

Dynamics and Importance of Soil Mesofauna

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ABSTRACT

Soil is a large reservoir of various organisms which together help in regulation of various biogeochemical cycles. Soil biodiversity is comprised of the organisms that spend all or a portion of their life cycles within the soil or on its immediate surface (including surface litter and decaying logs). The soil mesofauna are an important part of terrestrial ecosystems and a connecting link between microfauna and macrofauna which together form an essential part of soil decomposer community. They perform and regulate a major proportion of the organic matter transformations and nutrient fluxes in terrestrial ecosystems. The fluxes and flows are regulated to large extent by Soil mesofauna, being considered as 'Ecosystem webmasters'. The disturbance or perturbation of soils usually alters microarthropod numbers such as tillage, fire, and pesticide application typically reduce populations but recovery may be rapid and microarthropod groups respond differently.

Keywords: Acari, Collembola, Mesofauna, Litter transformers, Soil microarthropods

I INTRODUCTION

The word Human itself has its roots in the Latin '*Humus*', the organic matter in soil [1]. Animal members of the soil biota are abundant and diverse. The array of species is very large, including representatives of all terrestrial phyla. Many groups of species are poorly understood taxonomically, and details of their natural history and biology are unknown. The easiest and most widely used system for classifying soil organisms is to group them by size (body width) into three main groups: macrobiota, mesobiota and microbiota [2-3], depicted in Fig.1. Body width of fauna is also



related to their microhabitats. The microfauna (protozoa, small nematodes) inhabit water films. The mesofauna inhabit air-filled pore spaces and are largely restricted to existing ones. The macrofauna, in contrast, have the ability to create their own spaces, through their burrowing activities, and like the megafauna, can have large influences on gross soil structure [4-6]. The vast range of body sizes among the soil fauna suggests that their effects on soil processes take place at a range of spatial scales [7-8]. "Ecosystem engineers," earthworms, termites, or ants, alter the physical structure of the soil itself, influencing rates of nutrient and energy flow. "Litter transformers," microarthropods, fragment decomposing litter and improve its availability to microbes. "Micro-food webs" include the microbial groups and their direct microfaunal predators (nematodes and protozoans). These three levels operate on different size, spatial, and time scales.

II HABITAT, FUNCTION AND DISTRIBUTION OF MESOFUANA (MICROARTHROPODS)

A soil mesofauna taxon (group) also known as microarthropods is an invertebrate group (aptera) found within terrestrial samples with the size ranging from 0.1-2mm which include organisms/orders like Acari, Collembolans, Proturans, Diplurans, Symphellids, Enchytriaeids etc. Large numbers of the microarthropod group (mainly mites and collembolans) are found in most types of soils. A square meter of forest floor may contain hundreds of thousands of individuals representing thousands of different species [53]. Microarthropods have a significant impact on the decomposition processes in the forest floor and are important reservoirs of biodiversity in forest ecosystems. Soil microarthropods are significant reservoirs of biodiversity but it is not clear exactly how diverse they may be. Estimation of species richness is a difficult problem for many types of soil organisms (fungi, bacteria, nematodes, for example, as well as microarthropods). Unlike the macroarthropods, the mites and collembolans have little (by enchytraeids) or no effect on soil structure. Their dimensions allow them to use existing spaces in soil structure thus can be also termed as 'Interstitial animals'. Even the large, soft-bodied members of the mite group Prostigmata do not seem to create their own passageways. Some litter-feeding species do burrow into substrates such as petioles of decaying leaves and create tunnels, but these have no direct effect on soil structure per se. The microarthropods resemble the microfauna in this characteristic. Microarthropods also form an important set of linkages in food webs; many microarthropods feed on fungi and nematodes, thereby linking the microfauna and microbes with the mesofauna. Microarthropods in turn are prey for macroarthropods such as spiders, beetles, ants, and centipedes, thus bridging a connection to the macrofauna. Even some of the smaller megafauna (toads, salamanders) feed upon microarthropods, thus, it is essential to study soil as an ecosystem.

