Wood and leaf litter decomposition of *Dipterocarpus tuberculatus* Roxb. in a tropical deciduous forest of Manipur, Northeast India

A. Sarjubala Devi* and P. S. Yadava

Department of Life Sciences, Manipur University, Imphal 795 003, India

The decomposition of wood and leaf litter of a dominant tree species, *Dipterocarpus tuberculatus* Roxb. was studied from March 1999 to June 2000 in a tropical deciduous forest of Manipur, Northeast India. The weight loss pattern and concentration of nitrogen (N) and lignin during decomposition were also evaluated. The monthly weight loss was significantly correlated ($P < 0.05$) with soil moisture and rainfall in both types of litter. The rate of weight loss was faster in wood litter than leaf litter, probably due to termite-feeding activities.

Keywords: Leaf litter decomposition, lignin, nitrogen, wood decomposition.

LITTER decomposition plays a crucial role in the nutrient budget of forest ecosystems where vegetation depends mainly on the recycling of nutrients contained in the plant detritus. During this process plant nutrients became available for recycling within the ecosystem. Litter decomposition is influenced by environmental factors and also by physico-chemical properties of the parts such as stem wood, leaves, root, etc. of the species studied and decomposer organisms present in the soil[1,2]. Woody debris in the form of standing dead trees, fallen boles, large branches and roots is abundant in many forest ecosystems, and plays an important ecological role in the recycling of nutrients within the forest. This woody debris also reduces soil erosion, acts as a reservoir for nutrient and water storage, seed bed for plant establishment, and an habitat for fungi, bacteria, arthropods and a variety of vertebrates[3]. In Manipur, the *Dipterocarpus* forest occupies about 750 sq. km area along the Indo-Myanmar border, which is a part of the Indo-Malaya *Dipterocarpus* forest formation extending up to other South East Asian countries. This type of forest is gregarious in nature. *Dipterocarpus tuberculatus* is the dominant tree species and is a good timber-yielding plant. Therefore, in this study the pattern of decomposition of wood and leaf litter of *D. tuberculatus* Roxb. and the role played by abiotic variables have been taken into account.

The study was conducted in a tropical deciduous forest[4] located near Moreh town, Chandel District, between 23°49′–24°28′N lat. and 94°09′–94°31′E long. in Manipur along the Indo-Myanmar border of Northeast India at 300–360 m asl. The soil in the site is lateritic sandy loam (70% sand, 18% silt and 12% clay), reddish in colour and slightly acidic (pH 6.2). The site experiences three seasons – spring (March to May), rainy (June to October) and winter (November to February). The mean monthly maximum and minimum temperature ranged from 24.2 (January) to 36.0°C (May), and from 5.0 (January) to 23.1°C (August) respectively. The area receives 1245 mm annual rainfall, of which more than 80% occurs during the rainy season (Figure 1). The present forest is dominated by *Dipterocarpus tuberculatus* Roxb. and associated with *Ardisia peniculata* Roxb. *D. tuberculatus* exhibits[5] a density of 585–675 plants/ha and importance value index (IVI) of 27.36–60.70.

The study was conducted from February 1999 to May 2000. Different sizes and weights of wood slices have been taken from other studies[6,7]. However, in this study for convenience, one hundred slices of wood having a thickness of 3.5 cm were made from fresh branches and stem of *D. tuberculatus* having a girth size of 20 cm. They were air-dried in the laboratory and made into equal weights of 32 g by cutting-off the excess weights. The litter bag technique was used to quantify the remaining weight of leaves by taking freshly fallen leaves of *D. tuberculatus* and air-drying them to 10 g. They were kept in hundred nylon litter bags of 20 × 20 cm area, with a mesh size of 2 × 2 mm. The wood slices and litter bags were placed on the forest floor in five different plots having an area of 20 × 20 m each and monthly one each was collected from the plots until there was complete decomposition.

