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Soil micro arthropods assemblages in selected plantation in The Nilgiris, Tamilnadu, India

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Abstract

India is one of the twelve mega biodiversity in the world and the Western Ghats in Southern India are considered to be one of the 18 hotspots of biodiversity in the world. The natural areas of Nilgiris has been Shrunk by exotic tree plantation like Eucalyptus and Wattle. Recent researches have sought that more litter mass provides food and habitat for soil micro-arthropods. The period of the study was from March to August 2014. During litter decomposition nutrients like N, P and K release into the soil. But invasive species like Eucalyptus and Wattles of the area have given negative effects to the soil nutrients. So the environmental term illustrates the variation in soil fertility and decreases NPK. The comparative diversity of micro-arthropods in natural, Wattle and Eucalyptus plantations was studied in Nilgiris. Moreover, Eucalyptus and Wattle plantations decreased the availability of ground water consequently affecting the soil fertility. Hence the present study suggests minimizing the growth of Wattle and Eucalyptus plantations in the natural areas which may help to maintain the fertility of the soil.

Keywords: Western Ghats, The Nilgiris, Eucalyptus and Wattle, Micro-arthropods

Introduction

Invertebrates are a group of animals that have no backbone. With over 2 million well-known animal species on Earth, 98% of them are invertebrates. Scientists group or “classify” all of these different types of animals into broad categories called phyla, on the basis of their patterns of equilibrium and on the basis of their overall body plan. Among the animal kingdom phylum arthropod is the most extensive in the animal kingdom, both in number of species and in ecological distribution. Soils originate and accumulate in a sequence of events that mark the stages of ecological succession, the development of biotic communities. Hence, soil formation, or pedogenesis involves a set of physical, chemical, and biotic processes. The properties of soils arise from the interactions of five basic factors: parent material, topography, climate, biota, and time (Jenny, H. 1980).

However, much of the natural areas have transferred due to human activities. The potential for arthropods as indicators is especially promising in the case of the Atlantic Forest, for which scarce available data exist (Duarte, 2004; Baretta *et al*., 2008), despite this biome’s status as a conservation hotspot (Myers *et al*., 2000), and the important pressure to the development of agro-forestry systems, which includes the replacement of native forests by Eucalypt plantations for industrial use (Lima, 1996). Among the arthropods diversity, the typical micro-arthropods are mites, springtails, pseudo scorpions and insect larvae. The micro-arthropods are important in controlling the rate of decomposition and altering the nutrient cycles. Decomposition of leaf litter plays a fundamental role in the nutrient resources of forest ecosystem. This process was easily carried out by the micro-arthropods which dwells in soil and litter layer. Current researches have sought to more litter mass may provide more food and habitat for soil micro-arthropods. Soil hosts the greater part of the terrestrial biosphere. Soil arthropod communities are extremely rich in species, comprising a high proportion of diversity and contribute to fundamental services for terrestrial ecosystems (Brussaard *et al*., 1997; Chapman, 2012; Faber and van Wensem, 2012). The amount of organic carbon plays a major role in soil balancing with the help of new plant and animal material and this will be the constant losses where the carbon is decomposed and the constituents separate to mineral nutrients and gases, or are washed or leached away. Carbon levels build up where water, nutrients and sunlight are plentiful.

Soil is able to satisfy plant demands for nutrients including water and a physical matrix adequate for proper root development, which is significantly influenced by biological processes. The feeding activity of the invertebrates leads to determining the nutrient availability of the soil. Soil nutrient have been linked with the plant productivity of the forest. But invasive species Eucalyptus and Wattles gives negative effects to the soil nutrients of the area. The decomposition of the litter may be delayed by the chemical components of the leaves. Eucalyptus, Pinus and Wattle, Tectona do not provide organic matters, soil fertility (Evans 1992).*Acacia dealbata* soil is mostly affected by acacia plantation because in the depth of 0-30 cm, soil have small amount of carbon. So the environmental season shows the variation in soil fertility and it is decreased. The main objective of the present study includes scrutinize the soil micro-arthropods diversity, effect of invasive plantations in micro-arthropods, examine the soil fertility and determine the role of soil micro-arthropods on environment.

Materials and Methods

Study area: The total area of Biosphere Reserve is 5520 sq.km. The UNESCO has declared NBR as one among the twenty-one biosphere reserves in the world. The Biosphere comprises of five major forest types namely moist evergreen, semi evergreen, thorny scrub jungle, savannah woodland, shoal and grassland. The mountain is a part of the large Western Ghats chain making up the Southwestern edge of the Deccan plateau. The Nilgiri hills are a range of mountains in the westernmost part of the Tamil Nadu at the junction of Karnataka and Kerala in Southern India (Fig.1).

