

ECOLOGICAL STUDIES ON BIODEGRADATION OF LEAF LITTER OF ALDER
(Alnus nepalensis D. Don) **WITH SPECIAL REFERENCE**
TO THE ROLE OF MICROBES AND ISOPODS

BY
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CERTIFICATE

We certify that the thesis entitled, *ECOLOGICAL STUDIES ON BIODEGRADATION OF LEAF LITTER OF ALDER (ALNUS NEPALENSIS D. DON.) WITH SPECIAL REFERENCE TO THE ROLE OF MICROBES AND ISOPODS*, submitted by Mr. Highland Kayang for the Degree of Philosophy of the North-Eastern Hill University, Shillong, Meghalaya, embodies the record of original investigation carried out by him under our supervision. He has been duly registered and the thesis presented is worthy of being considered for the award of the Ph.D. Degree. This work has not been submitted for any degree of any other University.

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DEDICATED
TO MY
MOTHER
AND
FATHER

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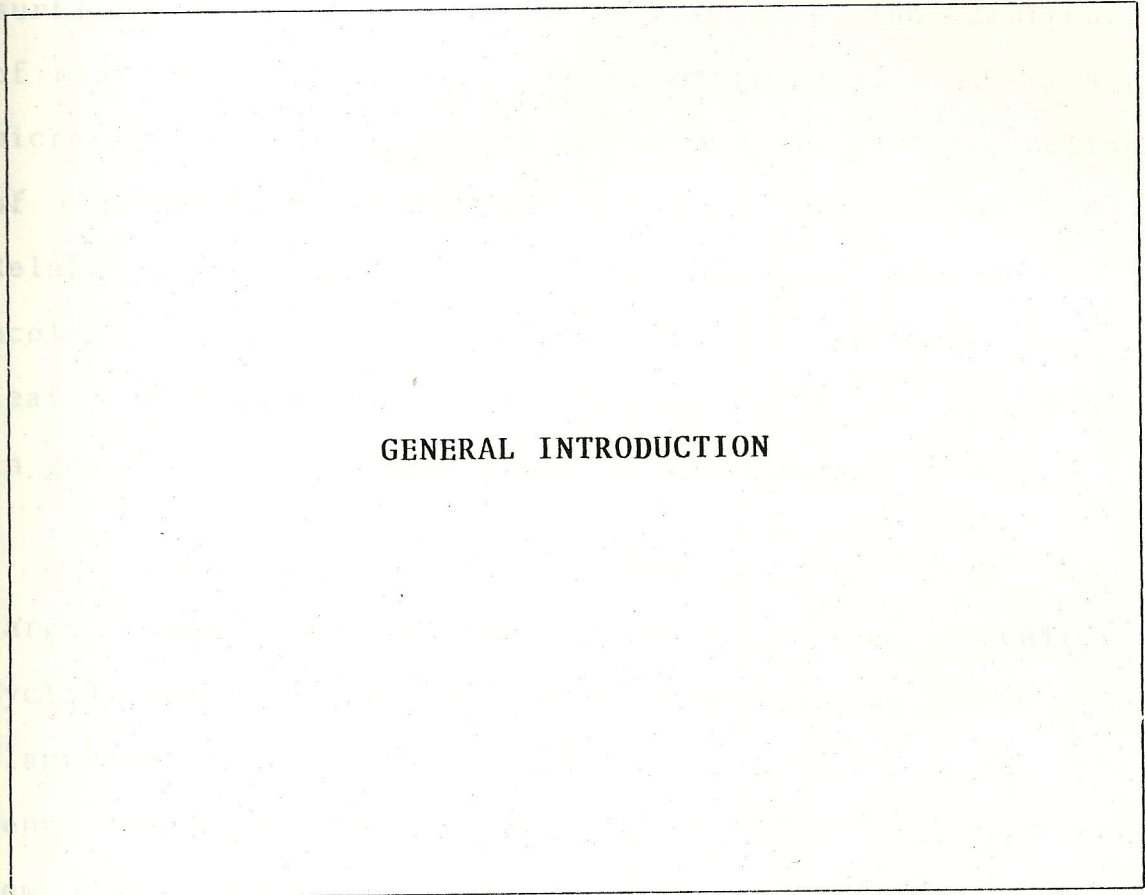
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SHILLONG

THE 15th APRIL 1993


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GENERAL INTRODUCTION

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The colonization of leaf surfaces by fungi presents an interesting study with regard to substrate relationship (Pugh and Buckley, 1971). The fungal colonizers on leaf surface comes either from air or from soil. The occurrence of many phylloplane fungi may be directly related to air microflora, which in turn is related to the production of the deciduous propagules elsewhere (Dickinson, 1976). Relatively, little work has been done to understand the ecology and role of naturally occurring microbes on the leaf surface and their relationship with air microflora in general and of forest trees in particular.

