RELEVANCE OF FOREST LITTER FAUNA IN ECOSYSTEM FUNCTIONING AND MAINTENANCE OF BIODIVERSITY

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ABSTRACT

A healthy and sustainable soil and litter system make the foundation on which the forest stands, and there is growing recognition that litter biota plays a vital role in modifying or even controlling many physical and chemical processes necessary for maintaining a sustainable soil system. The quality of plant litter is a key factor regulating the decomposition of litter and transformation of litter nutrients into soil humus. Analyses of decomposing litter inform us about the distribution and abundance (structure) of litter biota such as insects and arachnids and other invertebrates which in concert with various chemical changes, cause transformations in litter quality (eg. increase in nitrogen and phosphorus concentrations) that influence decomposition dynamics. Various basic aspects of the litter ecosystem are discussed.

INTRODUCTION - FOREST LITTER HABITAT

The forest floor represents the uppermost organic and organic enriched mineral soil horizons, formed by the deposition of intact leaves, twigs, larger branches, bark, flowers, fruits, spores, etc., which together form the litter and the subsequent biologically mediated decomposition. This organic material becomes mixed with the mineral soil and is

gradually decomposed. While the litter layer may not receive the same degree of attention as other components of an ecosystem, it is of great importance from the point of view of biological diversity (an enormous number of species live here), food chains (many start here) and ecosystem processes such as energy and nutrient cycles (Anathakrishnan 1996). The litter layer is vital in protecting the underlying soil from erosion, thus preventing the loss of valuable topsoil and helping to keep our waterways free of siltation. Litter softens the impact of raindrops and so protects the soil surface from erosion - with a good cover of litter the ability of the soil to retain moisture is increased, topsoil loss is minimised and siltation of waterbodies reduced. The litter layer also helps to maintain good soil structure and fertility, and aids moisture retention. Soil and litter organisms play a vital role in the decomposition of organic material and contribute to the dispersal of seeds and spores. Litter fauna are essential in maintaining good soil structure and fertility, aid seed dispersal and provide food for ground foraging birds, small mammals, reptiles and frogs. Yet people are often unaware of the abundance and diversity of life forms inhabiting the soil and litter.

There are several possible reasons:

- It’s a hidden world, at least from casual observation, as the activities of life and death go on mostly in darkness and out of sight of humans

- The life forms range in size from fairly small to microscopic and may require specialised equipment and techniques to be found and observed

- The organisms inhabiting the litter and soil - worms, mites, spiders, springtails, insect larvae and a wide range of other invertebrates, fungi and bacteria - may seem remote and unfamiliar to humans

In addition, due to 'taxonomic impediment.' the number of specialists able to process samples and identify specimens is limited (New 1999). Hence, there is limited knowledge of ecological roles, patterns of species diversity and distribution, little specific knowledge about invertebrate responses to environment changes, and the lack of clearly documented, easy-to understand, standardised sampling protocols. There is also limited support for invertebrates from the public, administrators and funding agencies who do not necessarily perceive invertebrates as charismatic animals warranting additional attention and funding.

LITTER FAUNA

A healthy and sustainable forest floor or litter/soil system is the foundation on which the forest stands, and there is growing recognition that forest litter organisms play vital roles in modifying or even controlling many physical and chemical processes necessary for maintaining a sustainable litter system (Ananthakrishnan 1996, Shaw *et al.,* 1991).

A fistful of forest litter is harboured by hundreds, if not thousands, of species of decomposer organisms. Forest floor/litter microbes and fauna make up a decomposer food web that is largely responsible for regulating nutrient cycles and, consequently, tree growth. Bacteria and fungi form the base of the litter food web. Groups of soil fauna represent the *grazers* (different groups feed on the various saprophytic and

mycorrhizal fungi, and living and dead plant material) and predators in the food web. In litter , the basic food web structure is similar to other food webs by containing primary producers, consumers (fungivores, detritivores & omnivores) and predators (Moore *et al.*, 1988).

Detrital food webs with dead organic matter and microbes at the base, and litter fauna on the top are exceptionally complex in structure and the number of trophic links may be much higher than in above-ground food webs (Usher 1976, Anderson 1977, Coleman 1996).

Predators include secondary, tertiary and quaternary consumers, including certain nematodes, beetles, fly larvae, centipedes, spiders and mites. Some mesofauna, such as nematodes and protozoa, may serve as predators or prey depending on the other species in the community (Griffiths 1994, Yeates and Wardle 1996). Numbers and biomass per volume of soil organisms decrease by orders of magnitude from bottom to top positions in the food chain. In contrast to other food webs, litter food webs tend to have longer food chains, many organisms are at least capable of feeding on other trophic groups and as a result, greater incidences of omnivory, and possibly greater complexity than other food webs (Walter 1987, Walter and Ikonen 1989, Mueller *et al.*, 1990, Bengtsson *et al.*, 1995). Further, all fauna depend on the primary producers (eg. for litter). Energy and nutrients obtained by plants (primary producers) eventually become incorporated in detritus/litter that provides the resource base of a complex litter detritius food web. The task of identifying litter fauna in our region is made easier by pioneering works on the litter habitat and invertebrates by Ananthakrishnan (1997).