Fig. 1 Study area: Nilgiris

There are almost 24 peaks above 2,000 meters (6,600ft). The study area falls geographically and it is located between 11^0 10′ - $11^0$30′ N and $76^0$25′- $77^0$00′ E at the junction of Eastern and Western Ghats in South India viz., Emerald (Site 1) $11^0$32′ N, Kodapmund (Site 2) $11^0$42′ N, Thalaikundha (Site 3) $11^0$44′ N, Aruvangadu (Coonoor) (Site 4)$11^0$36′ N, Kattabettu (Kotagiri) (Site 5) $11^0$41′ N, where Wattle and Eucalyptus plantations are a dominant species.

Sampling: Soil samples were collected during the early hours of morning 6.00 am to 8.00 am. The duration of the study was six months from March to August 2014. The soil and leaf litter samples was carefully collected from the upper surface, at a depth of 0-10, 10-20 and 20-30 cm using a shovel. Frequently, a square foot of about (30×30×30) 30 cm depth, 30 cm width and 30 cm length diameter was also used for the purpose. The samples were collected in a labeled polythene bags and transferred to the laboratory as early as possible for further extraction process. Soil invertebrates including micro arthropods are highly sensitive to the intensity of light and heat in the environment and desiccation of soil in which they live. Majority of soil animals are negatively phototropic and hence when exposed to heat and light, they try to move away. This behavior of soil animals is best utilized for their extraction from soil samples. The collected samples were placed in an open funnel apparatus to extract the micro-arthropods by the method described by Berlese, 1905. The heat helps to drive the micro-arthropods from top to bottom and gradually out of the samples, through the sides of the funnel into the collection vial. Depending upon the moisture content of the soil sample the period of extraction varied from 2 to 3 days. About 5 ml of 70% alcohol was taken in the collecting vial and kept under the funnel. This helped to preserve the animals falling into the vials. Slide mounted specimens of micro arthropods were subjected to microscope examination for taxonomy identification. Identification of the various species was made following Balogh (1972). The abundance of each morphotype was recorded and species richness and Shannon diversity values were calculated for each sample. Diversity calculations were performed using PAST software.

Data analysis: Shannon diversity data were found to be normally distributed and were analyzed by analysis of variance (Magurran, 1988), using Stat view software. Sample collection and Soil Nutrient analysis was done from March to August 2014.

Mathematical and statistical analysis: The following mathematical analysis was made towards estimating the species richness of aphidophagous natural enemies and the diversity indices

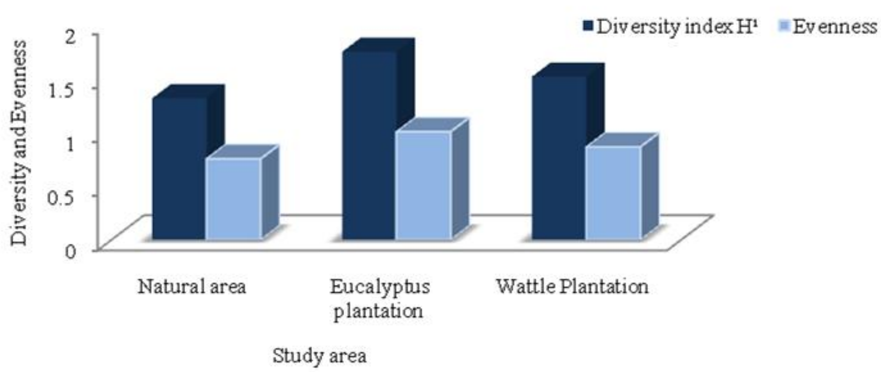
Shannon- Wiener Diversity Index:

$$\text{Index } (H^1) = \sum (pi)(\ln pi)$$

Where, H^1 = Species Diversity Index; S = Number of Species; In = Natural logarithm; *Pi* = Proportion of individuals in the species with respect total sample.

Results

Diversity and Evenness of soil micro-arthropods: The main database field for this paper's purposes, such as main ecological uses of arthropod groups. The total numbers of micro-arthropods from the collected samples in natural areas (186), Wattle Plantation (35) and Eucalyptus (21). Among 21 collected species 7 micro-arthropod species are consider as robust species and also the indicators of the selective study area. They are *Allogalumna pellusida*, *Autogneta amica*, *Dermanyssus gallinae*, *Gamasina* spp, *Varroa* spp, *Scheloribates praeincisus* and *Trombicula autumnalis* respectively. The result indicates that the diversity index value was 1.31 in natural plantation and 1.51 in Wattle plantation, 1.74 in Eucalyptus plantations respectively (Graph 1).