The recovered wood litter and litter bags were brushed and washed using tap water followed by distilled water with gentle agitation on a 1 mm mesh screen, and dried at 60°C in an oven until constant weight to determine weight loss, and grounded into powdered form in a Wiley mill (grinder) for chemical analysis. For estimation of initial substrate quality, five replicates from the fresh wood and

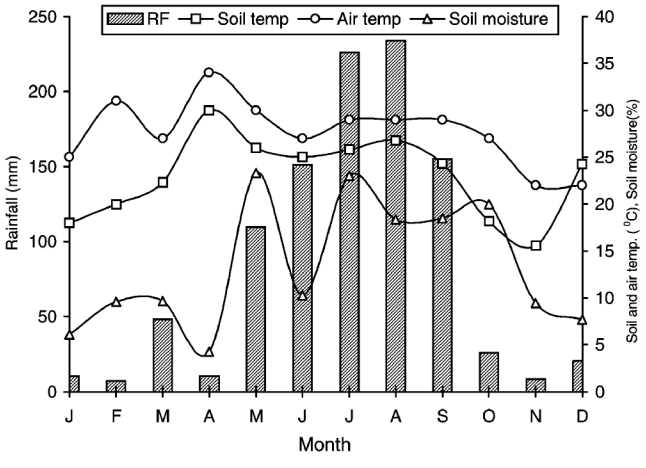

Figure 1. Monthly rainfall (mm), soil temperature (°C), air temperature (°C) and soil moisture (%).

*For correspondence. (e-mail: angom75@yahoo.com)

freshly fallen leaves were taken, air-dried and analysed. The decomposition constant (k) was calculated following the equation given by Olson[8]. Lignin was estimated by the digestion method using Fibertec (Tecator) and nitrogen by the Micro-Kjeldahl's method. Estimation of monthly lignin and nitrogen concentration was done for 12 months only.

In another experiment, five air-dried wood slices and litter bags having equal weight (32 g of wood and 10 g of leaf litter) with the first set of experiments were kept at the same spot every month and picked up the next month in order to study the weight loss rates per month.

The change in lignin and N concentration during decomposition of wood and leaf litter was calculated following the formula given by Harmon *et al.*[9]:

$$\text{Nutrient accumulation index (Nai)} = Wt\,Xt/Wo\,Xo,$$

where Wt is the dry weight of wood/leaf litter at time t, Xt the lignin/nitrogen concentration of wood/leaf at time t, Wo, the initial weight of wood/leaf, and Xo the initial concentration of lignin/nitrogen in wood/leaf.

Nai value of 1 indicates that decomposed litter contains the same amount of element as when the litter was placed in the field. Nai < 1 indicates net mineralization of element from the decaying litter, and Nai > 1 indicates net accumulation of element by the decaying litter.

Soil temperature of the study sites was determined using a soil thermometer, soil moisture by gravimetric method, soil pH by glass electrode (1 : 5 soil : water ratio) and soil texture by international pipette method.

The data recorded during the experiment were subjected to ANOVA (two-way, fixed effects model) to see the significant variations due to litter types. Correlation analysis was made to find out the relationship between wood and leaf litter loss rates with soil moisture and rainfall. The t-test was done to find out the significance of the comparisons made.

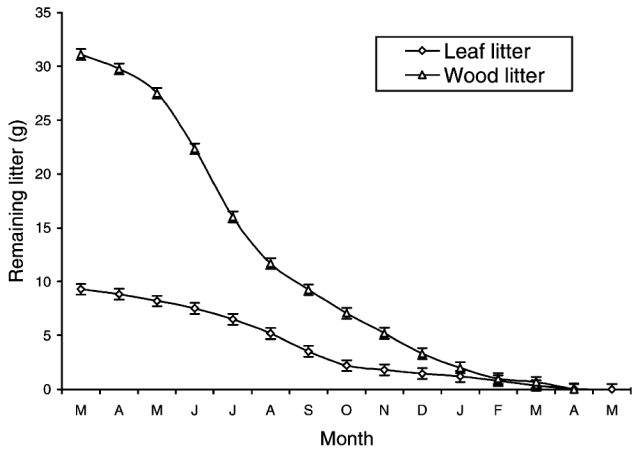

Figure 2. Monthly variation of remaining litter (g) in leaf and wood litter decomposition.

Fifty per cent of wood litter remained at the end of the fifth month (July), whereas for leaf litter it was at the end of the sixth month (August). About 3.1 and 8.4% of the wood and leaf litter respectively, remained at the end of the twelfth month (Figure 2). Wood litter decomposed completely in 14 months, whereas leaf litter decomposed completely in 15 months.

ANOVA of the remaining litter indicated a significant difference between the sampling months ($P < 0.01$) in both wood and leaf litter.

Loss of wood and leaf litter between the months increased consistently and attained a maximum value during September and August in wood and leaf litter respectively. Thereafter, it decreased till the termination of the experiment. Loss of wood and leaf litter was maximum during the rainy season followed by summer and winter seasons (Figure 3).

