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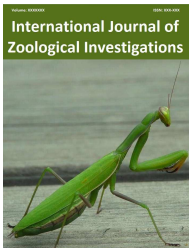

Influence of Topography on Soil Biota- a Case Study with Reference to Wayanad, South India.

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Abstract: During the past 20 years, the importance of soil fauna in the functioning of soils has been recognized. No component of ecosystem is potentially more important, both ecologically and economically than soils and their associated biodiversity. Soil reflects ecosystem metabolism since all the bio-geo-chemical processes of the different ecosystem components are combined within it. Soil quality fluctuations are considered to be a suitable criterion for evaluating the long-term sustainability of ecosystems. Distribution of soil fauna is affected by several factors such as topography, vegetation, climate, sampling time and so on. The present study attempts to examine effects of topography heterogeneity on soil fauna in four different habitats of Wayanad district in South India. Wayanad with an area of 2,125 km^2 is an elevated plateau in the Western Ghats, lying between 11^o 58'N and 11^o 30'N and 75^o 45'E and 76^o 28'E. The average altitude of the plateau is 700 m, but many peaks exceed 1500 m. The present study analyzed the distribution and biodiversity of soil fauna and measured the interaction of topography heterogeneity on its distribution.

Keywords: *Topography, soil fauna, ecosystem, habitat, soil quality fluctuations, biodiversity*

Introduction

Soil represents one of the most important reservoirs of biodiversity. Soils are one of the last great frontiers for biodiversity research and are home to an extraordinary range of microbial and animal groups. Biological activities in soils drive many of the key ecosystem processes that govern the global system, especially in the cycling of elements such as carbon, nitrogen and phosphorus (Fitter et al. 2005). Within the complex structure of soil, biotic and abiotic components interact closely in controlling the organic degradation of matter and the nutrient recycling processes. Microorganisms as well as microfauna, mesofauna and macrofauna play essential roles in nutrient recycling and organic matter decomposition in the soil (Kladivko 2001). In terrestrial ecosystems, soil decomposer animals are essential for nutrient mineralization (Bradford et al. 2002). The precise role of many soil organisms in these cycles is unknown, although the great diversity and abundance of microbial, plant and animal life in soil seems likely to influence ecosystem function in various ways (Fitter et al. 2005).

It is known that some soil animals are essential in the breakdown of some kinds of leaf material into its organic and inorganic

constituents and in the incorporation of these materials into soil structure (Stockli 1950, Mellanby 1960, Raw 1961). Human activities frequently cause a degradation of soil environmental conditions which leads to a reduction in the abundance and to a simplification of animal and plant communities, where species able to bear stress predominate and rare taxa decrease in abundance or disappear. The result of this biodiversity reduction is an artificial ecosystem that requires constant human intervention and extra running costs, whereas natural ecosystems are regulated by plant and animal communities through flow of energy and nutrients, a form of control progressively being lost with agricultural intensification. Hence, the conservation of soil biodiversity has become an important aim in international environmental policies.

Materials and Methods

Study areas:

The sites selected for the present study are from the Wayanad district of Kerala. Wayanad with an area of 2,125 km^2 is an elevated plateau in the Western Ghats, lying between 11° 58'N and 11° 30'N and 75° 45'E and 76° 28'E. It is an extension of the Deccan plateau to the west, bounded by Coorg and Mysore in the north and east; Nilgiri in the south and Malappuram and Calicut in the south west. The Ghat Section is separated by the Brahmagiri-Dindimal ranges, running at right angles to the Western Ghats with the Nilgiri-Kunda ranges forming the south-eastern limit and the eastern portion merging into the Karnataka table land. The average altitude of the plateau is 700m, but many peaks exceed 1500 m. The only river, the Kabani originates in the Western Ghats and flows east. The climate on the plateau is quite different from that of the plains. The temperature of the former ranges from 13°-33°C while at the foot of the ghats, the range is from 21°-38°c. From November to January mist is common and following a few showers in April and May, the south-east Monsoon brings 75% of the annual rainfall from June to August. Large scale migration of agriculturists from central Kerala from the 1950s onwards sealed the fate of the pristine forest in the region (Zacharias and Gaston 1993). During the last 200 years there has been massive transformation in the ecology and the environment of the area.

