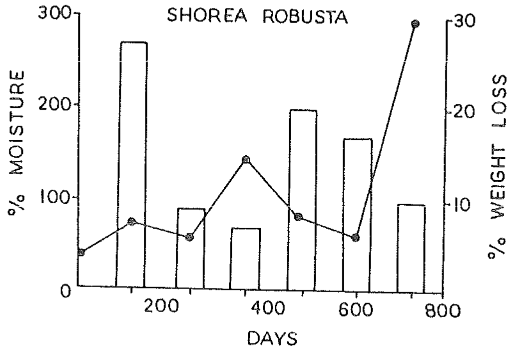

Fig. 1 : Branch wood litter decomposition of *S. robusta* in different time segments. Bars represent weight loss and bold line represents percent moisture in residual litter.

The seasonal decomposition rates of branch wood litter of *Shorea robusta* placed at the sal forest site are given in fig. 1. The mean dry weight of branch wood samples decreased by 89.36 %, for *Shorea robusta* at the end of 2-yr period. During the first four months *Shorea robusta* lost 27 % of its original weight. There existed a strong negative correlation between percent weight remaining and time elapsed for all species (r = -0.984 $p < 0.01$). It is indicated from analysis of variance on the data for percent weight loss that the difference in weightloss due to dates are significant at $p < 0.01$. It is clear that the wood litter of *Shorea robusta* decomposed at different rates in different seasons.

The moisture content of the decomposing litter in different periods varied markedly as did the periodic weight loss. Fig. 1 explores the relationship between weightloss and percentage moisture content in the residual litter.

Analysis of variance on litter moisture indicated significant difference due to time ($p < 0.01$).

Soil depth (cm)	Season	Organic C (%)	Total N (%)	Available P (%)	Exchangeable base (meq %)			
					Ca	Mg	K	Na
0-10	W	1.13 ± 0.010	0.123 ± 0.006	0.0070 ± 0.0005	6.59 ± 0.60	2.43 ± 0.12	0.358 ± 0.02	0.248 ± 0.02
	S	0.85 ± 0.027	0.061 ± 0.005	0.0065 ± 0.0004	7.46 ± 0.84	1.97 ± 0.05	0.322 ± 0.014	0.203 ± 0.004
	R	1.65 ± 0.012	0.203 ± 0.009	0.0085 ± 0.0007	7.13 ± 0.54	2.16 ± 0.08	0.482 ± 0.011	0.180 ± 0.005
10-30	W	1.08 ± 0.009	0.096 ± 0.004	0.0060 ± 0.0006	4.26 ± 0.43	1.94 ± 0.04	0.253 ± 0.028	0.097 ± 0.008
	S	0.77 ± 0.009	0.048 ± 0.005	0.0075 ± 0.0004	4.56 ± 0.34	1.84 ± 0.04	0.195 ± 0.008	0.163 ± 0.006
	R	1.62 ± 0.013	0.179 ± 0.004	0.0047 ± 0.0003	4.76 ± 0.43	1.62 ± 0.13	0.259 ± 0.018	0.166 ± 0.012

W = Winter season S = Summer season R = Rainy season

Table I : Seasonal nutrient concentrations in two soil depths of sal forest (± 1 SE)

Seasonal variation in major soil nutrients .

Table I illustrates the variation in seasonal nutrient status of 0-10 cm layer and 10-30 cm layer of soil of sal forest site. Across both the depths organic carbon, nitrogen and potassium concentration showed increasing trend from winter. The rainy season accounts for about 80 % of total rainfall (about 150 cm). The greater reduction in weight of litter in rainy season indicates the greater availability of labile and water soluble fractions in the mineral soil. This may help in the seed germination and seedling establishment of *Shorea robusta.* Recall, that regeneration of sal occur in rainy season only. VOGT (personal observation) in two *Abies* stand noted 4-25 % dry mass loss in litter bags from a simulated 2.5 cm rainfall. KVIST (1963) observed 0.9 to 16.5 % dry mass loss as a result of 24 hr. leaching with water. In the present study much higher weightloss was observed in winter season (8.53 % 1st year; 17.39 % 2nd year) compared to summer (7.2 % 1st year; 9.58 % 2nd year). So, winter season is likely to favour microbial and faunal population for the decay of branch wood litter. In winter season the present site received about 110 mm rainfall and mean monthly temperature never comes below or exceeds from 13-20° C. VOGT *et al.* (1983) and STARK (1973) have reported, respectiviely, 67 % and 85 % of annual loss during winter months. In summer seasons rainfall in the present study site is 400 mm, but the mean monthly temperature exceed 32° C. So, infrequent rainfall and the higher temperature contribute to increase evaporation of water. Thus, water becomes limited factor for decomposition. The similar weightloss in Ist and 2nd year summer season may be due to the termite activity of the site which may be the only active decomposer organism during summer season.