Loss of wood and leaf litter during different months was significantly correlated with soil moisture and rainfall in both types of litter (Table 1).

The initial lignin (IL) was found to be higher in wood litter, whereas initial N (IN) was found to be higher in leaf litter than wood litter (Table 2). However, the IL/IN ratio was higher in wood litter than leaf litter. The annual decomposition constant (k) was recorded to be higher in the wood litter compared to leaf litter.

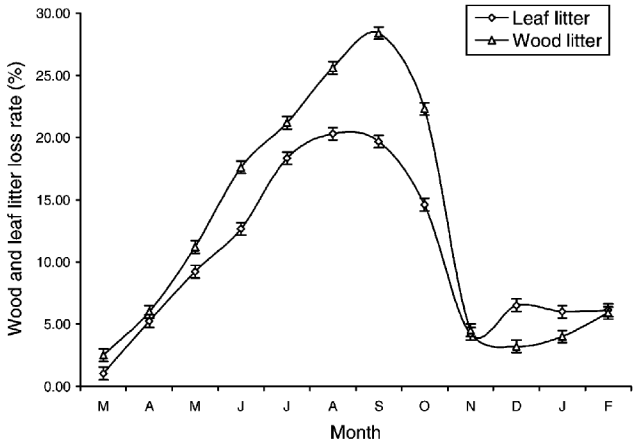

Figure 3. Monthly variation of leaf and wood litter loss rate (%).

Table 1. Correlation between rate of weight loss of wood and leaf litter with abiotic variables ($n = 12$)

Parameter	r
Wood	
Soil moisture	0.74*
Rainfall	0.80*
Leaf	
Soil moisture	0.73*
Rainfall	0.82*

*Shows significance at $P < 0.01$ level.

Table 2. Initial N (IN), initial lignin (IL), IL/IN, remaining weight (%) after 12 months, turnover rate decomposition constant (k) and nutrient accumulation index (Nai) of wood and leaf litter decomposition

	IN (%)	IL (%)	IL/IN	Remaining weight (%)	Turnover rate (days) 50%	k	Nai	
							Lignin	N
Wood	1.90	48.10	25.31	3.10	146	1.10	0.01	0.07
Leaf	2.70	20.10	7.45	8.42	165	1.07	0.07	0.14

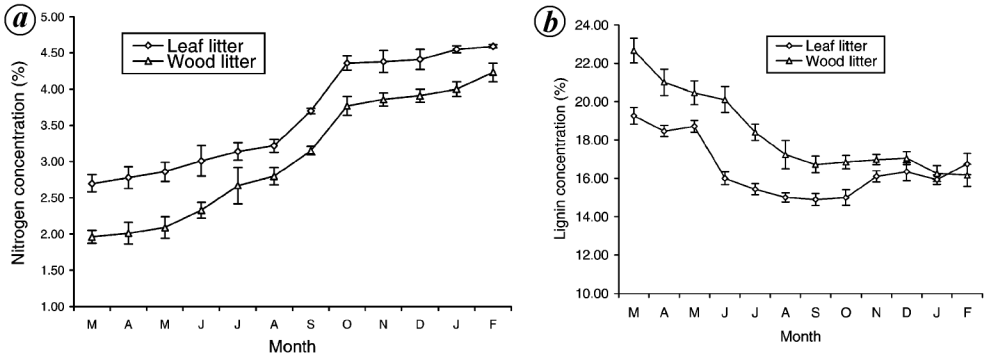

Figure 4. Monthly variation of (*a*) nitrogen (*b*) lignin concentration in leaf and wood litter decomposition.

Nitrogen concentration increased consistently during different months till the termination of the experiment in both wood and leaf litter (Figure 4 *a*). Lignin concentration decreased till the end of the experiment in wood litter decomposition, whereas in leaf litter decomposition the concentration of lignin declined in the initial stages and then increased slowly up to the final stage (Figure 4 *b*).

The values of Nai for wood and leaf litter were less than 1, showing that there is mineralization of lignin and N during the study. The Nai of both lignin and N in wood litter was less than that in leaf litter (Table 2), showing higher rate of mineralization in wood litter.

