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IMPACT OF DIVERSE SPECIES OF TREES ON POPULATION DYNAMICS OF SOIL FAUNA

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ABSTRACT

A multitude of fascinating relationships exists among insects and other life forms of a forest. The diversity of the forest plant species and their structural complexity provide numerous niches for insect inhabitation. Further, the litter associated with the forest serves as a unique habitat for vast variety of arthropod species. The present study was carried out at research station of Rain Forest Research Institute, situated at Nahoroni, Golaghat district of Assam, from February 2001 to January 2003 to assess the impact of different tree species on population dynamics of soil arthropods, which are important members of the forest ecosystem for the release of mineral nutrients by litter decomposition process and thus improve forest productivity. Results from this study indicate that Acarina and Collembola population was high in all the tree species surveyed. Acarina, Collembola, Hymenoptera, larvae of Coleoptera, Lepidoptera, and Diptera, centipede and millipede were major groups from soil samples known for litter decomposition. Arthropod population was high in winter season as compared to the summer. Trees such as *Gmelina arborea, Litsea nitida* have pronounced impact on dynamics of litter arthropods followed by *Dysoxylum procerum, Alstonia scholaris, Albizzia lebbek, Ficus hispida,* and *Samanea saman*. Trees such as *Melia azedarach, Taphrosia candita, Chukrasia tabularis,*

Lagerstroemia speciosa, Actinodaphneae angustifolia have least impact on dynamics of litter arthropods. Non Fabaceae tree species harboured more number of litter arthropods than the Fabaceae species.

Key words: Forest litter, soil Arthropods, diversity, bio-reclaimation of soil, population dynamics.

Introduction

Soil fauna is an important component of soil dynamics. It acts at many levels like in litter decomposition, humus formation and in the building and maintenance of soil physical structure. Among various parameters, vegetation is one of the factors regulating the population of soil fauna in general. In a wide range of soil types, the faunal diversity mainly depends on the contributions of two major groups viz., acari and collembolans. An understanding of their population and species diversity is essential to assess their role in humification process and soil productivity. Hammad *et al*., (1971) detected a maximum population density when the organic content and the water holding capacity of the soils were high. Dindal (1971) stated that changes in soil arthropod community resulted from the seasonal fluctuations and microclimatic changes. The aim of this study was to evaluate the soil fauna communities in different tree species association and other parameter (climate), which determine its structure. Measurement of relative frequency and density of micro and macro faunistic groups were carried out. A classification of the data was made to integrate them.

Material and methods

Study site

The study was conducted at Research Station located of Rain Forest Research Institute at Naharani, Golaghat district of Assam. Geographically it is situated at 26 45° N and 96 16° E in the central part of Brahmaputra valley Topographically, flat and 92 m above MSL. Region receives about ~2000 mm rainfall annually and relative humidity remains high through out the year. Average summer temperature ranges from 28.13° to 28.95°C and winter temperature ranges from 15.28° to 17.48°C. The study area was originally under tea cultivation, maintained by Assam Tea Corporation. The degraded area was brought under plantation during June – July 2000. Survey of soil fauna was carried out in this study area, covering diverse tree species viz., Kathalua - *Litsea nitida,* Singori - *Castanopsis indica,* Koroi - *Albizzia procera,* Moz - *Albizzia lucida,* Gamari - *Gmelina arborea,* Amari - *Dysoxylum procerum,* Medelua - *Taphrosia candida,* Sisoo - *Dalbergia sissoo,* Ghora Neem - *Melia azedarach,* Bogipoma - *Chukrasia tabularis,* Sotiana - *Alstonia scholaris,* Morolia - *Mallotus albus,* Sakihola - *Actinodaphneae angustifolia,* Rain tree - *Samanea saman,* Dimoru - *Ficus hispida,* Bhelkor - *Trewia nudiflora,* Kadam - *Anthocephalus chinensis,* Azar - *Lagerstroemia speciosa,* Samkathal - *Artocarpus chaplasa,* Siris - *Albizzia lebbek,* and a Grassland. Each species having 250 plants with 2mx 2m intervals (10 rows with 25 plants/row/species) covering in a total area of $20000 m^2$.

