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Mass loss and concentrations of nutrients in relation to microarthropod abundance, during needle decomposition in a pine plantation

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Abstract. Mass loss and concentrations of N, P, Ca and Mg of needle litter in relation to microarthropod population abundance during decomposition were investigated by the litter-bag method in a pine (*Pinus kesiya* Royle) plantation in north-eastern India. Collembola and Acarina together constituted 97·5% of the total microarthropods. Nitrogen slowly increased in its concentration in litter as decomposition progressed. Concentrations of Ca and Mg increased while that of K decreased in the litter. The microarthropods showed significant positive correlation with mass loss of the litter, but did not show any relationship with the N and Ca concentrations. Acarina abundance showed significant positive correlation with Mg concentrations of litter. The microarthropods other than Collembola and Acarina, however, showed significant negative correlation with K concentration of litter although they were recorded in meagre numbers.

Keywords. Microarthropods; needle litter; mass loss; nutrients; *Pinus kesiya* R.

1. Introduction

Mass loss of litter and its rate of mineralization during decomposition is significantly influenced by the abundance and activities of microarthropods (Swift *et al* 1979; Seastedt 1984). A number of studies have demonstrated that the soil fauna regulate these processes (Witkamp and Crossley 1966; Seastedt and Crossley 1980; Anderson *et al* 1983). While such reports are common from temperate regions, little information is available on the effect of fauna on decomposition and mineralisation in tropical ecosystems. Thus, the present investigation was undertaken to study the relationships between the abundance of microarthropods and the mass loss, and concentrations of some mineral nutrients of needle litter of pine (*Pinus kesiya* Royle ex-Gorden) during decomposition under field conditions.

2. Study area

The study area was a *P. kesiya* plantation of about 15 years old near Shillong (Lat. 25°34′ N, Long. 90°56′ E and altitude 1250 m above MSL, north-eastern India), which has been the location of an intensive study of the structure and function of this ecosystem since 1975. A detailed description of the area has been given in Reddy (1984). The climate is subtropical with monthly total rainfall, litter moisture and temperature ranging from 0–72·9 cm, 15–73·8% and 16·5–25·5°C respectively (figure 1). The rainy season extends from the end of March to October with maximum rainfall during June–July and minimum in February, winter being experienced from November to February and a mild summer in March.

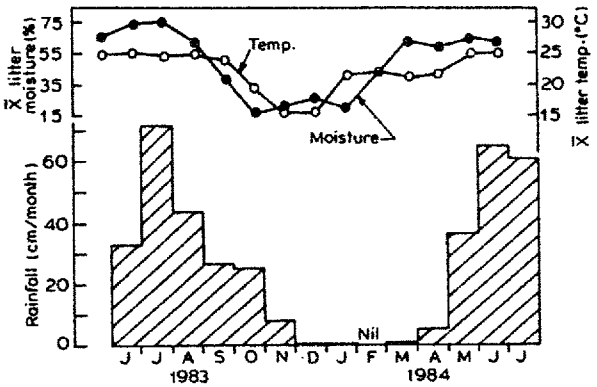

Figure 1. Seasonal changes in the total monthly rainfall, litter-moisture and litter-temperature at the plantation site.

3. Materials and methods

The abundance of litter inhabiting microarthropods and litter for the analysis of mineral nutrients such as N, K, Ca and Mg were sampled by the litter-bag method (Crossley and Hoglund 1962). The freshly shed pine needles were collected during the litter fall season from the plantation site, air-dried and cut into uniform size of 5 cm length. Ten g of the air dried litter was placed in 10 × 10 cm nylon mesh bags of 1 mm pore size. These litter filled bags were placed on the floor of the plantation and covered with a thin layer of freshly fallen needle litter. Three bags were collected from the field at monthly intervals beginning 30 days after placement of the bags on the plantation floor. Microarthropods were extracted with Tullgren funnels and were stored in 80% ethanol for identification and counting. The litter i.e. litter and associated microflora of the bags, was separated from adhering soil particles, oven dried at 75°C and weighed. Samples were then powdered and analysed for N, K, Ca and Mg following the methods of Allen *et al* (1974). Rate of mass loss was measured as loss in oven-dry weight (Curry 1969).

Data were analysed by a stepwise selective multiple regression model to assess the relationships between the population abundance of different groups of micro-arthropods, and mass loss and concentrations of the nutrients of the decomposed litter.

4. Results and discussion

The abundance of microarthropods per g of litter of the litter-bags varied considerably and was influenced by the abiotic factors, particularly rainfall (figure 2; Reddy 1984). Collembola comprised 67·5% of the total fauna, with *Isotoma trispinata* MacGillvray being dominant. The Acarina comprised 30% of the fauna and were dominated by a cryptostigmatid, *Galumna* sp. Miscellaneous groups such as Pauropoda, Diplopoda, Symphyla, Hymenoptera, Coleoptera, Araneida and Dipteran larvae constituted the remaining 2·5%.