The higher weight loss in wood and leaf litter in the initial stages and a gradual decreasing trend as observed in the present study may be due to high initial content of water-soluble materials and simple substrates; breakdown of litter by decomposers, especially microorganisms, and removal of leaf litter particles by soil animals. Wood litter decomposed faster in comparison with leaf litter, which may be due to termite activity in the decomposition of wood. It was observed during the study that termites rarely attacked the leaves, but attacked the woody litter vigorously. Therefore, feeding activities of termites may accelerate decomposition. The preference of termite to wood over leaf litter needs to be investigated further. Termites are an important faunal component for litter decomposition in tropical forests, accelerating the decomposition rates[10–13].

Greater weight loss during the rainy season may be due to high percentage soil moisture and soil temperature, and also due to leaching of water-soluble substances from the litter mass. Smaller weight loss during winter may be due to cool and dry conditions. This is obvious from the positive correlation between the rate of weight loss with soil moisture and rainfall[14–16]. A high value of k indicates that the rate of weight loss of wood as well as leaf litter was high. Since the value of k was higher in wood litter, it decomposed faster.

Although wood litter has high initial lignin content, the rate of weight loss was faster compared to leaf litter. This may be due to the difference in soil fauna attacking wood and leaf litter. Many studies have reported a decline in the rate of weight loss of litter due to high initial lignin content[16–18]. However, the present study is contrary to these. The reason for faster rate of decomposition of wood litter may be due to rapid mineralization as well as termite-feeding activities.

In the present study though wood litter exhibits higher IL/IN ratio compared to leaf litter (Table 2), it decomposed faster. Therefore, the IL/IN ratio cannot be a good predictor for the pattern of decomposition as reported by several workers[13,19].

Nitrogen concentration in both types of litter increased throughout the study, which may be due to addition as a result of one or more of the following mechanisms: fixation, absorption of atmospheric ammonia, throughfall, dust, insect frass, green litter, fungal translocation and/or immobilization. Many studies have reported similar trends of increase in N during leaf litter decomposition in different forest ecosystems[1,20–24].

The decrease in lignin concentration in wood litter can be attributed to the weight loss due to rapid breakdown of lignin by termite-feeding activities. In the leaf litter lignin

concentration followed an initial decrease, which slowly increased until the end of the experiment. This could be due to a decrease in mineralization in the later stages.

In the present study it was found that though wood litter had high initial lignin than leaf litter, weight loss was rapid due to feeding of termites as well as increase in the mineralization of nutrients. Therefore, it can be stated that the termites play an important role in decomposition of wood. Further investigations are required on this aspect. The decomposition rate is also influenced by soil moisture and rainfall.