Collection of soil fauna

Soil sample was collected using a barrel shaped steel container of about 24.5cm height and 14.5 cm of diameter. The steel container was inserted into the soil of about 10cm depth and the soil sample of 10cm depth was collected in polythene bags, brought into the laboratory for extraction of soil fauna. The same procedure was repeated three times. Soil fauna were extracted within 24hrs using Burlase Tullgren funnel using 100W bulb for heating and as a light source (Tullgren, 1918). Soil fauna extracted were stored in 70% alcohol for further identification. Records were maintained for the number of individuals of each species collected during each survey trip. The entire sampling was done for 2 years at 6 months interval from February 2001 to January 2003. The data collected were subjected to statistical analysis.

Data analysis

The data collected were analysed for percentage frequency and relative density of soil fauna using the following formulae (Misra, 1968)

$$\text{Relative density} = \frac{\text{No. of individuals of the species}}{\text{No. of individuals of all species}} \times 100$$

$$\text{Percent frequency} = \frac{\text{No. of sampling units in which the species occurred}}{\text{Total number of units studied}} \times 100$$

Dendrogram was also drawn using cluster analysis (Ludwig and Reynolds, 1988 – using the software Statistica for Windows version 4.5F) for better understanding and appreciation of different groups of soil fauna.

Results

Periodic surveys of soil fauna were carried out in the study area, covering diverse tree species viz., *L. nitida, C. indica, A. procera, A. lucida, G. arborea, A. wallichii, T. candita, M.azedarach, D. sissoo, C. tabularis, A. scholaris, M. albus, A. angustifolia, S. saman, F. hispida, T. nudiflora, A. chinensis, L. speciosa, A. chaplasa, A. lebbek,* and Grassland for assessing their impact on soil fauna from February 2001 to January 2003.

Occurrence of different orders of soil fauna in different tree species in the plantation areas are given in **Table 1**. The insect classification adopted here is from Mani (1973). The identification of soil fauna is complete upto order and in some cases upto the level of family. The bulk of information lies in the qualitative difference in species composition. Faunal group collected during the study period include collembolans, acari, hymenopterans, hemipterans, coleopterans, aranaea, pseudoscorpions, lepidopterans, dipterans, centepede, and millipede. In all the cases acari and collembolans were characteristically dominant ranging from 22-44% followed by hymenopterans with 20% of the total fauna **(Fig. 1.)**.

A comparative assessment of soil fauna under different tree species showed wide diversity and varied density. Significant difference was observed in species richness and percent frequency of soil fauna between barren land (grassland) and the plantation area. During the entire sampling period of 2 years, 14 orders with 432 individuals of soil fauna from *G. arborea*, of which Acarina with 196 individuals followed by 102 individuals of Collembola were recorded. *L. nitida* harboured 415 individuals falling under 13 orders. But *A. angustifolia* and the barren land harboured 209 and 175 individuals respectively **(Table 2.)**. A total of 6821 individuals from 16 different orders of soil fauna collected, acarina having 2944 individuals followed by Collembola with 1498 individuals. This indicated that these are the major groups of arthropods in the forest soil faunal assemblages. A comparison of population density of dominant groups like acari and collembolans are the indicators for efficient litter fragmentation and decomposition in the plantation areas. There was considerable decrease in population level during summer seasons (Acari 301 in 2000, 573 in 2002; collembolans 25 in 2000, and 276 in 2002) as compared to the winter seasons (Acari 787 in 2000, 1283 in 2002; collembolans 406 in 2000, and 772 in 2002) in the entire study period of two years. Among the different species of non Fabaceae, *G. arborea* harboured maximum number of acarina followed by *L. nitida, A. wallichii,* and *A. lebbek*. Among the Fabaceae *A. lucida* harboured maximum number of acari followed by *D. sissoo*. Maximum population of collembolans was registered in *S. saman* followed by *G arborea*. In general *G. arborea* harboured significantly larger population of soil fauna (432 individuals) followed by *L. nitida* (415) than the other species. The highest percent frequency of soil fauna was noticed in the tree species *G. arborea* (88%), *A. scholaris* (88%) and *A. lebbeek* (88%) **(Fig. 2.)**. Maximum relative density was observed in *G. arborea* (6.33%) followed by *L. nitida*, *A. wallichii, A. scholaris* and *A. lebbek.* Population density of acari, collembolans, and hymenopterans were very high in all the tree species including the barren land than the other groups of soil fauna.