During August 1983 and January 1984 when the populations of microarthropods were very low, the mass loss of litter from the litter-bags was also low. In contrast,

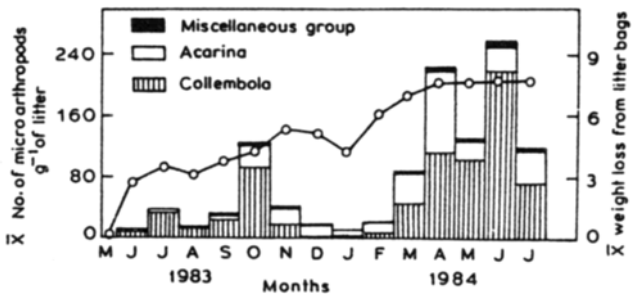

Figure 2. Seasonal abundance of microarthropods per g of the litter and mean loss of litter mass.

during the last 4 months of the investigation when the microarthropod populations were relatively more dense, the mass loss was maximum (figure 2). The fragmentation activities of the microarthropods in the litter was evident from the disintegrated litter recovered from the litter bags. Microinvertebrate activity in the bags was minimal due to the mesh size of the litter bags. Collembola, Acarina and miscellaneous taxa were all positively correlated with mass loss (table 1). The microarthropods along with abiotic factors such as rainfall, litter moisture and temperature showed significant combined influence on the mass loss of litter (multiple regression: $R^2 = 0{\cdot}75$; $P < 0{\cdot}05$). The mass loss in May–June was probably attributable to leaching of soluble organic compounds (Swift *et al* 1979). Decay after one year was about 80% of the litter, a value much higher than those reported for temperate zones (Cromack and Monk 1975; Fogel and Cromack 1977), and was most probably due to the combination of higher faunal densities in conjunction with greater microbial activity.

Seasonal patterns of N, K, Ca and Mg concentrations in litter showed much less seasonal variation than would be expected from the bimodal pattern of rainfall (figure 3). Nitrogen concentrations slowly increased throughout the first year of decay while Mg exhibited no clear pattern. Calcium exhibited a sharp decline during the initiation of the dry period, while K showed an increase in concentrations during the dry periods. This increase is correlated with an apparent absolute increase in litter mass (figure 2), suggesting dry particulate deposition on the litter (Seastedt and Crossley 1980). Nutrient loss from decomposing litter is the net effect of changes in nutrient concentrations and litter mass. The general absence of changes in nutrient concentrations relative to the densities of fauna (table 1 and figure 2) indicates that intense periods of microbial immobilization followed by rapid pulses of mineralisation do not occur. Given that the densities of fauna are generally high per g of litter [often over two to four times those reported by Seastedt *et al* (1983) for southern appalachian litter of similar age], fragmentation and grazing effects appear to be the dominant factors influencing elemental dynamics. This would explain the strong correlations with monthly mass loss, but few correlations with nutrient concentrations of decaying litter.

Although microarthropods have often been reported to influence the net mineralisation of the chemical elements of litter (Seastedt 1984), there were no significant correlations between N and Ca concentrations of the decomposed needle litter and the abundance of any of the groups of microarthropods (table 1). The lack

Table 1. Regression equations between the abundances of different groups of micro-arthropods, and the mass loss and concentration of N, K, Ca and Mg (% of dry mass) of the decomposed needle litter.

Different arthropod taxa	Loss in litter mass	N	K	Ca	Mg
Collembola	$Y=5{\cdot}58+0{\cdot}007X$ $t=2{\cdot}05^{*}$	—	—	—	—
Acarina	$Y=5{\cdot}9+0{\cdot}02X$ $t=2{\cdot}9^{**}$	—	—	—	$Y=0{\cdot}2+0{\cdot}004X$ $t=2{\cdot}08^{*}$
Miscellaneous	$Y=6{\cdot}17+0{\cdot}28X$ $t=4{\cdot}0^{**}$	—	$Y=0{\cdot}07-0{\cdot}014X$ $t=2{\cdot}19^{**}$	—	—

Level of significance: $^{*}P<0{\cdot}05$; $^{**}P<0{\cdot}01$.

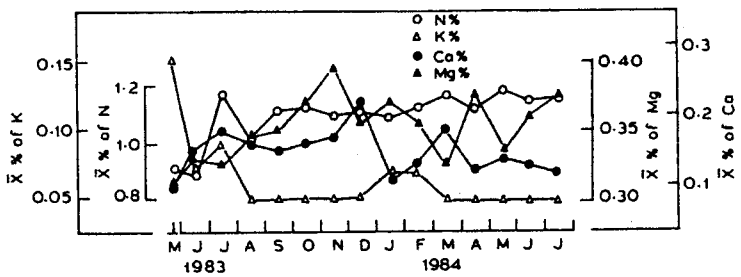

Figure 3. Seasonal changes in the mean concentration of N, P, Ca and Mg (% of dry mass) of the decomposed litter.

of a relationship supports the findings of Macauley (1975) that microarthropods have little effect on the nitrogen concentrations of the decomposed litter. However, Anderson *et al* (1983) reported that Collembola have a considerably great effect on the loss of N from the decomposed litter than any other taxa of soil fauna. Similarly, these microarthropods may have little effect on the amount of Ca (Seastedt 1984). However, Ineson *et al* (1982) reported that grazing of Collembola significantly increased the leaching of ammonium, nitrate and Ca from decomposed oak litter. The K concentration of the decomposed litter, while not showing any correlation with the abundance of Collembola and Acarina, was significantly negatively correlated with the abundance of other (miscellaneous) microarthropods (table 1). This group, although few in number, may facilitate the leaching of K from litter. However, Ineson *et al* (1982) reported that this element was little affected by microarthropods. The Mg concentration of litter showed significant positive correlation with the abundance of Acarina in litter bags (table 1), but there was no correlation between its concentration and the abundance of Collembola and the miscellaneous microarthropods. Seastedt (1984) reported that microarthropods have no consistent effect on Mg of the decomposed litter. Overall, this study suggests that microarthropods played a significant role in the mass loss of the decaying needle litter while having very little effect of nutrient concentrations. The net result of rapid mass loss with no significant increase in elemental concentrations of this decaying mass implies very rapid mineralization effects of tropical fauna.

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