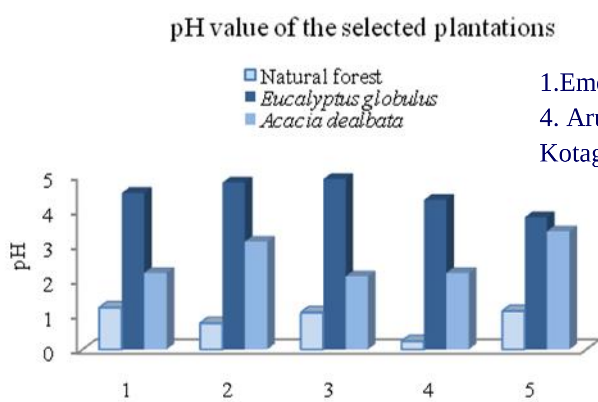


Graph 1. Shannon diversity index and evenness of soil micro-arthropods

Table 1 Species list of soil micro-arthropods observed in five selective study sites.

S.No	Class	Order	Family	Genus	Species
1.	Arachinda	Sarcoptiformes	Galumnidae	Allogalumna	*Allogalumna pellusida*
2.	Arachinda	Sarcoptiformes	Galumnidae	Galumna	*Galumna chuji*
3.	Arachinda	Sarcoptiformes	Galumnidae	Galumna	*Galumna discifera*
4.	Arachinda	Sarcoptiformes	Autognetidae	Autogneta	*Autogneta amica*
5.	Arachinda	Sarcoptiformes	Scheloribatidae	Scheloribates	*Scheloribates gallinae*
6.	Arachinda	Sarcoptiformes	Scheloribatidae	Scheloribates	*Scheloribates rectus*
7.	Arachinda	Sarcoptiformes	Scheloribatidae	Scheloribates	*Scheloribates* spp
8.	Arachinda	Sarcoptiformes	Haplozetidae	Trachyoribates	*Trachyoribates ampulla*
9.	Arachinda	Sarcoptiformes	Haplozetidae	Trachyoribates	*Trachyoribates rectus*
10.	Arachinda	Sarcoptiformes	Austrachipteriidae	Lamellobates	*Lamellobates bengalensis*
11.	Arachinda	Sarcoptiformes	Austrachipteriidae	Sagittazetes	*Sagittazetes agressor*
12.	Arachinda	Sarcoptiformes	Oppidae	Oppia	*Oppia kuehnelti*
13.	Arachinda	Sarcoptiformes	Oppidae	Lanceoppia	*Lanceoppia lancearia*
14.	Arachinda	Sarcoptiformes	Phthiracaridae	Hoplophthiracarus	*Hoplophthiracarus bengalensis*
15.	Arachinda	Sarcoptiformes	Tectocepheidae	Tectocepheus	*Tectocepheus velatus*
16.	Arachinda	Sarcoptiformes	Trhypochthoniidae	Allonothrus	*Allonothrus giganticus*
17.	Arachinda	Sarcoptiformes	Trhypochthoniidae	Pergalumna	*Pergalumna intermedia*
18.	Arachinda	Mesostigmata	Dermanyssidae	Dermanyssus	*Dermanyssusgallinae*
19.	Arachinda	Mesostigmata	Acari	Gamasina	*Gamasina* spp
20.	Arachinda	Mesostigmata	Acari	Varroa	*Varroa* spp
21.	Arachinda	Trombidiformes	Trombiculidae	Trombicula	*Trombicula autumnalis*

The *Allogalumna pellusida* species were absent in both Wattle and Eucalyptus plantation of Thalaikundha (Site 3) and it is also not seen in the Eucalyptus plantation of emerald. *Autogneta amica* species were found in Kattabettu (Site 4), Wattle plantation and Emerald Eucalyptus plantation. *Dermanyssus gallinae* species were very less in Eucalyptus plantation of all five selective areas. *Gamasina and Varroa* Species were not predictable in the areas Kodapmund (Site 2) and Thalaikundha (Site 3) Eucalyptus plantation. *Scheloribates praeincisus* were documented only in Emerald and found both wattle and eucalyptus plantations (Table 1).