1. Vesterdal, L., Influence of soil type on mass loss and nutrient release from decomposing foliage litter of beech and Norway spruce. *Can. J. For. Res.*, 1999, **29**, 95–105.
2. Wedderburn, M. E. and Carter, J., Litter decomposition by four tree types for use in silvipastoral systems. *Soil Biol. Biochem.*, 1999, **31**, 455–461.
3. Stephen, C. H., Nitrogen transformation in fallen tree boles and mineral soil of an old-growth forest. *Ecology*, 1999, **80**, 1385–1394.
4. Champion, H. G. and Seth, S. K., In *A Revised Survey of the Forest Types of India*, Government of India, Delhi, 1968, pp. 56–106.
5. Supriya, L., Plant biodiversity, biomass and nutrient dynamics of *Dipterocarpus* forest of Manipur, Ph D thesis, 2002.
6. Genet, J. A., Genet, K. S., Thomas, M. B., Murphy, P. G. and Lugo, A. E., Response of termite community and wood decomposition rates to habitat fragmentation in a sub-tropical dry forest. *Trop. Ecol.*, 2001, **42**, 35–49.
7. Miller, M. M., Varama, M., Heinonem, J. and Hallaksela, A. M., Influence of insects on the diversity of fungi in decaying spruce wood in managed and natural forest. *For. Ecol. Manage.*, 2002, **166**, 165–181.
8. Olson, J. S., Energy storage and the balance of producers and decomposers in ecological systems. *Ecology*, 1963, **44**, 322–331.
9. Harmon, M. E. *et al.*, Ecology of coarse woody debris in temperate ecosystem. *Adv. Ecol. Res.*, 1986, **15**, 133–302.
10. Peterson, H. and Luxton, M., A comparative analysis of soil fauna populations and their role in decomposition processes. *Oikos*, 1982, **39**, 288–388.
11. Yamashita, T. and Takeda, H., Decomposition and nutrient dynamics of leaf litter in litter bags of two mesh sizes set in two *Dipterocarpus* forest sites in peninsular Malaysia. *Pedobiologia*, 1998, **42**, 11–21.
12. Sandhu, J., Sinha, M. and Ambasht, R. S., Nitrogen release from decomposing litter of *Leuceana leucocephala* in the dry tropics. *Soil Biol. Biochem.*, 1990, **22**, 859–863.
13. Swift, M. J., Heal, O. W. and Anderson, J. M., In *Decomposition in Terrestrial Ecosystems*, Blackwell Scientific Publications, UK, 1979.
14. Dasselar, A. V. V. and Latinga, E. A., Modelling the carbon cycle of grassland in the Netherlands under various management strategies and environmental conditions. *J. Agric. Sci.*, 2000, **43**, 183–194.
15. Okeke, A. I. and Omaliko, C. P. E., Leaf litter decomposition and carbondioxide evolution of some agroforestry fallow species in southern Nigeria. *For. Ecol. Manage.*, 1992, **50**, 103–116.
16. Austin, A. T. and Vitousek, P. M., Precipitation, decomposition and litter decomposability of *Metrosideros polymorpha* in active forests on Hawaii. *J. Ecol.*, 2000, **88**, 129–138.
17. Bilbro, J. D., Undersander, D. J., Fryrear, D. W. and Lester, C. M., A survey of lignin, cellulose and acid detergent fiber ash contents of several plants and implications for wind erosion control. *J. Soil Water Conserv.*, 1991, **64**, 314–316.
18. Reid, I. D., Biodegradation of lignin. *Can. J. Bot.*, 1995, **73**, S1011–S1018.
19. Laishram, I. D. and Yadava, P. S., Lignin and nitrogen in the decomposition of leaf litter in a subtropical forest ecosystem in Shiroy Hills in north-eastern India. *Plant Soil*, 1992, **106**, 59–64.
20. Bargali, S. S., Singh, S. P. and Singh, R. P., Patterns of weight loss and nutrient release from decomposing leaf litter in an age series of eucalyptus plantations. *Soil Biol. Biochem.*, 1993, **25**, 1731–1738.
21. Couteaux, M. M., Mctiernan, K. B., Berg, B., Szuberla, D., Dardenne, P. and Bottner, P., Chemical composition and carbon mineralization potential of scots pine needles at different stages of decomposition. *Soil Biol. Biochem.*, 1998, **30**, 583–595.
22. Taylor, B. R., Air drying depresses rates of leaf litter decomposition. *Soil Biol. Biochem.*, 1998, **30**, 403–412.
23. Musvoto, C., Campbell, B. M. and Kirchmann, H., Decomposition and nutrient release from mango and miombo woodland litter in Zimbabwe. *Soil Biol. Biochem.*, 2000, **32**, 1111–1119.
24. Ribeiro, C., Madeira, M. and Araújo, M. C., Decomposition and nutrient release from leaf litter of *Eucalyptus globulus* grown under different water and nutrient regimes. *For. Ecol. Manage.*, 2000, **171**, 31–41.

Received 1 April 2006; revised accepted 22 March 2007

Nyctibatrachus karnatakaensis nom. nov., a replacement name for the giant wrinkled frog from the Western Ghats

K. P. Dinesh[1,*], C. Radhakrishnan[1], A. H. Manjunatha Reddy[2] and K. V. Gururaja[3]

[1]Zoological Survey of India, Western Ghats Field Research Station, Calicut 673 002, India
[2]Indgen Life Technologies, 114/5, 18th 'A' Main, Muneshwara Block, Bangalore 560 026, India
[3]Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560 012, India

Amphibian research in the Western Ghats looks promising, as 21 new species have been described since 2000. Moreover, it has also provided better insights into the aspects of biogeography, Gondwana relicts and endemism. On the other hand, lack of proper systematics is leading to ambiguities and chaos in amphibian taxonomy. We are presenting a case of a recently described species, *Nyctibatrachus hussaini*, as an invalid name due to lack of typification and deposition of type specimen in any museum. Here we propose a replacement name for the species – *Nyctibatrachus karnatakaensis* nom. nov., – as well as holotype designation and vouchering the same in a museum.

Keywords: Amphibians, nomenclature, *Nyctibatrachus karnatakaensis*, *Nyctibatrachus hussaini*, the Western Ghats.

*For correspondence. (e-mail: zsicalicut@sancharnet.in)