

Seasonal soil micro-arthropod association in different habitats with special reference to a terrestrial isopod, *Phyloscia javanensis* (Rich)

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Abstract- Population density, diversity, and species association of soil groups in general and species association of a soil isopod *Phyloscia javanensis* in particular was studied. The monsoon season has maximum soil animal group density followed by post monsoon and summer. The vertical migration and thermal sensitivity of most of the soil animals contributes to the decrease of population density of most of the groups in summer in both ecosystems. The species under special study showed maximum association in monsoon in both ecosystems and least during summer. This species has low association ability when compared with others micro-arthropod groups. This is because the soft bodied animal often happens to be the prey of many of the soil macro arthropods and Gastropods. So they always go to the seat of safety in the crevices of pebbles and stones. So their density will be always low in the collecting samples.

Index Terms- Animal association, seasonal variation, soil macro invertebrates, isopod, *Phyloscia*

I. INTRODUCTION

The soil is at the inter phase between the atmosphere and lithosphere. It also has an interphase with water bodies of fresh and salt (Anderson *et.al.*, 1978). The soil sustains the growth of many plants and animals and forms part of the biosphere. Soil macrofauna includes vertebrate animals mainly of burrowing types such as mole and rabbits which live partially or wholly underground. Microfauna represent small invertebrate animals included in the phylum annelida, arthropoda, nematoda and mollusca. The microbiota includes the soil algae, bacteria, fungi and protophyta

Soil microfauna play an important role in all the decomposition process in the soil. The most important groups involved in the turnover of organic matter are Arthropods and Annelids. Soil microarthropods include the Isopods, Arachnids Insects and Myriapods. The more numerous are the mites and many of the insects present as adults and larvae. Mites and spring tails feed on plant remains and fungi in the litter especially where thick mats build up agricultural land and undisturbed grassland. Their droppings appear as characteristic pellets in the litter. They may also be found in the large pores. Some species of mites prey on spring tails (Ulrich and Fiera, 2009, White, 1979.).

Many beetles and insect larvae live in the soil. Some of them feed saprophytically whereas others feed on living tissues and are serious pests of agricultural crops. The termites have been called the tropical analogue of earth worms and indeed they are important of all forms of litter-tree trunks, branches and leaves in the forests and especially the seasonal rainfall regions (Savanna) of the tropics. Most species are surface feeders and build nests called termitaria by packaging and cementing together soil particles with organic secretions and excrement (Anderson *et. al.*, 1978, Wood, 1988). Millipedes feed on vegetation much of which in the form of living roots, bulbs and tubers. Earthworms are more important in the consumption of litter than all other invertebrates. Earthworms feed purely on dead organic matter (Bhatnagar, 1975).

Relevance of soil studies based on the relationship of soil organisms and their association had been a subject of curiosity among pedologists for long time. Various types of soil organisms interact with each other. This interaction may be either interspecific or intraspecific in nature (Choudhuri and Roy, 1970). Extensive data in this regard is quite helpful to arrive at conclusions. Present study assesses the correlative basis for the association among the soil organisms, their density and diversity with special reference to soil isopod, *Phyloscia javanensis* (Rich).

II. MATERIALS AND METHODS

Experimental groups

Soil animal groups of various orders inhabiting along with *Phyloscia javanensis* were selected for this study. Species association of different groups in general and association of *Phyloscia javanensis* in particular were studied.

Collection of samples

Soil samples were collected from eight different sites of Chengannur Taluk of Central Kerala, of which four were grasslands and other four were agricultural land respectively from 2013 June to 2014 February. Samples were collected in three seasons viz monsoon (June-August), post monsoon (September- November) and summer (December – February). Ten samples of moist surface soil were collected from each study site using a soil auger (25cm² area). The collected soil samples were transferred to polythene cover and brought to the soil laboratory. The soil samples were then taken to the Berlesse funnel apparatus and the animals were extracted in beakers containing 2% picric acid. After the extraction of animals, they were identified order wise with the help of a dissection microscope and their numbers counted. The population density (mean ±SD in m²) of each group was then calculated.