1.Emerald; 2. Kodapmund; 3. Thalaikundha; 4. Aruvangadu-Coonoor; 5. Kattabettu - Kotagiri

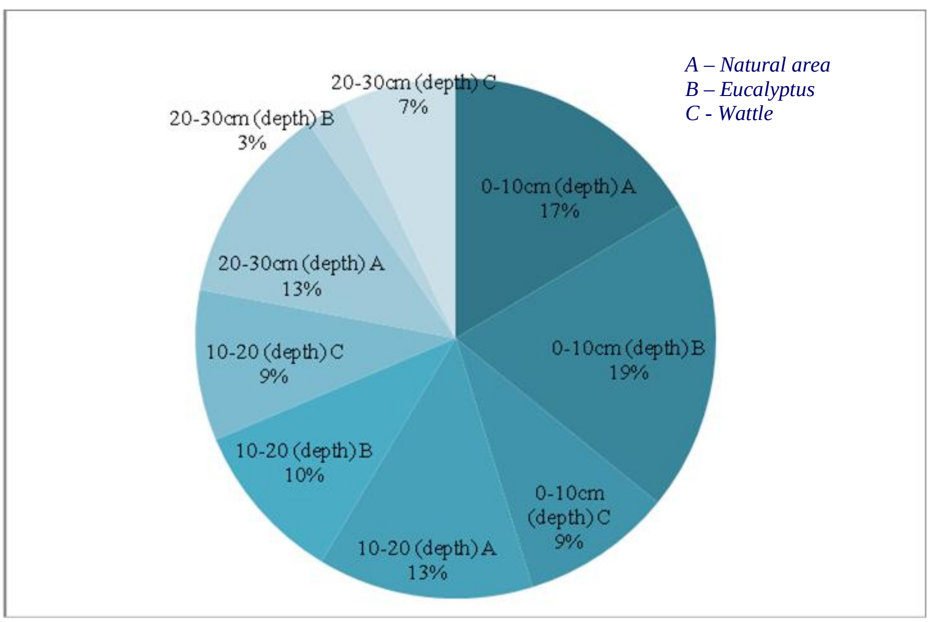
Graph 2. The variation among the pH of the study area.

Soil pH: The results showed the variation among the pH of the study area. The pH values were high in the Eucalyptus plantation, when compared to the natural and wattle plantation. The result of the pH analyses reveals that Aravankadu (site 4) area shows the high level of soil pH variation between natural and Eucalyptus plantation soils. Soil pH was 0.23 in the natural forest and pH 4.9 Eucalyptus plantation soil(Graph 2).

Table 2 Data analysis of soil Micro arthropods in Natural areas in Nilgiris.

S.No	Species name	No of Individuals	Relative abundance	In (Pi)	Pi(In pi)
1.	*Trachyoribates ampulla*	17	0.09	-2.39	-0.21
2.	*Galumna chuji*	13	0.06	-2.66	-0.18
3.	*Galmuna discifera*	12	0.06	-2.74	-0.17
4.	*Lamellobates bengalensis*	9	0.04	-3.02	-0.14
5.	*Oppia kuehnelti*	15	0.08	-2.51	-0.20
6.	*Lanceoppia lancearia*	22	0.11	-2.13	-0.25
7.	*Scheloribates rectus*	8	0.04	-3.14	-0.13
8.	*Trachyoribates* spp	21	0.11	-2.18	-0.24
9.	*Tectocepheus velatus*	13	0.069	-2.66	-0.18
10.	*Allonothrus giganticus*	8	0.04	-3.14	-0.13
11.	*Pergalumna intermedia*	10	0.05	-2.92	-0.15
12.	*Scheloribates rectus*	22	0.11	-2.13	-0.25
13.	*Hoplophthiracarus bengalensis*	13	0.06	-2.66	-0.18
14.	*Sagittazetes agressor*	11	0.05	-2.82	-0.16
15.	*Hoplophthiracarus bengalensis*	9	0.04	-3.02	-0.14

Total number of species (N) 186, Shannon-Weiner Index H'=1.31



Graph 3 Organic carbons in the leaf litter of Natural area, Eucalyptus and Wattle plantations.

Table 3 Data analysis of Soil Micro arthropods in Eucalyptus Plantation

S.No	Species Name	Number of individuals	Relative abundance	In (Pi)	Pi(In pi)
1.	*Allogalumna pellucida*	6	0.28	-1.25	-0.35
2.	*Autogneta amica*	1	0.04	-3.04	-0.14
3.	*Dermanyssus gallinae*	0	0	0	0
4.	*Gamasina* spp	3	0.14	-1.94	-0.27
5.	*Varroa* spp	1	0.04	-3.04	-0.14
6.	*Scheloribates praeincisus*	2	0.09	-2.35	-0.22
7.	*Trombicula autumnalis*	8	0.38	-0.96	-0.36

