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Leaf Litter Decomposition, Abiotic Factors and Population of Micro-arthropods in a Sub-tropical Forest Ecosystem, Manipur, North East India

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ABSTRACT

Microclimatic variation can influence litter decomposition rates directly, or indirectly through changes in microarthropod population. This study examines the rates of leaf litter decomposition of two dominant species viz., *Quercus serrata* and *Castanea sativa* at two elevational plots which have varied microclimatic in sub-tropical forest ecosystem. One year litter bag experiment was performed to determine the rate of leaf litter decomposition and microarthropod population. The remaining mass for leaf litter in the litterbags was found more for *Q. serrata* – 33.2% at lower elevation and 37.6% at upper elevation. The population of microarthropods ranges from 12.8 to 68.4 per g of leaf litter at upper elevation and 16.3 to 71.2 per g of leaf litter at lower elevation. The moisture content and litter accumulation were comparatively higher at the lower elevation. In both sites, the rate of decomposition and microarthropods population were found positively correlated with moisture content and rainfall.

Key Words: Litter Decomposition, Microarthropod, Litter Bag, Population, Elevation.

INTRODUCTION

The litter decomposition process namely fragmentation, leaching and catabolism are related to the abundance of soil microarthropods in association with various abiotic factors such as temperature, moisture, rainfall etc. Decomposition of plant litter, in nature occurs with the active involvement of microorganism and invertebrates as mediated by various abiotic environmental factors. These factors play a significant role in mass loss of litter (Witkamp and Drift 1961, Witkamp and Crossley, 1966). Microarthropods (<10 mm) which are considered as members of the Mesofauna of the soil play a critical role in the process of decomposition. They respond quickly to changes in climate and physico-chemical properties of soil. Acarina and collembola represent the bulk, about 72 to 97% of the total arthropod fauna of soil. Microarthropods, one of the several agents involved in litter decomposition are important in breaking down the plant litter (Shadangi and Nath 2006). Little is known about the response of litter microarthropods to change in climate and their influence on the rate of decomposition. This study aims to determine the rate of decomposition of leaf litter of two tree species viz., *Quercus serrata* Murray (sp. Q.) and *Castanea sativa* Mill (Sp. C) at two elevations and the population of microarthropods in the decomposing leaf litter.

Study Site

The study was conducted at Phayeng protected sub-tropical forest ecosystem which is situated about 15 km west of Imphal. Its altitude ranges from 880m to 1765 m above MSL. The study area has a monsoon type, rainforest climate. The total annual rainfall recorded during the study period was 1463.05 mm. Most of the rainfall occurred during the period from May to October. The mean minimum and maximum temperatures recorded during the study period were 8.5^{0}C (January) to 28^{0}C (July) respectively. Table 1 shows the physico-chemical characteristics of the soil of the two study plots.

MATERIAL AND METHODS

The litter bag technique (Crossley and Hoglund, 1962) was used to monitor the mass loss of litter and to assess microarthropods population. Freshly fallen leaves of *Q.*

Table 1. The physico chemical characteristics of the study plots.

Parameters	Plot-I	Plot -II
Soil temperature (^{0}C)	16.5	15.15
Soil moisture (%)	21.25	23.83
Soil pH 5.9	5.7	
Soil N (%)	2.52	2.56
Soil P (%)	0.2	0.19
Litter temperature (^{0}C)	16.6	15.8
Litter moisture (%)	39.21	44.58

serrata and *C. sativa* were gathered from forest floor of the study sites during the peak period of litterfall in January 2004. These were air-dried, weighed 10 g each and placed in 10x10 cm nylon bags (2 mm mesh size) and placed on the soil surface of the study areas. Three litterbags per species were collected from each plot at monthly interval. Litter from the litterbags were removed and washed by tap water in the laboratory and oven dried to a constant weight to determine the remaining mass of leaf litter.

Decay constants were determined for the different leaf litter remaining mass using an exponential decay model (Boulton and Boon 1991).

$$m_t = m_o e^{-kt}$$

where, m_t = mass remaining at time t; m_o = initial mass; and k = breakdown rate constant

Turnover time is expressed as the reciprocal of turnover rate, 1/k.

Microarthropods were extracted by placing the litter bags in modified Tullgren funnel for 6 to 7 days. Microarthropods were preserved in 75% ethanol with 3 to 4 drops of glycerol. They were sorted out, counted and identified using a binocular microscope.