Association study

Ten samples were collected from each habitat during different seasons. Presence or absence data for a pair of group were considered to find out the association between species. The method described by Robert (1974) was followed to find out association coefficient (C). The data were arranged in a 2×2 contingency table and the association coefficient was calculated as follows:

If $bc > ad \geq a$ then, $C = \frac{ad - bc}{(a+b)(a+c)}$

If $bc > ad$ and $a > d$ then, $C = \frac{ad - bc}{(b+d)(c+d)}$

If $ad \geq bc$ then, $C = \frac{ad - bc}{(a+b)(b+d)}$

Where, a = Sample containing both species A and B

b = Sample containing only species B

c = Sample containing only species A

d = Sample containing neither species.

C = +1 = maximum association;

C = -1 = negative association and

C = 0 = association by chance.

The isopod *Phyloscia javanensis* was selected specifically from each sample during sorting to find out its association with other groups during different seasons.

Mean and standard deviation was calculated for the animal density estimation. A two way Anova test was conducted to find any significant difference in the population density of different animal groups at different collection sites and also between different groups.

III. RESULTS & DISCUSSION

Population density and diversity

Grassland Community – Monsoon Season (June- August)

Eleven groups of soil animals were recorded from the grassland community during monsoon season. They were Acari, Diplopoda, Isopoda, Annelida, Collembola, Hymenoptera, Isoptera, Orthoptera, Coleoptera, Gastropoda and Pauropoda. Collembolans were the most abundant group where as Coleoptera and Orthoptera were least abundant in both monsoon and postmonsoon (Table 1 and 2).

Table 1
Density and diversity of soil organisms at different sites in the grassland community during monsoon
(Mean ± SD per m²)

Species	Site I	Site II	Site III	Site IV
Acari	11.85 ± 1.65	10.54 ± 1.73	14.45 ± 1.34	13.36 ± 2.08
Diplopoda	18.54 ± 1.55	07.65 ± 0.09	10.74 ± 1.73	11.22 ± 2.56
Isopoda	13.74 ± 2.08	08.45 ± 2.64	05.54 ± 1.89	10.45 ± 1.56

Annelida	09 .65± 2.64	11.66 ± 1.65	07.96 ± 1.41	12.14 ± 1.98
Collembola	26.47± 2.08	24.48 ± 1.33	30.47 ± 2.64	20.65±2.081
Hymenoptera	10.56 ± 1.732	08.56 ± 3.60	12.54 ± 2.56	14.00 ± 1.527
Isoptera	06.98± 2.645	04.78± 1.73	03.54 ± 2.64	07.87 ± 1.732
Orthoptera	01.89 ± 1.98	03.56 ± 1.73	0.00 ± 0.00	0.00 ± 0.00
Coleoptera	02.56 ± 1.73	0.00 ± 0.00	01.45 ± 1.73	01.98 ± 0.89
Gastropoda	04 .78± 1.98	06.45± 3.60	03.87 ± 1.73	05.56 ± 2.645
Paupoda	7.67 ± 3.98	04 .78± 1.89	03.89 ± 1.32	05.65 ± 1.732

Table 2
Population density and diversity of soil organisms at different sites in the grassland community during post monsoon (Mean ± SD per m²)