Cluster analysis followed by ploting the dendrogram with the help of Euclidean distance revealed that *G. arborea, L. nitida* form one group falling within 30 linkage distance, which are closely related to the follwing group comprises *A. wallichii, A. scholaris, F. hispida* and *A. lebbek* in relation to population density **(Fig. 3.)**. During the study period the population of soil fauna registered maximum during winter than the summer **(Fig. 4)**. More or less similar trend was observed in the same season of the following year. The population fluctuation was erratic in other groups of soil fauna during different seasons. This may be indicated that the abiotic factors appeared to have influence on the population dynamics of soil fauna.

Discussion

Soil fauna play a vital role in the nutrient cycling processes of an ecosystem. The interaction of soil fauna and litter brings about rapid reduction in the size of the litter materials and thereby increases surface area for further microbial attack. The litter habitat provides large and varied assortment of ecological niches enabling different arthropod groups to occupy a variety of trophic positions. In a forest ecosystem, the litter inhabiting arthropods play a major role in the break down of leaf litter which in turn increase the humus and soil fertility. Soil fauna especially springtails and mites cause rapid disappearance of the fallen leaf litter (Gentry and Whitford, 1982). Soils devoid of microfauna are vulnerable to compaction and structural collapse, accelerated erosion and rapid degradation (Lal, 1988). Interestingly, in this study collembolans and mites are predominant in the soil of all the tree species. The degraded sites could be reclaimed by colonizing with those soil fauna. In the present study trees such as *G. arborea, L. nitida, A. wallichii, A. scholaris and A. lebbek* and *S. saman* harboured maximum number of acarina and collembola. It is clearly evident that these trees species may be planted in the degraded forest areas for the increase in soil nutrient content towards rejuvenation of the soil there by increasing the productivity. Comparison of entomofauna associated with soil in various tree species showed considerable variation both in terms of faunal assemblages and density. During the study period the population of soil fauna registered maximum during winter than the summer. Peak population of soil fauna under sal and eucalyptus plantations was observed during early winter when compared to the summer (Bahuguna, 1991). Return of sub soil material to the forest floor in small litter concealed mounds by ants is important process (Lyford, 1963). In the present study, hymenopterans especially ants density is comparatively high next to the mites and collembolans. The soil arthropods have influenced the decomposition process of litter through fragmentation of the litter or in any other manner as a part of food chain of the ecosystem (Kevan, 1962).

Saprophagus mites constitutes one of the most important group of Arachnida which helps in decaying through their feeding activity on leaves. In the present study, comparison of soil fauna resources associated with different species of trees reveals their abundance in non-Fabaceae trees compared to Fabaceae. Decomposition of the substrates was found to process at different rates depending on the composition of faunal community (Setala and Huhta, 1990). Nutritional relationships of arthropods are among the most important ecological factors determining the development and distribution of species. The direct role of the animals could not be directly correlated to the decomposition process and subsequent mineralisation. It is however well known that fragmentation of litter is carried out by mites and springtails. These animals may be instrumental in the reclaimation of degraded lands, if suitable tree species providing good quality leaf litter as a good substrate for faunal activity are planted at the degraded site. Further interlinked role of soil fauna, microbes litter biomass, physico-chemical parameters of the soils would generate good information for the management of plantation for increased productivity. The enhancement of the productivity of the lands under forest cover will precisely be the index of success of rejuvenation of soil in the degraded land.