Soil and litter moisture were determined by gravimetric method after oven drying the samples at 105^{0}C to constant weight. The soil nitrogen and phosphorous were analysed by FIASTAR 5000. Litter lignin was analysed by Fibertec system M 1017 Hot Extractor.

RESULTS

The remaining litter mass in the litterbags decreased linearly with time for both plots and litter types. Both litter and elevation effects were varied. The rate of decomposition in plot-I at the higher elevation is found to be lesser than plot-II which is at the lower elevation (Figure 1). The litter bag of plot-I retained higher percentage of its initial mass, however the percentage of litter retained is more on the litter bag of sp. Q than sp. C after twelve months. The remaining litter mass of sp. Q and sp. C after twelve months were 37.6% and 29.5% at plot-I and, 33.2% and 26.9% at plot-II respectively.

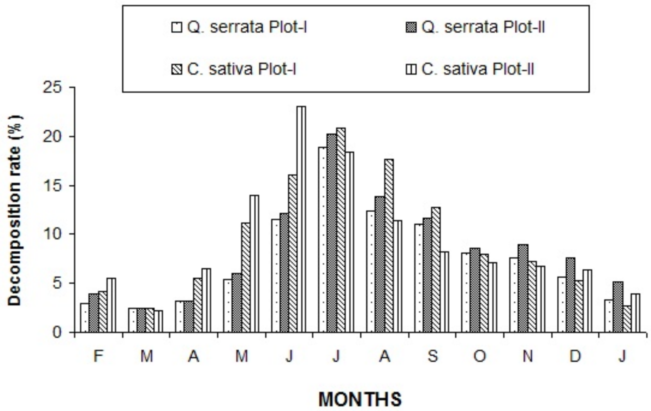

Figure 1. Leaf litter decomposition rate of *Q. serrata* and *C. sativa* at two plot in different months

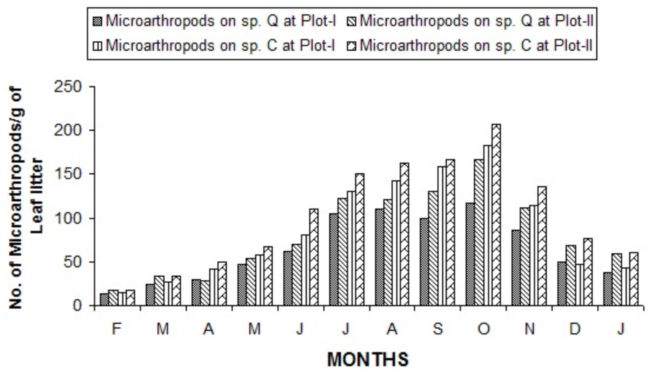

Figure 2. Number of microarthropods per g of leaf litter of two species at plot-I and at plot-II

Annual decay rate constants were calculated for both litter types and plots. The decay rate constants of sp. Q and sp. C observed from the present investigation were k = 0.035 and k = 0.044 at plot-I and k = 0.039 and k = 0.048 at plot-II respectively. The rate of leaf litter decomposition of the two species were found to exhibit peak value during the rainy season in both the study plots.

The population of microarthropods (per g of leaf litter) were found to differ through time, and between litter species and plots (Figure 2). Plot-II had higher population than plot-I, although this was not statistically significant. Comparative analysis between the litter species shows higher population of microarthropods in the decomposing leaf litter bag of sp. C than that in sp. Q litterbags at both plots. Population variation through time followed a seasonal pattern which was remarkably similar for both plots and litter types. Population was found to be higher during the period from June to October and lower during the December to January synchronizing with decomposition rate. And it attained the peak value in the month of October.

DISCUSSION

In both the study plots the disappearance rate of leaf litter and the microarthropod abundance increased significantly between June and October. This coincides with the timing of canopy closure, temperature increase and maximum rainfall. The canopy protects the forest floor from direct sunlight and rapid desiccation. This condition was more significant in the forest floor of plot-II. Lower rate of decomposition and population of microarthropods occurred at plot-I. This may be an effect of direct exposure to sunlight and more air drainage due to loose canopy cover. Plot-II had higher rate of decomposition and population of microarthropods; this may be the outcome of deep litter layer which remain intact for a longer period under the high relative humidity.