Species	Site I	Site II	Site III	Site IV
Acari	16.45 ± 2.51	14 .47± 2.46	20.33 ± 1.73	17.74± 1.66
Diplopoda	12.33 ± 1.01	16.87 ± 1.52	19.14 ± 1.01	10.47 ± 1.73
Isopoda	09.36± 3.60	15.45 ± 1.45	12.78 ± 1.03	11.65 ± 2.25
Annelida	08.41± 3.21	13.54 ± 1.52	14 .47± 2.64	17.85 ± 1.45
Collembola	35.69 ± 4.35	34.98 ± 3.60	32.99 ± 2.64	31.85 ± 1.65
Hymenoptera	04.36± 1.02	08.99± 2.01	07.74 ± 1.45	06.45 ± 1.66
Isoptera	07.17 ± 1.73	03.69± 1.33	04.25 ± 0.25	09.89 ± 1.73
Orthoptera	01 .36± 0.36	00.00 ± 0.00	03.36 ± 0.21	01.45 ± 1.73
Coleoptera	01.58 ± 1.01	02 .58± 1.73	00.00 ± 0.00	01 .88± 1.66
Gastropoda	03.88 ± 1.73	02.98 ± 2.00	03.36 ± 1.45	06.87 ± 2.64
Paupoda	04 .47± 1.65	03.65 ± 2.64	05.89 ± 2.64	06.98 ± 1.73

Two way Anova conducted revealed that there is significant difference in the population density of different groups of animals (F = 60.4254, P< 0.05) and no significant difference between the density of same group of animals at different sites (F = 1.0668, P> 0.05)

Grassland Community- Summer (December –February)

During summer season Orthoptera and Coleoptera were not at all represented in the sample in all sites. Here also Collembola predominates among the soil animals. Acari, Isopoda, Diplopoda and Annelida were moderately represented whereas Gastropods and Paupods were least represented (Table 3).

Table 3
Population density and diversity of soil organisms at different sites in the grassland community during summer season (Mean ± SD per m²)

Species	Site I	Site II	Site III	Site IV
Acari	10.25 ± 02.66	08.88 ± 01.73	12.99 ± 01.32	09.98 ± 01.73
Diplopoda	11.58 ± 01.54	09.65 ± 01.73	10.98 ± 01.32	06 .21± 01.33
Isopoda	07.78 ± 01.01	09.47 ± 02.64	10.88 ± 01.02	06.45 ± 01.01
Annelida	08.89 ± 01.73	04.96 ± 01.58	04.97± 00.04	03.99 ± 01.21
Collembola	22.89 ± 02.64	18 .65± 01.47	19.97 ± 01.98	21.01 ± 02.64
Hymenoptera	16.79 ± 01.52	14.88 ± 01.73	17.47 ± 01.33	13.04 ± 00.57
Isoptera	07.99± 01.73	05.78 ± 01.73	04.08 ± 01.73	06 .32± 01.73

Orthoptera	00.00 ± 00.00	00.00 ± 00.00	00.00 ± 00.00	00.00 ± 00.00
Coleoptera	00.00 ± 00.00	00.00 ± 00.00	00.00 ± 00.00	00.00 ± 00.00
Gastropoda	02.97 ± 02.01	05.91 ± 02.64	04.64 ± 01.73	03.63 ± 02.64
Paurododa	02.99 ± 01.78	04.96 ± 02.02	02.99 ± 01.73	01.98 ± 01.01

A two way Anova conducted showed that there is significant difference in the population density of different animal groups (F = 65.232, P < 0.05) whereas no significant difference was found in the density of same animal groups at different sites (F = 0.8955, P > 0.05)

Agricultural land Community -Monsoon (June – August)

Nine groups were identified from different sites of agricultural land community during monsoon. Collembola were the most abundant group followed by Acari and Isopoda. Isoptera and Coleoptera were not at all represented whereas Orthoptera were obtained from one site. population density was observed for Gastropoda, Diplopoda, Pauropoda and Annelida (Table 4).