Four different study sites were selected from two study areas with different vegetation types of South Wayanad based on the topography of the areas. Two of them were cultivations and the other two were natural vegetations of the Wayanad Wildlife Sanctuary. The slopes of the areas were assessed on a degree gradient. Diversity of the soil fauna in the four sites were analyzed in detail by collecting samples from 2x2x2 feet pits in each site. The study was conducted during the months of November and December 2013 by opportunistic observation methods and the results were tabulated for species diversity and analyzed. For analyzing the descriptive statistics (mean, standard deviation and frequency) and parametric statistics (Independent sample t-test) Statistical Package for Social Sciences (SPSS version 20) software was used.

Ondeyangady Forest: Site No. 1 and2

It is a semi-evergreen patch spread into 140 ha. in the Thrissilery reserve forest of Begur range of the South Wayanad forest division. It is an isolated patch, without having any continuity with other natural forests of the area. It is surrounded by the Mananthavady-Mysore road towards the eastern boundary, paddy fields of the Thrissilery villages to the west and pepper, Coffee and other mixed cultivations to the north and south. There are three small perennial streams flowing through it. Villagers from the western side

have accessibility to the Manathavady-Mysore road crossing through this stretch of forest. This forest type is an intermediate between the tropical evergreen and moist deciduous forms. This is mainly because of the change in environment or human interference or both. Two sites were selected from this area site no.1 with a slope of 10^0 and site no.2 with a slope of 80^0.

Ayilamoola area: Site No. 3 and 4

This is a village spreading over 120 ha. with habitations and agricultural fields with plantation crops, fruit trees, vegetables, cereals and pulses etc. Annual and seasonal tilling operations are carried out. Paddy fields, small perennial streams, wells etc. are present in the area. The ground will be usually covered with weeds from June to October. The chief vegetables and fruits grown are *Amorphophallus paeoniifolius, Anacardium occidentale, Citrullus lanatus, Colocasia esculenta, Lablab purpureus, Mangifera indica, Manihot esculenta*, *Musa spp., Artocarpus heterophyllus* etc. Besides these plantation crops such as *Coffea arabica, C. robusta, Hevea braziliensis, Camellia sinensis* and *Theobroma cocao* are largely cultivated. Some of the condiments and spices like *Cinnamomum verum, Curcuma longa, Elettaria cardamomum, piper nigrum and Zingiber officinale* are also cultivated.

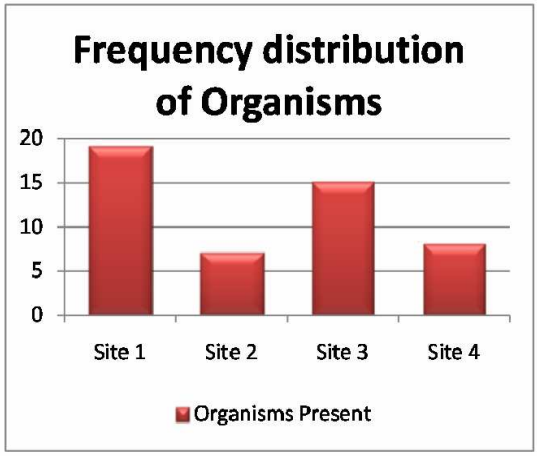

Figure 1

Other economically important plants like *Areca catechu, Cocos nucifera*, and *Saccharum officinarum* are also cultivated in some areas. Two sites were selected from this area site no.3 with a slope of 10^0 and site no. 4 with a slope of 80^0.

Results and Discussion

The organisms collected from the four different sites were identified and were grouped into micro, meso and macrofauna based on their size. Most of the organisms identified were insects. Seven different orders were consistently sampled including members of Collembola, Coleoptera, Acarina, Isoptera, Hymenoptera, Chilopoda and Diplopoda. Larval forms of diptera were observed in site no. 1. There were also representatives from scorpionida, pseudoscorpionida and neuroptera. The other organisms included slugs, snails, earthworm, toad, mabuya, garden lizard, rat snake, sand boa, Indian mole rat and house rat.

Soil macrofauna comprises a large number of zoological groups hence leading to a typical multivariate data set (Rossi et al. 2005). The data was analyzed by means of descriptive statistics (frequency and percentage) and non-parametric statistics (Chi -square). The frequency of organisms present in the Site 1, Site 2, Site 3 and Site 4 were 19, 7, 15 and 8 (Fig. 1). The percentage of frequency in the sites 1 to 4 was found to be 90.5%, 33.3%, 71.4% and 38.1% respectively.