Conclusion

High population of microarthropods like Acarina (Mites),Collembola (Spring tails), and Hymenoptera (ants) in the study area are indicators of efficient litter fragmentation and decomposition. High population of micro, meso and macroarthopods like mites, collembollans, larvae of Coleoptera, Lepidoptera, followed by centipede (Chilopoda) and millipede (Diplopoda) in the soil are responsible for the increase in rate of litter conversion and mineralisation. Trees species like *G. arborea, L. nitida, A. wallichii, A. scholaris, A. lebbek, F. hispida, and S. saman* harbouring more number of soil arthropods lead to increase the soil organic matter. In conclusion, the degraded site could be reclaimed by colonizing with mites and springtails under suitable forest cover with tree species viz., *G. arborea, L. nitida, A. wallichii, A. scholaris, A. lebbek, F. hispida, and S. saman.*

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Table 1. Occurrence of different orders of soil fauna under different tree species

S. No.	Tree Species	Protura	Diplura	Collembola	Acarina	Araneae	Diplopoda	Chilopoda	Isopoda	Coleoptera	Lepidoptera	Hymenoptera	Homoptera	Isoptera	Thysanoptera	Diptera	Dermaptera
1	*L. nitida*	+	+	+	+	+	-	+	+	+	+	+	+	+	-	-	-
2	*C. indica*	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	-
3	*A. procera*	+	+	+	+	+	+	+	-	+	+	+	+	+	+	+	-
4	*A. lucida*	-	+	+	+	+	-	+	+	+	+	+	+	+	+	+	-
5	*G. arborea*	+	+	+	+	+	+	+	+	+	+	+	+	-	-	-	+
6	*A. wallichii*	+	+	+	+	+	-	+	+	+	+	+	+	+	+	+	-
7	*T. candita*	-	+	+	+	-	+	+	+	+	+	+	+	+	+	-	+
8	*D. sissoo*	+	+	+	+	+	+	-	+	+	+	+	+	-	-	+	+
9	*M.azedarach*	+	+	+	+	+	+	+	+	+	+	+	+	-	+	+	-
10	*C. tabularis*	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
11	*A. scholaris*	+	+	+	+	+	-	+	+	+	+	+	+	+	-	+	-
12	*M. albus*	+	+	+	+	+	-	-	+	+	+	+	-	+	+	+	-
13	*A. angustifolia*	+	+	+	+	+	-	+	+	+	+	+	+	+	+	+	-
14	*S. saman*	+	+	+	+	+	-	+	+	+	+	+	+	+	-	-	+
15	*F. hispida*	+	+	+	+	+	-	+	+	+	+	+	+	+	-	+	+
16	*T. nudiflora*	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-
17	*A. chinensis*	-	+	+	+	+	+	+	-	+	+	+	+	-	+	+	+
18	*L. speciosa*	+	+	+	+	-	-	+	+	+	+	+	+	-	-	+	+
19	*A. chaplasa*	+	+	+	+	+	-	-	+	+	+	+	+	+	-	+	+
20	*A. lebbek*	+	+	+	+	+	-	+	+	+	+	+	+	+	-	+	-
21	Grassland	-	-	+	+	-	-	+	-	+	+	+	-	+	-	-	-

+ - Presence
- - Absence

Fig. 1. Relative percent of population density of each orders under different tree species