Swift and Bignell (2000) classified belowground invertebrates according to their feeding habits and distribution as follows:

(a) Epigeic species are biota, which live and feed on the soil surface. These invertebrates effect litter comminution (reduction in litter size) and mineralisation (nutrient release), but do not actively redistribute plant materials. They are mainly‘surface-active’ arthropods e.g. ants, beetles, cockroaches, centipedes, millipedes, woodlice, orthopterans, together with gastropods (snails) and small, dark coloured earthworms.

(b) Anecic species are biota, which eat litter from the soil surface and transport it to the deeper soil layers. Through their feeding activities, a considerable amount of topsoil, minerals and organic materials become distributed through the soil profile; this is also accompanied by channels and an increase in soil porosity. Fauna included in this group are earthworms, nonsoil-feeding termites and arachnids (spiders).

(c) Endogeic species are biota, which live in the soil and feed on organic matter and dead roots, also ingesting large quantities of mineral materials. Fauna included in this group are non-pigmented earthworms and soil-feeding termites.

SEASONAL VARIATION IN LITTER HABITAT

The litter provides a spatially diverse habitat, which changes over time. The amount of litter fall may change on a seasonal basis or based on the forest vegetation type resulting in litter depth peaking perhaps once or twice through the year

(Ananthakrishnan 1996). In rainforest, litter fall may be high yet litter can be sparse on the ground as the leaves are more rapidly consumed by litter fauna. The composition of the litter may also vary. For example, leaves of different plant species and a range of different fruits and flowers may be present at different times of the year. Some animals, such as spiders and ants, range freely over the surface of the litter while others, such as earthworms, tunnel through the soil or live permanently in burrows. Many insects such as cicadas and beetles spend their larval or nymphal life stage in the litter or soil while the adults live in the forest canopy where they may provide a food source for a range of insectivorous birds, mammals and reptiles. Termites build large specialised structures on the surface or below ground. Some animals migrate to different depths within the litter and soil depending on the season, prevailing environmental conditions and the life stage of the animal. Many soil and litter animals are very susceptible to drying out and so emerge to forage on the surface during the night or on wet overcast days. Generally the number of species of litter fauna will depend on the depth, complexity of structure and composition of the litter. More fauna species will usually be found where litter is deeper and formed from a greater range of plant species. The presence of fallen branches and rotting logs will add to the structural diversity and so influence the numbers and types of species present. Total numbers of individual animals present or active will vary on a seasonal basis. After the wetter weather of the S.W. and N.E. monsoon the faunal number may increase rapidly as reproductive rates are staggering and some individuals may emerge from a period of inactivity through the wetter months.

THE DECOMPOSITION PROCESS

On the forest floor, fallen litter becomes mixed with soil and is gradually decomposed. Litter organisms drive the decomposition and recycling process by breaking the litter into smaller fragments, digesting it and excreting it in forms which can be consumed by smaller organisms and by physically mixing the organic material with the soil and transporting it to where the plants can make use of it.

The rate at which litter decomposition occurs is determined by the climate (faster in warm humid climates than in dry or cold climates) and by the physical and chemical quality of the leaves. Some leaves, like those of most rainforest plants, are palatable while some leaves are tougher or contain chemicals which soil and litter organisms find difficult to digest. If soil and litter organisms are not present, some break down of organic material will occur through various abiotic processes but it will happen very slowly indeed and nutrients will remain trapped in the unprocessed litter for years, unable to be recycled.

THREATS TO LITTER LAYERS

Natural ecosystems, which are degraded by clearing some of the vegetation, inappropriate fire regimes and weed invasion, invariably suffer a decline in the diversity of the soil and litter fauna. Generally, things, which reduce the number of plant species and pose problems to the litter habitat and fauna are:

- Clearing and thinning of trees and/or removal of understorey plants, resulting in less litter, less shade, less

humidity and more wind, all of which contribute to the loss of soil and litter fauna;

- Changes to the “natural” fire regime

- Trampling and compression by stock or vehicles/intensive grazing by cattles and forest product collectors

- “Tidying up” of the litter layer

An essential question is: is the remarkable diversity of litter decomposers/litter arthropods needed to maintain the growth and well being of the forest? It was recently proposed, the so called "spare wheel hypothesis", that high diversity of species is important when a system is faced with a disturbance. Under such conditions a high number of species spreads the risk of being lost. Therefore, a diverse system can substitute the species, and the function it carries along, more easily than a system with only a few species.

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