Table 4
Population density and diversity of soil animals at different sites of agricultural land community during monsoon season (mean ± SD per m²)

Species	Site I	Site II	Site III	Site IV
Acari	11.11 ± 1.65	13.45 ± 1.52	09.14 ± 1.32	14.96 ± 1.23
Diplopoda	07.45 ± 1.73	05.47 ± 1.73	03.74 ± 1.21	07.47 ± 1.73
Isopoda	06.32 ± 2.02	04.85 ± 1.732	07.01 ± 1.25	08.85 ± 2.14
Annelida	03.87 ± 1.36	02.22 ± 1.02	03.98 ± 1.73	04.74 ± 1.21
Collembola	18.87 ± 2.64	14.47 ± 2.32	13.78 ± 0.54	12.54 ± 1.36
Hymenoptera	06.78 ± 1.12	04.88 ± 1.02	05.87 ± 1.73	05.47 ± 2.64
Isoptera	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00
Orthoptera	00.00 ± 0.00	01.87 ± 1.98	00.00 ± 0.00	02.99 ± 2.01
Coleoptera	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00
Gastropoda	03.89 ± 1.73	04.47 ± 2.21	02.74 ± 1.73	04.45 ± 1.36
Pauropoda	03.45 ± 2.64	03.01 ± 4.35	06.56 ± 1.73	04.12 ± 2.54

A two way Anova conducted showed that there is significant difference in the density of different groups (F = 40.465, P < 0.05) and no significant difference in the density of same groups at different sites (F = 1.419, P > 0.05).

Agricultural land Community - Post Monsoon (September-November)

Only eight groups of soil animals were recorded from agricultural land community during post monsoon season. Isoptera, Coleoptera and Orthoptera were not at all represented in any of the study sites. Acari and Collembola were well represented. Diplopoda and Isopoda were moderately represented whereas Pauropoda, Gastropoda, Hymenoptera and Annelida were least represented (Table 5).

Table 5
Population density and diversity of soil animals at different sites of agricultural land community during post monsoon (mean ± SD per m²)

Species	Site I	Site II	Site III	Site IV
Acari	12.54 ± 2.64	15.54 ± 2.54	13.98 ± 2.08	10.88 ± 3.12
Diplopoda	08.33 ± 1.73	10.87 ± 2.32	13.58 ± 3.78	09.87 ± 2.64
Isopoda	08.41 ± 2.64	07.87 ± 1.73	09.25 ± 2.33	04.84 ± 2.64
Annelida	03.45 ± 1.22	05.32 ± 2.64	02.04 ± 1.21	07.98 ± 2.01
Collembola	12.47 ± 2.64	11.96 ± 2.01	10.78 ± 2.64	13.87 ± 3.05
Hymenoptera	06.85 ± 2.32	04.25 ± 1.04	00.00 ± 0.00	05.07 ± 2.04
Isoptera	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00

Orthoptera	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00
Coleoptera	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00
Gastropoda	00.00 ± 0.00	02.99 ± 1.73	01.87 ± 1.01	00.00 ± 0.00
Pauropoda	03.48 ± 3.60	01.45 ± 1.01	02.05 ± 1.73	03.47 ± 1.73

Two way anova conducted with this data showed a very significant difference in the population density of different animal groups (F = 32.115, P<0.05) and no significant difference between the population density of animal groups at different sites (F = 0.148, P> 0.05).

Agricultural land Community – Summer (December – February)

Only seven animal groups were extracted from the agricultural land community during summer. Gastropoda, Coleoptera, Orthoptera and Isoptera were not at all represented. Collembola were well represented followed by Acari and Diplopoda. Isopoda and Hymenoptera were moderately represented whereas Annelida was least represented (Table 6).

Table 6
Population density and diversity of soil animal groups at different sites in the agricultural land community during summer (mean ± SD per m²)