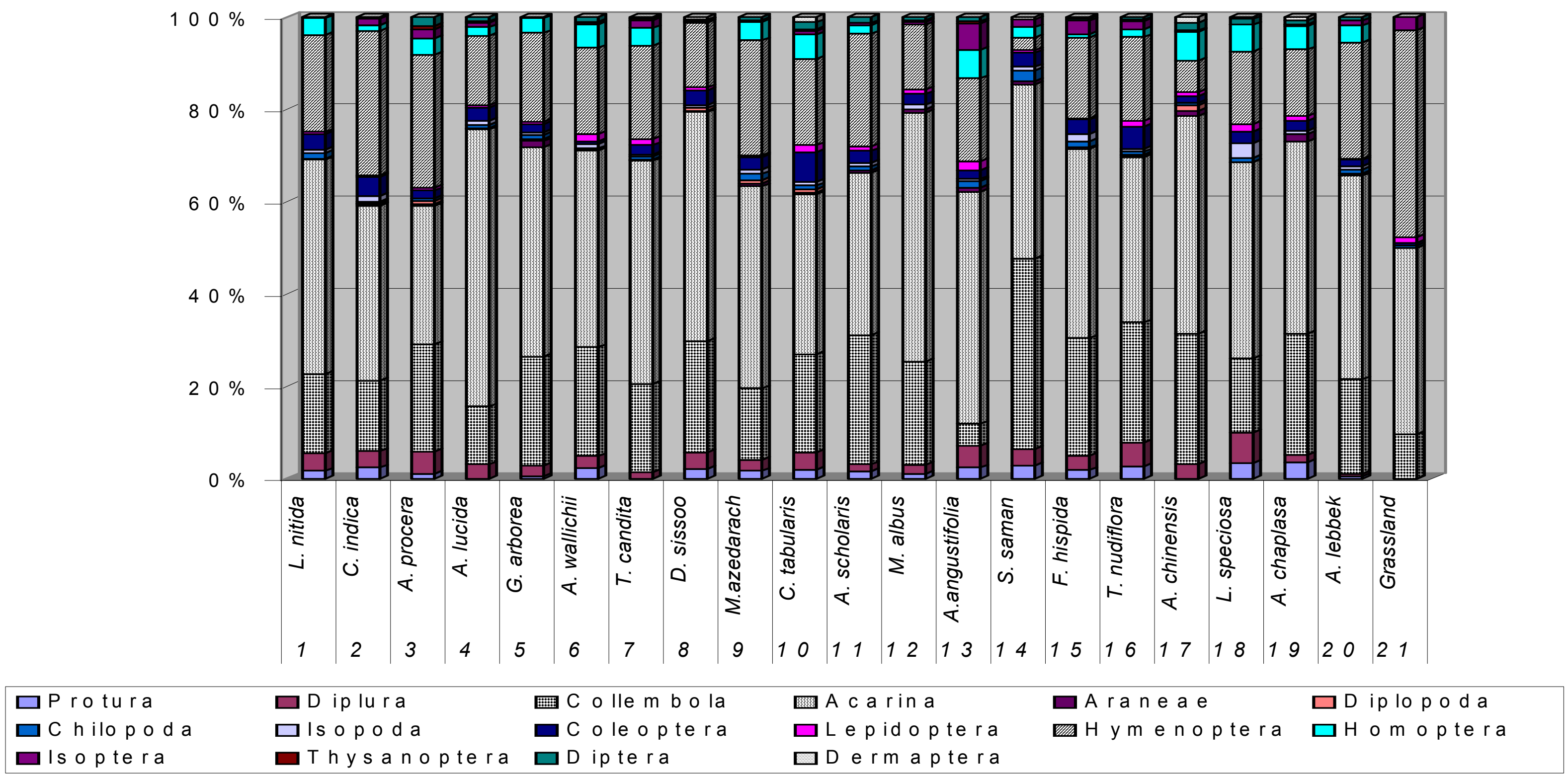

Fig 2. Arthropod faunal composition in forest soil under different species of trees