Decreased moisture availability in summer season could reduce decomposition activity (FOGEL & CHROMACK, 1973).

Nutrient availability in soil vs. weightloss

The faster rate of decay in rainy season is also due to presence of higher organic matter and nitrogen in the soil during rainy season which provides ready made source to microbes to attack on fresh litter. C/N ratio, as expected was also minimum in rainy season. Higher C/N ratio was observed in summer season which slows down the decay rate of branch wood litter of *S. robusta.* Except for Na and Mg all the nutrient in the soil were highest in rainy season. Presence of greater Na in winter and summer seasons reflect the importance of fauna in the decomposition in these two seasons. REICHLE (1969) has reported that Na concentration was 17 times high in

Month	*O. obesus* Worker	*O. obesus* Total	*M. championi* Worker	*M. championi* Total	*O. obesus* CO_2 production (ml CO_2/day/mound)	*M. championi* (ml CO_2/nest/day)
August	115.5	152.9	152.6	184.5	7 856.6	957.6
September	106.8	177.3	146.7	178.6	19.8	789.9
October	59.9	149.7	111.5	143.2	5 372.9	515.3
November	71.1	139.2	127.7	136.5	5 981.2	537.3
December	73.7	136.8	128.2	134.5	6 219.4	535.2
January	88.8	141.6	128.1	133.4	6 249.8	591.4
February	72.7	137.6	135.9	139.6	6 234.6	661.9
March	72.7	133.4	131.4	132.3	5 981.2	574.5
April	51.6	121.5	105.8	130.9	4 612.6	540.7
May	78.7	145.6	112.6	137.0	10 340.4	656.0
June	90.6	146.5	115.1	141.1	14 496.8	712.6
July	86.6	152.9	124.3	149.0	6 879.7	777.2

Table II : Monthly fluctuations in population density and CO_2 production of *Odontotermes obesus* and *Microcerotermes championi* (number m^{-2})

saprovores than that of plant leaves. GOSZ *et al.* (1973) have found 55 % loss of Na from decomposing leaves in winter months. REICHLE (1969) have also reported greater Na content in summer and autumn months for availability of heterotrophs.

Termite activity and branch wood litter decomposition

During the course of present investigation seasonality in termite population peaks and troughs are apparent. The activity of foraging by termites usually stops in rainy season which results in the high population densities of worker in the mound and nest. The lower values of workers population in October, March and April is due to the migration of these from their habitat to select litters for intense foraging. The greater weightloss in summer season in the present site, thus, is in conformity with the intense foraging activity. The litter after falling to the forest floor in March-May were fragmented by termites, thus, making the greater favourable condition for microbial attack and increased moisture. Apart from termites during wet season, faster decomposition in the present study may also be caused by microbes, mites and collembolans. SHARMA *et al.* (1984) found highest number of microarthropods in rainy season and SINGH and SINGH (1984) found greater number of bacteria, fungi and actinomycetes on the decomposing litter at Sal forest site. MADGE (1965) found that litter disappearance in tropical forests of Nigeria during the wet season was largely caused by mites and collembola.

Since soil respiration is the sum total of all metabolic functions, the CO_2 production from mounds and nests in May, June, July and August indicates the greater metabolic activity of the termites. Higher decay rates in these two seasons estimated in the present study signify the impact of termites on plant litter decomposition in tropical and sub-tropical forests.

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