Species	Site I	Site II	Site III	Site IV
Acari	07.25 ± 1.73	09.47 ± 1.05	06.87 ± 1.21	08.65 ± 3.01
Diplopoda	06.65 ± 1.73	05.98 ± 1.10	07.25 ± 2.64	06.98 ± 2.64
Isopoda	04.47 ± 2.47	03.98 ± 3.35	02.65 ± 1.73	04.74 ± 1.25
Annelida	02.25 ± 1.02	02.85 ± 2.64	03.85 ± 1.01	01.47 ± 1.01
Collembola	10.89 ± 1.73	13.36 ± 1.73	09.87 ± 2.64	12.58 ± 5.56
Hymenoptera	06.98 ± 1.04	08.32 ± 2.64	04.47 ± 1.73	07.87 ± 1.32
Isoptera	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00
Orthoptera	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00
Coleoptera	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00
Gastropoda	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00	00.00 ± 0.00
Pauropoda	00.00 ± 0.00	02.45 ± 1.21	01.32 ± 0.05	01.74 ± 0.02

Two way anova conducted with this data showed a very significant positive difference in the density of different animal groups (F = 63.21, P< 0.05) and no significant difference in the population density of same animal groups at different sites (F = 1.9365, P>0.05)

SPECIES ASSOCIATION

Species association in grassland soil – Monsoon

A very good species association among soil animal groups was found in the grassland soil during monsoon. A significant positive association (C=+1) was found between Acari and Diplopoda, Isopoda, Collembola and Hymenoptera; Diplopoda has positive association with Acari, Isopoda, Collembola, Hymenoptera, Gastropoda and Pauropoda. Isopoda has positive association with Acari, Diplopoda, Annelida, Collembola, Hymenoptera, Coleoptera and Gastropoda. Annelida has positive association with Isopoda, Collembola, Hymenoptera, Coleoptera and Gastropoda. Collembola has negative association (C= -1) with only Orthoptera and Gastropoda and by chance association with Coleoptera (C=0). Similarly Hymenoptera has negative association with only Gastropoda and Pauropoda. Isoptera has positive association with Collembola, Hymenoptera, Orthoptera, and Coleoptera. Orthoptera has positive association with Hymenoptera, Isoptera and Coleoptera. Coleoptera showed a positive association with all the other groups except Acari, Diplopoda, and Pauropoda.

Gastropoda has association with Diplopoda, Isopoda, Annelida, Coleoptera and Pauropoda and by chance association with Acari. Pauropods have positive association with only Diplopoda, Collembola and Gastropoda (Table 7).

Table 7
Species association coefficient between different animal groups in the grass -land soil during monsoon season

	Acari	Diplopoda	Isopoda	Annelida	Collembola	Hymenoptera	Isoptera	Orthoptera	Coleoptera	Gastropoda	Paupoda
Acari	-	+1	+1	0	+1	+1	-1	-1	-1	0	-1
Diplopoda	+1	-	+1	0	+1	+1	0	-1	-1	+1	+1
Isopoda	+1	+1	-	+1	+1	+1	0	0	+1	+1	-1
Annelida	0	0	+1	-	+1	+1	0	-1	+1	+1	-1
Collembola	+1	+1	+1	+1	-	+1	+1	-1	0	-1	+1
Hymenoptera	+1	+1	+1	+1	+1	-	+1	+1	+1	-1	-1
Isoptera	-1	0	0	0	+1	+1	-	+1	+1	0	-1
Orthoptera	-1	-1	0	-1	-1	+1	+1	-	+1	-1	-1
Coleoptera	-1	-1	+1	+1	0	+1	+1	+1	-	+1	-1
Gastropoda	0	+1	+1	+1	-1	-1	-1	-1	+1	-	+1
Paupoda	-1	+1	-1	-1	+1	-1	-1	-1	-1	+1	-

Species association in the grassland soil –Post monsoon

During Post monsoon species association was less between different groups compared to monsoon season. Acari have well association except with Orthoptera, Coleoptera, Gastropoda and Paupoda and by chance association with Hymenoptera and Isoptera. Diplopoda has negative association with Gastropoda and Paupoda and by chance association with Isoptera, Orthoptera and Coleoptera. Isopoda has negative association with Orthoptera and Gastropoda and by chance association with Isoptera and Paupoda. Annelida and Collembola have negative association with only Orthoptera. Hymenoptera has by chance association with Acari, Collembola, Isoptera and Gastropoda. Isoptera has positive association with Annelida Orthoptera, Coleoptera and Paupoda. Orthoptera has positive association with Isoptera, Coleoptera and Paupoda. Coleoptera has negative association with only Acari. Gastropoda has positive association with Annelida and Collembola. Paupoda has negative association with Acari and Diplopoda (Table 8).