The leaf surface releases fungal spores which largely contribute to the air spora of the locality. Cycling phenomenon between fungi spores of air, soil and plant surface may be maintained in the specialized environment (Mishra and Srivastava, 1971a). There are, however, few fungal species specific to either air or to phylloplane (Lamb and Brown, 1970; Sinha, 1971; Mishra and Tiwari, 1976a).

The seasonal and diurnal periodicities of microbes in the air is mainly dependent on climatic conditions especially temperature, relative humidity, rain and wind

speed. The spores present in the air may have a great impact on the leaf surface mycoflora where leaf surface acts as a landing site (Pugh and Buckley, 1971; Gregory, 1971). Relatively little work has been done to understand the effect of air fungal population over different fields in relation to the leaf surface fungi (Sinha, 1971; Mishra and Tiwari, 1976a; Kumar and Gupta, 1976, 1980; Dixit and Gupta, 1980).

Further, studies on leaf surface mycoflora are helpful in understanding the succession of decomposers responsible for active turnover of minerals from leaf litter (Gupta, 1982). The leaf surface supports a unique habitat to a definite microbial community by providing different ecological niches. The leaves of different plant species may therefore harbour a distinctive microbial community (Lamb and Brown, 1970). Host specificity is, however, controlled by the physical and chemical nature of the leaf (Kerling, 1964). Many workers (Gregory, 1950, 1961; Last, 1955a; Mishra, 1968; Sinha, 1971; Kumar and Singh, 1981; Pennycook and Newhook, 1981) have noticed that climatic factors like temperature, humidity, wind, light and rain influence the leaf surface microorganisms. Quantitative and qualitative composition of the microflora is affected by the weather conditions and the age of leaf

(Mishra and Srivastava, 1970a; Sinha, 1971; Sharma and Mukherjee, 1976; Hayes, 1982).

Decomposition of plant litter is governed by a complex interactions between biotic factors such as microorganisms, soil fauna, nutrient and carbon components of litter and abiotic factors i.e., temperature and moisture. Microorganisms and soil animals interact synergistically in the biodegradation of litter and both of them are strongly influenced by factor like soil, litter quality, temperature and moisture (Crossley, 1970 and Witkamp, 1971).

The litter consists of dead or decaying leaves, twigs, branches, flowers, fruits, bark and other debris; leaves however contributes towards the major litter component. The accumulation of organic matter on the forest floor, represents an energy and nutrient storage pool, a diverse habitat for many different types of heterotrophic organisms, and a substratum for plants. The amount and nature of litterfall has an important bearing on soil formation and the maintenance of its fertility. ✓

Swift et al (1979) distinguished among three different processes that contribute to complete the decomposition, catabolism, cominution and leaching. Catabolism

involves the biological conversion of organic compounds into inorganic forms such as carbon dioxide and mineral nutrients. It can be regarded as the final step in the decomposition of complex molecules whereas other two processes mainly have a modifying effects on the decomposition rate.

✓ Decomposition accomplishes a fundamental role in ecosystem cycling processes by keeping plants supplied with essential nutrients. A vital sets of energy flows ✓ and nutrient transfer results from litterfall and its subsequent biodegradation in forest ecosystem (Crossley, 1970 and Witkamp, 1971). ✓ Litterfall is the major pathway for the return of dead organic matter and many of its contained nutrient and non essential elements from the aerial parts of the plant community to the surface of the soil.

✓ The amount, composition and subsequent decomposition of litter in forest ecosystem is of major importance in studies of energy flow, nutrient cycling and primary production (Ovington, 1962). The quantity of litterfall over the entire year is equally an important parameter as its seasonal periodicity. Differences between the rates of litterfall and its breakdown result in the formation of a layer of dead and decomposing leaves, woody material,

reproductive structures and other organic materials on the surface of the soil known as the litter layer, forest floor or the O horizon. The amount of the litter accumulation is dependent on its input, organism successional time and the rate of its decomposition (Olson, 1963). The decomposition rate is, in turn ^{is} determined by the nature of the litter input, temperature, moisture, soil type, altitude etc.

The litter is decomposed in the soil litter subsystem by a variety of microorganisms which are involved in succession phases of colonization, exploitation and exhaustion of organic substrate and are responsible for the chemical transformations and degradation of complex organic molecules into simpler ones. Microorganisms predominate in litter decomposition, primarily because of their enzymes capable of biodegrading simple and complex carbohydrates like lignins and their products (Witkamp, 1971). Enzymes produced by microorganisms in the forest soils are mainly responsible for the decomposition of organic matter and mineral cycling.