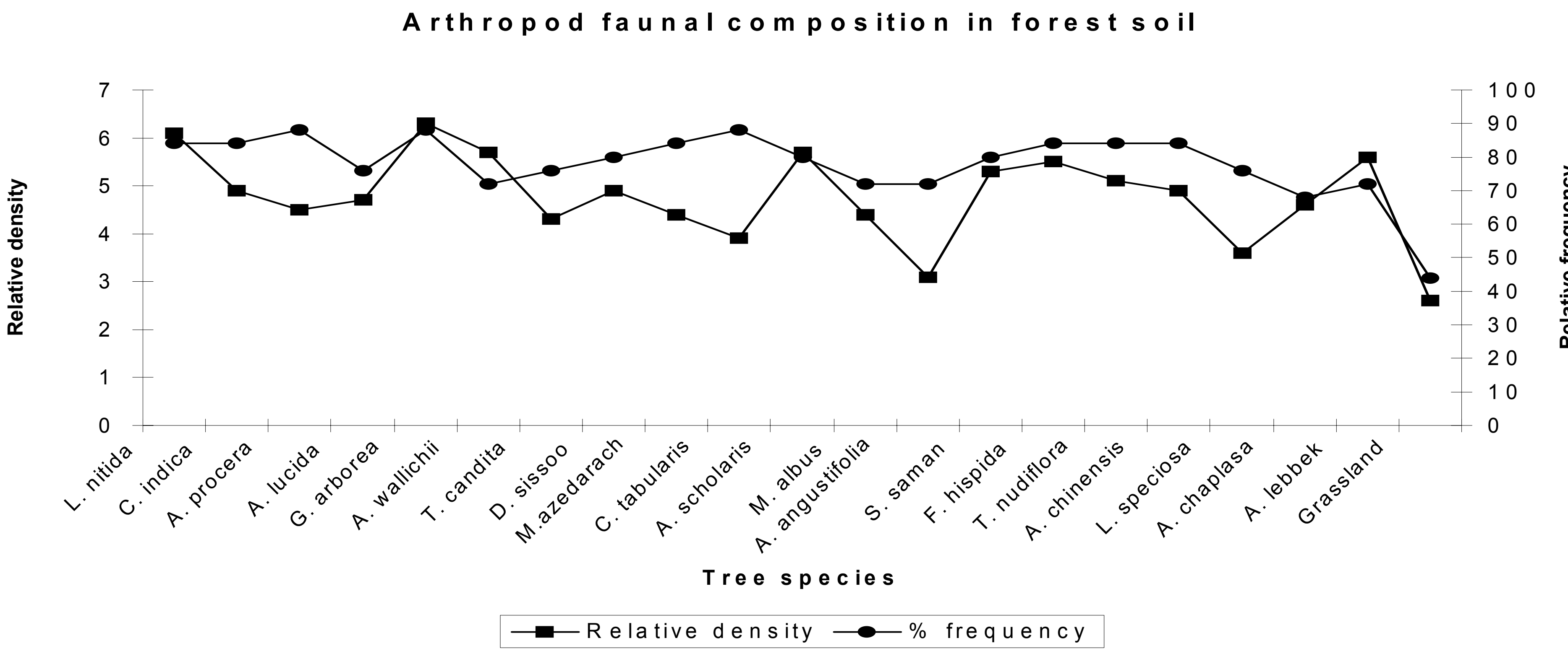

Table 2. Population density of soil fauna under different tree species

Tree Species	Acarina	Collembola	Hymenoptera	Homoptera	Diplura	Coleoptera	Protura	Isoptera	Lepidoptera	Isopoda	Chilopoda	Diptera	Araneae	Diplopoda	Dermaptera	Thysanoptera	Total	Relative density (%)
G. arborea	196	102	83	14	10	8	2	0	2	2	4	0	6	2	1	0	432	6.33
L. nitida	192	71	87	15	16	14	7	1	2	3	5	0	1	0	0	0	415	6.08
A. wallichii	166	92	73	20	10	2	9	1	6	4	1	4	1	0	0	1	390	5.72
A. scholaris	136	108	94	7	6	10	6	2	4	3	3	5	2	0	0	0	387	5.67
A. lebbek	168	78	96	14	2	5	2	4	1	3	3	3	2	0	0	0	381	5.59
F. hispida	155	96	66	3	12	12	7	11	1	6	5	2	1	0	1	0	378	5.54
S. saman	136	149	10	8	13	11	10	6	2	3	8	0	3	0	2	0	361	5.29
T. nudiflora	124	90	63	6	18	17	9	6	4	2	2	2	1	1	0	1	346	5.07
A. chinensis	160	96	23	21	11	5	0	0	3	0	2	6	4	4	4	1	340	4.98
D. sissoo	166	81	47	1	12	11	7	0	2	2	0	1	1	2	2	0	338	4.96
C. indica	127	51	105	4	12	14	8	5	1	4	1	0	1	1	0	1	335	4.91
A. lucida	192	40	48	6	10	9	0	3	2	3	2	3	1	0	0	1	320	4.69
A. chaplasa	130	82	45	16	5	7	11	1	3	2	0	3	5	0	2	0	312	4.57
A. procera	92	71	88	11	15	5	3	6	2	0	2	6	1	2	0	2	306	4.49
M. albus	162	67	42	0	6	7	3	2	3	3	0	2	2	0	0	1	300	4.4
M.azedarach	130	46	74	12	7	8	5	0	1	3	4	2	2	2	0	1	297	4.35
T. candita	141	56	59	11	4	6	0	5	4	1	2	0	0	1	1	1	292	4.28
C.tabularis	91	56	49	14	10	17	5	2	4	2	2	4	1	2	3	1	265	3.89
L. speciosa	103	39	38	14	16	6	8	0	4	8	2	3	0	0	1	0	242	3.55
A. angustifolia	106	10	38	13	10	4	5	12	4	1	3	2	2	0	0	1	209	3.06
Grassland	71	17	79	0	0	1	0	5	2	0	1	0	0	0	0	0	175	2.57
Total	2944	1498	1307	213	205	179	107	72	57	55	52	49	35	19	16	13	6821	