Table 8
Species association coefficient between different animal groups in grassland soil during post monsoon

	Acari	Diplopoda	Isopoda	Annelida	Collembola	Hymenoptera	Isoptera	Orthoptera	Coleoptera	Gastropoda	Paupoda
Acari	-	+1	+1	+1	+1	0	0	-1	-1	-1	-1
Diplopoda	+1	-	+1	+1	+1	+1	0	0	0	-1	-1
Isopoda	+1	+1	-	+1	+1	+1	0	-1	+1	-1	0
Annelida	+1	+1	+1	-	+1	+1	+1	-1	0	+1	+1
Collembola	+1	+1	+1	+1	-	0	0	-1	+1	+1	+1
Hymenoptera	0	+1	+1	+1	0	-	0	-1	-1	0	+1

Isoptera	0	0	0	+1	0	0	-	+1	+1	0	+1
Orthoptera	-1	0	-1	-1	-1	-1	+1	-	+1	0	+1
Coleoptera	-1	0	+1	0	+1	+1	+1	+1	-	0	+1
Gastropoda	-1	-1	-1	+1	+1	0	0	0	0	-	0
Paupoda	-1	-1	0	+1	+1	+1	+1	+1	+1	0	-

Species association in the grassland soil- Summer

During summer most of the soil animal groups showed a significant positive association or by chance association (Table 6.14). Negative association was found only between Collembola and Paupoda; Hymenoptera with Isoptera and Orthoptera; Isoptera with Hymenoptera, Orthoptera and Paupoda; Orthoptera with Hymenoptera, Isoptera and Paupoda; Coleoptera with Paupoda and Paupoda with Collembola, Isoptera, Orthoptera and Coleoptera (Table 9).

Table 9
Species association coefficient between different animals groups in grassland soil during summer season

	Acari	Diplopoda	Isopoda	Annelida	Collembola	Hymenoptera	Isoptera	Orthoptera	Coleoptera	Gastropoda	Paupoda
Acari	-	+1	+1	+1	+1	+1	0	0	+1	0	+1
Diplopoda	+1	-	+1	+1	+1	+1	+1	0	+1	0	+1
Isopoda	+1	+1	-	+1	+1	+1	0	0	+1	+1	0
Annelida	+1	+1	+1	-	+1	+1	+1	0	+1	0	0
Collembola	+1	+1	+1	+1	-	0	0	+1	+1	0	-1
Hymenoptera	+1	+1	+1	+1	0	-	-1	-1	+1	+1	0
Isoptera	0	+1	0	+1	0	-1	-	-1	+1	0	-1
Orthoptera	0	0		0	+1	-1	-1	-	+1	+1	-1
Coleoptera	+1	+1	+1	+1	+1	+1	+1	+1	-	+1	-1
Gastropoda	0	0	+1	0	0	+1	0	+1	+1	-	+1
Paupoda	+1	+1	0	0	-1	0	-1	-1	-1	+1	-

Species association in agriculture soil- Monsoon

A very well positive association was seen between different groups in the agricultural soil during monsoon. Negative association was seen only with Acari with Isoptera, Orthoptera and Gastropoda; Annelida with Isoptera, Orthoptera and Paupoda; Collembola with Orthoptera, Gastropoda and Paupoda; Hymenoptera with Orthoptera; Isoptera with Gastropoda, Coleoptera with Paupoda and Gastropoda with Paupoda (Table 10).