Total number of species (N) 21, Shannon- Weiner Diversity Index H'=1.51

Table 4 Data analysis of Soil Micro arthropods in wattle plantation

S.No	Species Name	Number of individuals	Relative abundance	In (Pi)	Pi(In pi)
1.	*Allogalumna pellucida*	11	0.31	-1.15	-0.36
2.	*Autogneta amica*	2	0.05	-2.86	-0.16
3.	*Dermanyssus gallinae*	4	0.11	-2.16	-0.24
4.	*Gamasina* spp	4	0.11	-2.16	-0.24
5.	*Varroa* spp	5	0.14	-1.94	-0.27
6.	*Scheloribates praeincisus*	1	0.02	-3.55	-0.10
7.	*Trombicula autumnalis*	8	0.22	-1.47	-0.33

Total number of species (N) 35, Shannon- Weiner Diversity Index H'=1.74

Table 5 Soil nutrients in Natural area, Eucalyptus and wattle plantations

S.No	Selected areas	Nitrogen (Kg/ha)			Phosphorus (Kg/ha)			Potassium (Kg/ha)		
		A	B	C	A	B	C	A	B	C
1.	Emerald	145	155.1	384.7	17	15	23.9	120	27	153.8
2.	Kodapmundh	124	122	350.4	22	24	32.1	114	35	125.4
3.	Thalaikundha	132	151	255.4	21	18	27	110	18.5	13.5
4.	Aravankadu	141	154.5	332	20	17	42	118	74.2	128.1
5.	Kattabettu	110	172	374.3	16	13	25.4	101	35.4	162.4

A-*Acacia dealbata* , B-*Eucalyptus globules*, C- Natural forest

Organic carbon of the study areas: The results of the study observed that the availability of organic carbon differs among the soil depths in the study site. In 0-10cm depth the organic carbon value of natural, Eucalyptus and wattle plantation is 1.76, 2.07, 1 gm in Emerald (Site 1), 1.81, Kodapmundh (Site 2) (1.81,2.12,1.01), Thalaikundha (Site 3) (1.51,1,1), Coonoor (Site 4) (1.11,2,1.05), Kotagiri (Site 5) (1.70,3.12,1) respectively. (Graph 3) But the availability of organic carbon was lower in the depth of 10-20 cm and 20-30 cm of all the study sites. In Eucalyptus plantation the organic carbon values were elevated in 0-10 cm depth soil than natural and Wattle plantation. But in case of 20 cm-30 cm soil depth contains very low amount of carbon than the other plots in all five selective locations.

Discussion

The assessment of biological indicators like micro-arthropods can also contribute to reveal the condition of the study area. As biological indicators, soil micro-arthropods are very sensitive to environment changes in soil sub systems. The present study deals with the leaf litter micro-arthropod diversity and their functions in the selected areas of Niligiris. Identification of the filters of biodiversity is a first step in conservation of an organism. For conservation of soil micro-arthropods, conservation of virgin forests seems to be most important (Henk Siepel, 1996). Generally, the micro-arthropods are very high in the natural forest area than the macro arthropods. In this study, the diversity of natural forest micro-arthropods were compared with the *Acacia dealbata* and *Eucalyptus globules* plantations in Nilgiris. But in case of monoculture plantations of Wattle and Eucalyptus tree, leaf litters alter the chemistry of the soil by addition of inorganic and organic nutrients and polyphenols (Cadish and Giller, 1997). Eucalyptus were also found as a succession catalyst that facilitates the recolonization of some native flora through their influence on understory microclimate and soil fertility, suppression of dominant grasses and provision of habitats for seed dispersing animals (Lugo 1992; Loumeto and Huttlee 1997; Parrotta *et al.,* 1997; Eshetu 2001; Feyera and Demel 2001; Feyera *et al.,* 2002; Mulugeta and Demel 2004; Mulugeta *et al.,* 2004).

The nitrogen value is more in the wattle plantation than the natural and eucalyptus plantations. Selected plantation is not a nitrogen fixing trees and hence the only source of nitrogen is the soil. The tap root systems facilities nutrient update from deeper layers compared with natural forest root systems(E.A.EI-Amin *et al.,* 2001) Low nitrogen status in the soils could be due to low amount of organic carbon in the soil (Srinivasan and Poongothai, 2013). Statistical analysis showed that the nitrogen content was not significantly affected under the land use practices or depth of (0-90 cm). The finding shows that the selected area had low nitrogen in soil.

The amount of organic carbon was very low in wattle and eucalyptus plantations than natural areas. The wattle and eucalyptus plantations decreased in the diversity soil micro-arthropods due to high percentage chemical content released by the resin.

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