Chi-square test was conducted to evaluate whether there was any significant difference between the diversity of organisms based on topography heterogeneity. Four sites were compared with equal expected frequencies. The chi-square goodness-of-fit test was significant, $\chi 2\ (3) = 8.06$, $p<.05$. Based on these results, Site 1 and Site 3 were found to have significantly more amount of organisms

compared to the expectation, whereas Site 2 and Site 4 were found to have significantly less amount of organisms than expected. From the study, it is found that the slope of the land and diversity of soil organisms are found to be inversely proportional. Strong statistical significant correlation was calculated at 5 % level of significance as shown below:

Site

	Observed N	Expected N	Residual
Site 1	19	12.3	6.8
Site 2	7	12.3	-5.3
Site 3	15	12.3	2.8
Site 4	8	12.3	-4.3
Total	49		

Test Statistics

	Site
Chi-Square	8.061[a]
Df	3
Asymp. Sig.	.045

Among terrestrial groups, species richness tends to be lower at high elevations than at mid elevations or near sea level (Colwell 1994). When the percentage gradient of the slope decreased there was a corresponding decrease in the variety of organisms both in natural vegetation and the cultivation. When the land is more slopy, fertility of the soil is less due to erosion, lack of litter resulting from wind action etc. This may be the reason for less soil organisms in site numbers 2 and 4. Topography heterogeneity has significant effects on the distribution of soil fauna, which may be related to biotic and abiotic characteristics of habitats (Xin et al. 2013).

Organisms having a “pupae” stage in their life cycle play a minor role in the soil during these phases, while the “larvae” stage is much more important for the ecology of soil, especially when the population density is high. Most larvae can act as both detritivores and predators. Several Coleoptera groups (e.g. carabides, scarabeids) spend their larval stage in the litter or in the upper layers of mineral soil, and when adults, use soil as a food source, refuge and for other purposes. Depletion of soil biota is a serious threat to the fertility of soils. There are top-down and bottom-up influences between larger and smaller organisms which reflects the mixing and redistribution of organic resources in the soil (Lavelle 2000). There are many reasons for the depletion of the biota. Among them, the most widespread at a worldwide level are erosion, the loss of fertility and a decline in organic matter, compaction, and phenomena of flooding and landslides and contamination. The urbanization process leads to the conversion of indigenous habitat to various forms of anthropogenic land use, the fragmentation and isolation of areas of indigenous habitat, and an increase in local human population density. The urbanization process has been identified as one of the leading causes of decline in arthropod diversity and abundance.

Factors those are often important in maintaining biodiversity and preventing competitive exclusion by a particular group of organisms are, for example, a degree of special heterogeneity, instability, and predation (Huston 1994). Hence, topography of a particular area can also decide the soil biota of that area. The growing significance for the conservation of Western ghats makes the study more significant. All of these factors may lead to reductions in biodiversity if intense (Giller et al. 1997). Greater understanding of soil ecology could lead to more precise management of soil organisms for beneficial purposes (Kladivko 2001). The toolkit provided by advanced techniques such as molecular biology, stable and radioisotopes,

or remote sensing offers exciting opportunities for exploring new frontiers of soil ecology (Wolters 2000).

Conclusion

Soil is the foundation upon which society is sustained and evolves. It is a vital component of ecological processes and cycles, as well as the basis on which our infrastructure rests. Soil quality and its protection contribute significantly to preserving the quality of life, and that the nutrition and health of humans and animals cannot be separated from the quality of the soil. Growing pressures from an ever increasing global population, as well as threats such as climate change and soil erosion, are placing increasing stresses on the ability of soil to sustain its important role in the planet's survival. Evidence suggests that while increased use of mono-cultures and intensive agriculture has led to a decline in soil biodiversity in some areas, the precise consequences of this loss are not always clear. It is the processes that occur within soil, most of which are driven by the life that is found there, which drive ecosystem and global functions and thus help maintain life above ground. Soil performs numerous ecosystem functions and services, ranging from providing the food that we eat to filtering and cleaning the water that we drink. Life within the soil is hidden and so often suffers from being 'out of sight and out of mind'. A more complete knowledge of soil fauna is needed for biodiversity conservation. We need to embark on a truly sustainable use of soil perceived as a resource and build a proper Man - Soil relationship to be left to future generations.

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