Table 10
Species association coefficient between different animal groups in agriculture soil during monsoon season

	Acari	Diplopoda	Isopoda	Annelida	Collembola	Hymenoptera	Isoptera	Orthoptera	Coleoptera	Gastropoda	Paupoda
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Acari	-	+1	+1	+1	+1	+1	-1	-1	0	-1	+1
Diplopoda	+1	-	+1	+1	+1	+1	+1	0	+1	0	+1
Isopoda	+1	+1	-	+1	+1	+1	+1	0	+1	+1	+1
Annelida	+1	+1	+1	-	0	0	-1	-1	0	0	-1
Collembola	+1	+1	+1	0	-	+1	+1	-1	0	-1	-1
Hymenoptera	+1	+1	+1	0	+1	-	+1	-1	0	+1	+1
Isoptera	-1	+1	+1	-1	+1	+1	-	+1	+1	-1	0
Orthoptera	-1	0	0	-1	-1	-1	+1	-	+1	0	+1
Coleoptera	0	+1	+1	0	0	0	+1	+1	-	0	-1
Gastropoda	-1	0	+1	0	-1	+1	-1	0	0	-	-1
Paupoda	+1	+1	+1	-1	-1	+1	-1	+1	+1	-1	-

Species association in the Agricultural Soil- Post monsoon.

In the Postmonsoon season by chance association was more prevalent among different groups than negative association. 26 positive association, 16 by chance association and 13 negative association was seen between 11 groups identified (Table 11).

Table 11
Species association coefficient between different animal groups in the agriculture soil during post monsoon

	Acari	Diplopoda	Isopoda	Annelida	Collembola	Hymenoptera	Isoptera	Orthoptera	Coleoptera	Gastropoda	Paupoda
Acari	-	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1
Diplopoda	+1	-	+1	+1	0	0	+1	-1	-1	+1	0
Isopoda	+1	+1	-	+1	0	0	+1	-1	0	0	-1
Annelida	+1	+1	+1	-	+1	+1	0	0	+1	-1	0
Collembola	+1	0	0	+1	-	+1	+1	-1	0	-1	0
Hymenoptera	+1	0	0	+1	+1	-	-1	-1	-1	-1	+1
Isoptera	+1	+1	+1	0	+1	-1	-	+1	-1	0	-1
Orthoptera	+1	-1	-1	0	-1	0	+1	-	+1	0	0
Coleoptera	+1	-1	0	+1	0	-1	-1	+1	-	+1	-1
Gastropoda	+1	+1	0	-1	-1	-1	0	0	+1	-	+1
Paupoda	-1	0	-1	0	0	+1	-1	0	-1	+1	-

Species association in the agriculture soil- Summer

During summer positive association was more when compared to by chance association and negative association. Collembola has maximum by chance association with others groups. A total of 34 positive association, 12 by chance association and 8 negative association was found between 11 groups of soil animals isolated (Table 12).

Table 12
Species association coefficient between different animal groups in the agriculture soil during summer season

	Acari	Diplopoda	Isopoda	Annelida	Collembola	Hymenoptera	Isoptera	Orthoptera	Coleoptera	Gastropoda	Pauropoda
Acari	-	+1	+1	+1	+1	+1	+1	-1	+1	0	+1
Diplopoda	+1	-	+1	+1	+1	0	0	+1	+1	0	+1
Isopoda	+1	+1	-	+1	+1	0	0	+1	+1	0	+1
Annelida	+1	+1	+1	-	-1	0	-1	+1	0	+1	-1
Collembola	+1	+1	+1	-1	-	+1	+1	+1	+1	+1	+1
Hymenoptera	+1	0	0	0	+1	-	+1	0	+1	-1	-1
Isoptera	+1	0	0	-1	+1	+1	-	+1	0	+1	+1
Orthoptera	-1	+1	+1	+1	+1	0	+1	-	-1	-1	0
Coleoptera	+1	+1	+1	0	+1	+1	0	-1	-	+1	0
Gastropoda	-1	0	0	+1	-1	-1	+1	-1	+1	-	+1
Pauropoda	+1	+1	+1	-1	-1	-1	+1	0	0	-1	-

SPECIES ASSOCIATION WITH *PHYLOSCIA JAVANENSIS*

Grassland Soil

During monsoon *Phyloscia* has positive association with Acari, Diplopoda, Isopoda and Annelida, Hymenoptera, Isoptera and Pauropoda. During post monsoon *Phyloscia* has positive association with Isopoda, Coleoptera and Gastropoda. During summer *Phyloscia* has association with Acari, Diplopoda and Isopoda (Table 13).