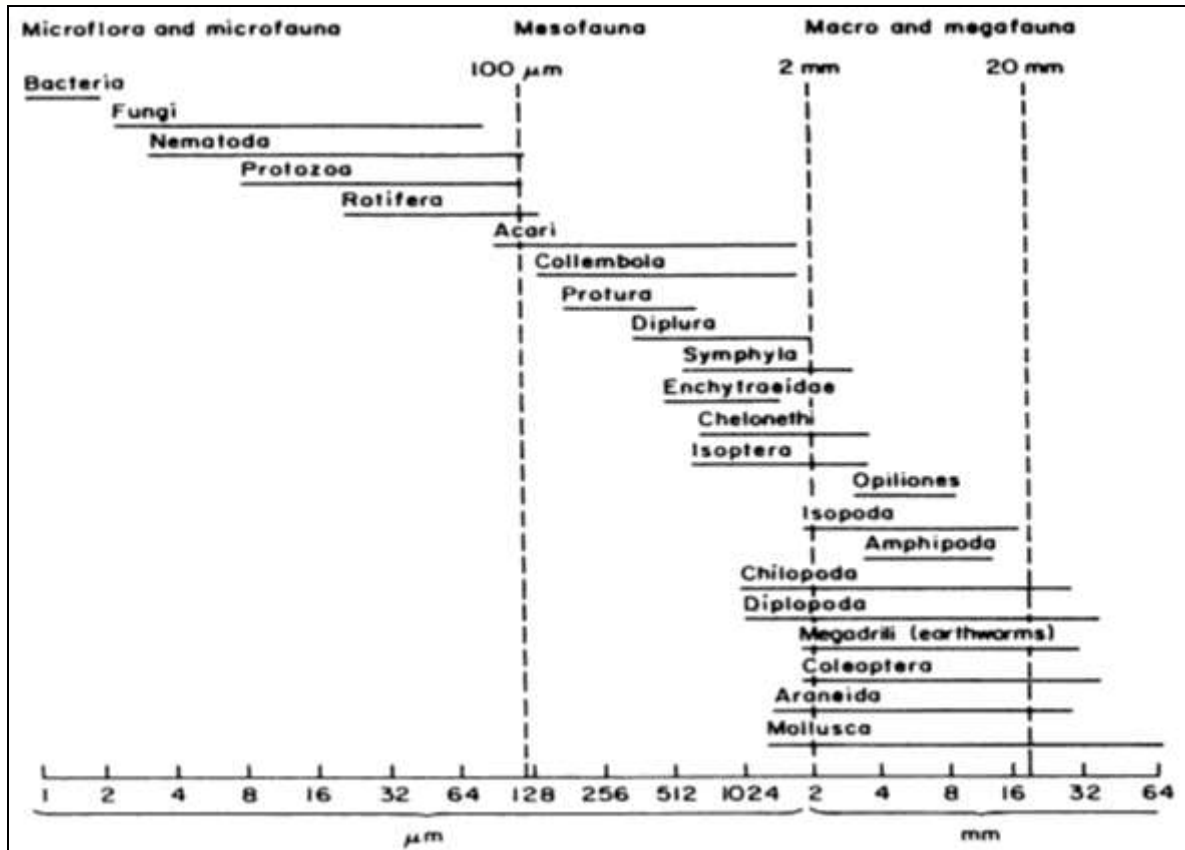


Fig. 1 Size classification of organisms in decomposer food webs by body width [9]

III MESOFAUNA COMMUNITY AND THEIR ROLE IN SOIL ECOSYSTEM SURVIVAL

Generally, temperate forest floors with large accumulations of organic matter support high numbers, whereas tropical forests where the organic layer is thin contain lesser numbers of microarthropods [10]. Disturbance or perturbation of soils usually alters microarthropod numbers such as tillage, fire, and pesticide application typically reduce populations but recovery may be rapid and microarthropod groups respond differently. Soil mites usually outnumber collembolans but these become more abundant in some situations. In the springtime, forest leaf litter may develop large populations of “Snow fleas” (*Hypogastrura nivicola* and related species). Among the mites they themselves usually dominate but the delicate Prostigmata may develop large populations in cultivated soils with a surface crust of algae. Immediately following cultivation, numbers of Astigmatic mites have been seen to increase dramatically [11]. In addition, the mesofauna is mobile and migrates through different soil layers, passively transporting bacteria, fungi and their propagules in the gut or on the body surface to new microsites and substrates. Despite being minuscule compared to macrofauna species like earthworms and millipedes, which are the main bioturbators, the soil mesofauna may significantly contribute to forming the microbial habitat. Humus material (H layer) of forest ecosystems on acid soils



may almost entirely consist of fecal pellets of collembolans and enchytraeids. Micro- and mesofauna do not affect their food source solely by harvesting; selective grazing on certain microbial species may also change the community structure of the microflora. This alters abundance and activity of bacteria and fungi and modifies the pattern of organic matter decay [12-14].