Fig. 3. Dendrogram for clustering of tree species in relation to soil arthropods

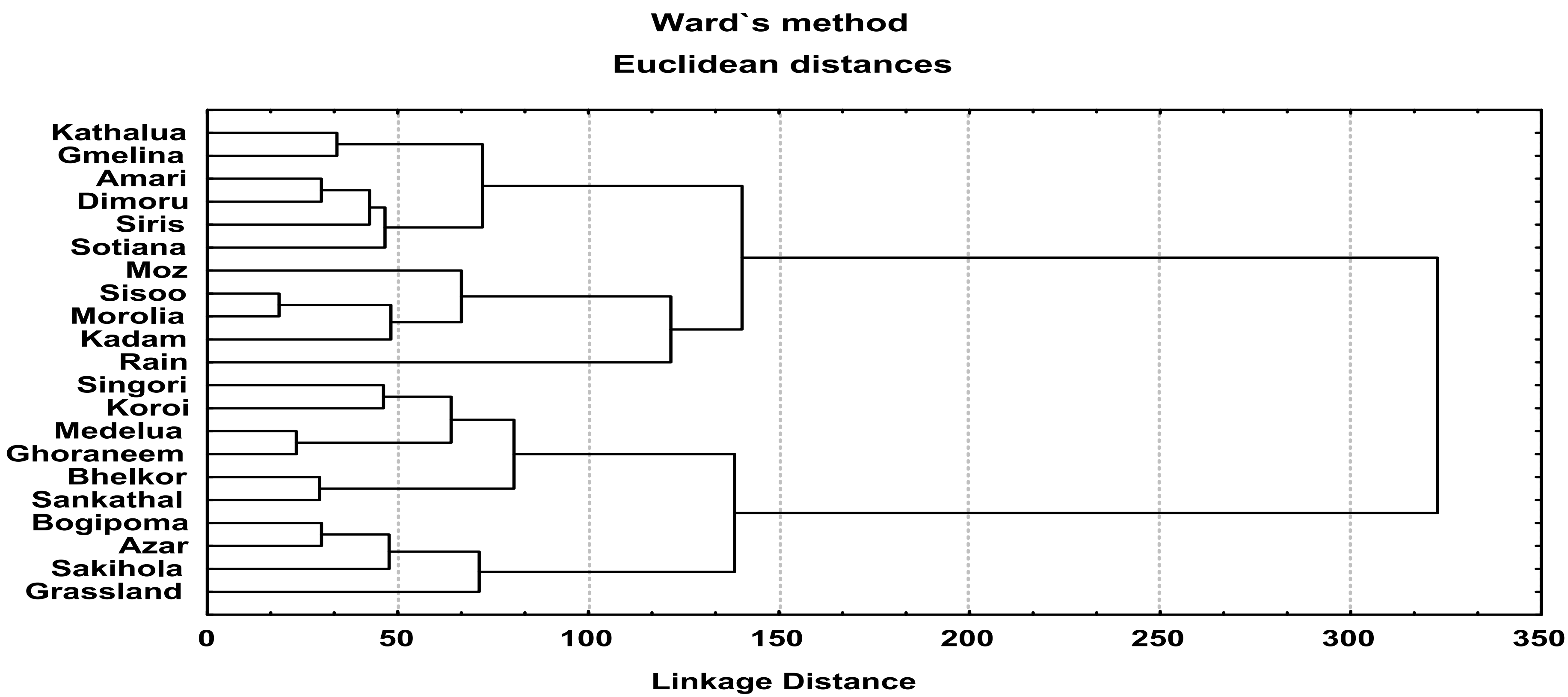

Fig. 4. Population of soil fauna in relation to seasons