Decomposition of litter is basically carried out by microorganism, and fungi are known to be the chief colonizers and decomposers of plant litter (Hudson, 1968 and Hayes, 1979). Several workers have emphasized that

the early colonizers of leaf litter are bacteria, ascomycetes, fungi imperfects and some basidiomycetes which attack simple carbohydrates and cellulose and subsequently these organisms are followed by phycomycetes. Fungi and bacteria convert plant nutrient resource for soil animals. Soil invertebrates through grazing activity, litter communication and faeces production stimulate microfloral growth and make new substrates available for microbial exploitation. The breakdown of organic matter in the litter layers and soil is mediated through the synergistic activities of the fauna and flora combined with the leaching action of rainfall and throughfall which transports the breakdown products to the soil. The rates of activity of the soil and litter saprovores are directly affected by environmental factors, particularly the rainfall and temperature regimes.

Alexander (1961) stated that as the decomposition proceeds, hemicellulose and cellulose disappear whereas lignin like materials remain. He observed that during decomposition hemicellulose may have disappeared at a more rapid rate than the cellulose. He further stated that as the plant materials are decomposed by fungi, a variety of organic constituents are presented in turn to a succession of ecological groups of fungi, each orga-

nism or group of organisms altering the organic constituents until the process is complete. Later, he noticed that the fungi decomposing sugars and simple carbohydrates belonged predominantly to phycomycetes, cellulose decomposing ones to the ascomycetes, basidiomycetes and deuteromycetes and the lignin decomposers were restricted to the basidiomycetes only.

In plant litter, lignin is the component which is the last to start degradation (Berg et al, 1982) and it has been observed to be degraded comparatively slowly (Waksman, 1938) and being a slowly decomposed component, it will be rate determining for decomposition of a large part of the litter (Berg and Staaf, 1980). The release of nutrients from litter is dependent on the decomposition of the organic substances which acts as a carrier and has been observed to be proportional to weight loss (Staaf and Berg, 1977, 1982). With litter decomposition rate being critical for nutrient release it appears important to find factors which regulate the mass loss rate.

The role of fauna and microflora in the litter decomposition has been discussed and the possible effect of fauna on the growth and activity of specific components of the microflora has been documented.

Whilst generalizations may be made from litter fauna studies which include field observations, gut content

Which group of fungi decompose sugar, cellulose and lignin?

analysis and feeding preference experiments, it is difficult to make real conclusions on the effects of microbe-feeding litter invertebrates on the growth of specific microorganisms and on the capacity of such microorganisms for competitive colonization and exploitation of available substrates (Parkinson et al., 1979).

Forest ecosystems are inhabited by large numbers of soil invertebrates which depend primarily on a microflora food source. The invertebrates that inhabit soils are extremely diverse in form, differ greatly in size, occur in extremely large numbers, are more or less aggregated in distribution, both vertically and horizontally and often live deep with soil particles.

Soil invertebrates influence litter decomposition in both direct and indirect ways. The direct influence involves passage through the gut and subsequent digestion and assimilation. It may be of relatively little consequence since only 5-10% of total soil metabolism can be attributed to fauna (Macfadyen, 1963; Butcher et al., 1971). The more important indirect role of invertebrates involves factors such as inoculation of litter with microflora and alteration of microfloral activity by grazing and fragmentation of litter by feeding activity (Macfadyen, 1963; Burges, 1967; Ghilarov, 1970; Crossley, 1977). The

progress of litter decomposition encompasses interactions among different populations of microbes and microorganisms and environmental variables (Gunnarsson et al. 1988) each one affecting the quality of the litter as a substrate for other decomposers (Richard, 1987 and Choudhury, 1988). The size of the particles left by litter consumers determines which organisms are likely to attack the material subsequently (Richards, 1987 and Hagvar, 1988). Resource quality influences the types and rate of microfloral growth, faunal grazing and palatability to the saprophytic fauna, hence rate of litter decomposition. In spite of immense importance of fauna in microbial degradation, studies are meagre on isopod-microbe interaction during litter biodegradation.

The present investigation was therefore, carried out to understand the role of microbes-isopods during forest tree litter, as outlined below.

- Seasonal study of air fungal population at two forest stands of Alnus nepalensis D. Don in relation to the leaf surface fungi.
- Seasonal changes in microbial and isopod population during litter decomposition of alder (A. nepalensis).
- Mass loss and nutrient mineralization from alder

- litter in relation to the microbes and isopods.
- Microbial enzyme activity during alder leaf litter decomposition.
 - Influence of isopods on microbial population and nutrient release during the decomposition of leaf litter of alder.
-