The soil mesofauna community in undisturbed habitats with special reference to Oribatid mites possesses large diversity of mesofauna compared to the disturbed ones [15]. While studying the effects of acid rain on litter decomposition in a beech forest it was reported that presence of mesofauna significantly reduced the ability of the acid rain to inhibit carbon mineralization [16]. Gamasid mites are good indicators of the soil quality as their high sensitivity to external impact combined with their importance for ecosystem functions make soil mesofauna extremely valuable for ecotoxicology [17]. The rainforests contain a huge variety of soil microarthropods [18]. The seasonal abundance of oribatid mites numbers are correlated positively with radiation on the day of collection [19]. The role of Orbatid mites in the decomposition of the cones of Scots Pine (*Pinus sylvestris*) is of prime importance and the oribatid mites are great decomposers compared to other groups of soil mesofauna [20]. The effects of summer warming on the total population densities of soil-dwelling microarthropods in the high arctic region has no significant effect of temperature elevation on oribatid mite populations while as there is negative impact on springtail numbers [21].

The effects of manipulated soil microclimate on mesofaunal biomass and diversity in a warmer, drier summer, in contrast, experimental heating depress diversity and biomass in drier zone of the plots and diversity in the moist zone but enhance biomass in the moist zone and both the biomass and the diversity are positively correlated with soil organic matter [22]. There is decline of soil mesofaunal biodiversity due to the application of pesticides as evident from the application of DDT in high-input grasslands showed a high density of microarthropods with a high fraction of thelytokous reproduction, associated with a decrease in genetic variation [23]. The highly abundant and diverse mesofauna populations are capable of higher rates of litter fragmentation and the short term decreases of soil pH has no negative effect populations of collembolans [24]. While working on the impact of Collembola and Enchytraidae on soil surface roughness and properties, it was observed that the surface roughness increased due to mesofaunal activity [25]. The role of soil microarthropods (Acari and Collembola) in organic matter decomposition and nutrient cycling in a forest ecosystem is vital and the small changes in the structure of soil microarthropod assemblages can have significant effects on the local mobilization of nutrients [26]. The influence of microarthropods on litter decomposition at three forested sites -two tropical and one temperate reveal that the microarthropod populations are very much effective in litter decomposition which is minimal in the temperate region where the fauna tend to increase the decomposition rate only towards the end of the year. In contrast, the effect of fauna in the tropical regions are marked within months of the start of the start of experiment thus it become evident that the diversity of mesofauna is greater in the tropical regions [27]. The functional role of Collembola in the ecosystem is plant litter decomposition processes and in forming soil microstructure while as soil acidification, nitrogen supply, global climate change and intensive farming have



negative impact on Collombolan diversity[28].The mineral amendments on soil fauna in an acid breech forest floor show that nitrogenous amendment decrease the numbers of oribatid mites [29].Most of the predatory mites – Gamasina or Mesostigmata are free living predators in soil and litter, on the soil surface or on plants and Mesostigmata are important predators of Nematoda, Collembola and insect larvae and can serve as bioindicators [30].Soil microarthropods mainly Acari negatively respond to altered soil-water availability in tall grass prairie ecosystems and are less abundant in irrigated plots and at the wetter lowland sites which confirm the importance of soil water content in affecting microarthropod densities and distributions in grasslands, and suggest complex, non-linear responses to changes in water availability[31].

The long-term effects of compaction in arable land due to conventional soil tillage, has negative impact on collembolan number while as, the harvesting and tillage support population growth of Collembola in conservation tillage. The stability analysis of soil Oribatid mite communities from environmentally stressed habitat and relatively well preserved habitat with the perspective of consistency as a primary criteria of stability reveal that concluded that oribatid community from preserved habitat are more stable than from environmentally stressed habitat[32].The effects of constant temperature versus diurnally fluctuating temperature and uniform versus varying moisture, on the population densities and species richness of Collembola and Mesostigmata in coniferous forest humus and birch leaf litter are well understood by the fact that fluctuating moisture and temperature regime, Collembola are most abundant, and species richness of Collembola remain higher, whereas Mesostigmata are more numerous at constant temperature[33].