Rainfall together with high temperature and high relative humidity during rainy season lead to an increase in the moisture content of the soil and litter which proliferated the growth of the ground vegetation and microflora. High temperature during this period facilitated litter decomposition after resulting into an increase in the soil acidity, which is favourable for more colonization of many microarthropods (Figure 2). Singh (1978) and Datta Munshi et al. (1987) also reported that the fast disappearance rate of litter during rainy season might be due to the accelerated growth of microbial population as well as their activities to decompose the material in the presence of sufficient moisture and optimum temperature, while it was moderate in winter season and at slow rate in summer season. In study, the moisture contents of the soil and litter during the rainy season (June to October) were not less than 25% and 35% respectively and the number of microarthropods per bag averaged more than 500. In both the plots, the rates of decomposition were positively correlated with moisture ($r=0.88$ for sp. Q and $r = 0.77$ for sp. C), with rainfall of previous months ($r = 0.85$ for sp. Q and $r = 0.93$ for sp. C) and with microarthropods population ($r = 0.82$ for sp. Q and $r = 0.77$ for sp. C). This may be due to physical determinants, particularly soil and litter moisture content, temperature and evapotranspiration rate for the activity of the decomposers.

Sp. C had higher rate of disappearance in both study plots; this appears to be outcome/function of the lower value of the ratio of initial lignin to the initial nitrogen (IL/IN = 8.65). Berg and Ekbohn (1991) also observed that species with high nitrogen content disappeared at greater rates. The impact of litter quality on litter invertebrates and decomposition processes has been shown in temperate forests within the range between mor and mull humus types (Anderson 1973, Swift et al. 1979). Litter high in lignin not only contains a large amount of decay resistant carbon material, but also has a relatively small proportion of the easily decomposed substrate (i.e., cellulose, carbohydrates; Murphy et al. 1998). Meentemeyer and Berg (1986) reported that the initial nitrogen is moderately well correlated with weight loss.

Observations correlating increased microarthropod abundance with mass loss from a variety of substrates are commonplace regarding both tropical and temperate sites (Crossley and Hoglund 1962, Reddy 1995). Similar observation was made at the subtropical forest ecosystem in the present study (Figure 3). By their grazing activity on fungi, collembola and acarina play an important role in the slow but gradual mineralization of nutrient (Teuben and Roelofsma 1990). Collembola and Acarina together constituted >82% of the total microathropods inhabiting both mesh-size types of litter bags (Reddy 1992). In the present study, collembola and mite were abundant and dominated the micro-arthropods population in the decomposing leaf litter bags. The percent contribution of the Acarina to the leaf litter decomposition was more than that of Collembola and other microarthropods (Table 2). This may be due to the availability of sufficient nutrients for feeding and favourable climatic parameters. Cryptostigmata, a suborder of Acarina, were the dominant ones as they were more capable of penetrating even into the fine mesh litterbags through

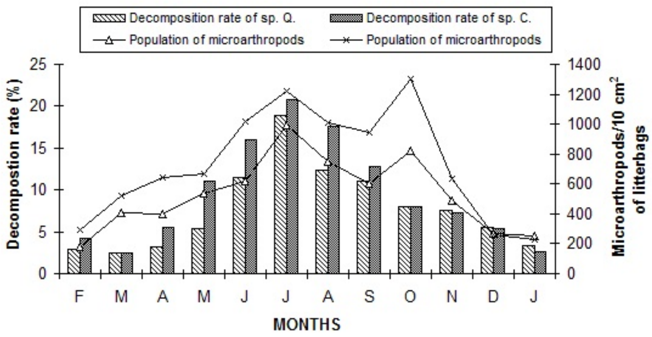

Figure 3. Comparison of the rate of leaf litter decomposition and abundance of microarthropods in the litter bags of *Q. serrata* and *C. sativa*

Table 2. Contribution (%) of litter fauna during leaf litter decomposition at two plots.

Microarthropods	Plot - I		Plot - II	
	Sp. Q	Sp. C	Sp. Q	Sp. C
Acarina				
(i) Cryptostigmata	39.11	43.59	38.99	39.47
(ii) Mesostigmata	13.91	12.61	5.21	14.96
(iii) Prostegmata	10.31	6.96	9.37	9.96
(iv) Astigmata	2.77	3.34	2.91	3.19
Total Acarina	66.10	66.27	66.48	67.37
Collembola	32.39	32.21	32.26	31.48
Other litter fauna	1.50	1.51	1.25	1.46

holes caused by biological factors, like root penetration. This can be attributed to a protective effect produced by the mesh size that did not allow the entrance of predator groups (particularly Araneae and Pseudoscorpiones). Vossbrink et al. (1979) observed high mite population which were related to moisture content in the litter bags, average daily temperature and precipitation. The population of Collembola occurred in greater proportion on the decomposing leaf litter of both sp. Q and sp. C at both the elevations.

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