The possible host habitat specialization in two major groups of soil arthropods, the oribatid and mesostigmatid mites, under three tree species viz., *Eucalyptus pilularis*, *Eucalyptus propinqua* and *Allocasaurina torulosa* show differences between tree species are insufficient to change species composition of mites [34].The disturbance of vegetation and soil resulted by tropical rainforest fragmentation are the major factor affecting the diversity of soil mesofauna and the soil condition with more soil organic matter, total N and P, higher pH value and lower soil bulk density become more favorable to the soil mesofauna while as the species richness, abundance and diversity of soil mesofauna in fragmented forests are higher than those in continuous forest, but the similarity of species composition in fragmented forest to the continuous forest is minimal[35].In case of dynamics of springtail and mite populations, there is no evidence for regulation of springtail numbers by mites or for regulation of mite numbers by macroarthropods [36].correlations between Collembola, total C and N are usually weak under field conditions and omnivory is probably the prevailing feeding strategy in Collembola [37].The relationships between Collembola, Soil chemistry and humus types in forest stands reveal that the Collembola seem to be linked closer to the physical structure of humus than to its chemical parameters[38.]The relative abundance of Collembola and three suborders of mites (Oribatida, Mesostigmata and Prostigmata) during decomposition are greater in old litter than in fresh litter [39] .Organic matter removal and vegetation control generally cause a significant decrease in collembolan populations; while compaction did not significantly affect collembolan populations [40]. The groundwater level is also one of the the main environmental



factors influencing the composition of collembolan and oribatid mite assemblages [41]. The responses of soil microarthropods to experimental short-term manipulates of soil moisture show that drought decrease microarthropod species richness. As the Oribatid mites and Collembola respond differently to the irrigation treatments that the latter community show species evenness and diversity in the frequently irrigated plots while as the former community in the infrequently irrigated ones [42]. The population abundance of Collembola and Acari remain low during drought conditions and the humidity is the most important factor determining distribution, abundance, and survival of soil Collembola in tropical forest. And high predation and low accumulation of organic matter cause low population abundance of Collembolan in the tropical habitat [43]. The variations in the population density of soil invertebrates are controlled by the particular soil ecological conditions. Dominant mesofauna species are morphologically and physiologically adapted for living near the soil surface [44]. The long term effects of different regimes of repeated fertilization on fine roots, mycorrhizae, and soil mesofauna in young stands of lodgepole pine (*Pinus contorta* Dougl. var. *latifolia* Engelm.) and interior spruce *Picea glauca* (Moench) Voss, *Picea engelmannii* Parry, and their naturally occurring hybrids) show that fine root attributes and mesofauna respond differently to repeated fertilization regimes at the pine and spruce study sites [45]. Phenanthrene affect the population dynamics of mesofauna and soil biological functioning depending on exposure duration, type of community, or both [46]. The impacts of invertebrate soil micro- and mesofauna (grazers and predators) on plant productivity and microbial biomass indicate that soil fauna help to regulate ecosystem production, especially in nutrient-limited ecosystems [47].

Soil mesofauna act as the Potential Biological indicators of success in reclaimed soils for recolonization and the mesofaunal densities are greater in natural soils than in reclaimed soils and community structure differ between natural and reclaimed soils [48]. The effects of soil mesofauna and microclimate on nitrogen dynamics in leaf litter decomposition along an elevation gradient give conclusion that the rapid accumulation of N in lower elevation sites can result in the retention of mobile N in soils and the effects of soil mesofauna on N dynamics may be intimately associated with microclimate (warm and humid) and faunal diversity along the elevation gradient [49]. The stable-isotope labeling and probing of recent photosynthates into respired CO₂, soil microbes and soil mesofauna using a xylem and phloem stem-injection technique on Sitka spruce (*Picea sitchensis*) reveal that the Stem injection of large trees with ¹³C-enriched compounds is a successful tool to trace C-translocation belowground. In particular, the significant ¹³C enrichment of CO₂ and enchytraeids near the base of the tree and the significant ¹³C enrichment of phosphor-lipid fatty-acid (PLFAs) up to 20 m away indicate that mature Sitka spruce (*Picea sitchensis*) have the capacity to support soil communities over large distances [50].

The meso-fauna foraging on seagrass pollen may serve in marine zoophilous pollination and aid in the pollination of *T. testudinum* when visiting female flowers [51]. The diversity of acari and collembola along a pollution gradient in soils of a Pre-pyrenean forest ecosystem around a steel mill reveal that the density of acari and collembola significantly decrease with the increase in concentration of Cr, Mn, Zn, Cd and Pb. Mites appear to be more sensitive to heavy metal



pollution than springtails. From the review of literature it is quite evident that the soil mesofauna are an important part of terrestrial ecosystems and a connecting link between microfauna and macrofauna which together form an essential part of soil decomposer community [52].

IV CONCLUSION

Soil mesofauna are able to use the existing pore space in soil, cavities or channels. They constitute important reservoirs of biodiversity and are reflectors of ecosystem metabolism. Furthermore, the soil mesofauna regulate plant productivity and microbial biomass and are key organisms to regulate ecosystem production, especially in nutrient-limited ecosystems.

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