Table 13

Species association of *Phyloscia javanensis* with others groups during different seasons in the grassland soil

	Collembola	Acari	Diplopoda	Isopoda	Annelida	Hymenoptera	Gastropoda	Isoptera	Pauropoda
<i>Phyloscia javanensis</i> (Monsoon)	0	+1	+1	+1	+1	+1	+1	+1	+1
<i>Phyloscia javanensis</i> (Post monsoon)	+1	0	0	+1	0	-1	+1	-1	-1
<i>Phyloscia javanensis</i> (Summer)	-1	+1	+1	-1	0	-1	-1	0	-1

Agricultural Soil

In the monsoon season *Phyloscia* has significant positive association with Acari, Isopoda and Hymenoptera. In the post monsoon *Lobella* associate positively with Acari, Hymenoptera and Isoptera. In summer it associates with only Acari (Table 14).

Table 14

Species association of *Phyloscia javanensis* with other groups during different seasons in the agriculture soil

	Acari	Isopoda	Hymenoptera	Isoptera	Annelida	Orthoptera	Gastropoda	Paupoda	Diplopoda
<i>Phyloscia javanensis</i> (Monsoon)	+1	+1	+1	0	0	-1	-1	0	-1
<i>Phyloscia javanensis</i> (Post monsoon)	+1	0	+1	+1	-1	-1	0	0	-1
<i>Phyloscia javanensis</i> (Summer)	+1	0	0	0	-1	-1	0	-1	0

The population density of most of the soil animal groups was well represented in the grassland soil during monsoon. The low density of Orthoptera and Isoptera in soil was due to their adult life in air. Diplopodans were highly found during the monsoon, which is the active feeding time of this group. The young leaves of grasses are the prime food of Diplopodans. (Ellis, 1971).

Post-monsoon temperature of soil favours the reproduction and multiplication of soil micro arthropods (Andren, 1984). This accounts for the rapid increase in the density of Collembolan during post monsoon. During post monsoon Coleopterans go very deep into the soil for egg laying (Joffe, 1949). This is the reason for the low population density of this group during post monsoon.

In summer most of the soil animals show vertical migration. They go very deep into the soil to avoid extreme temperature rise of the top soil. This is the reason for the low population density of soil animal groups in both grasslands and agricultural soil.

Comparatively grassland soils showed more population density of most of these animal groups when compared to agricultural land soil. This may be due to the undisturbances of the grassland soil when compared to agricultural soil.

The population density of different groups showed drastic variations in the number among different groups but no significant difference among same groups at different sites as revealed by anova tests. This showed that even distribution of species in the soil and dominance and over dominance of certain species over the other.

The species association revealed that maximum possible association was found in the monsoon season in both agricultural land and grass land. This is due to the multiplication and reproductive timing of most of the soil groups (Kuhnelt, 1961). The least possible maximum association in summer was observed for many of the soil of animal groups. This is due to aestivation and vertical migration of most of the prominent group of animals. The group Acari and Collembola showed maximum association in all seasons in both grassland and agricultural soil because both groups can tolerate a wide range of temperature and moisture content of soil (Lal, 1987).

The isopod *Phyloscia javanensis* is a soft bodied animal showing high degree of vertical migration. The seasonal variation of this species is also drastic and the reproductive timing coincides with monsoon (Kurup, 1982). This is the reason for maximum possible positive association of this species with other groups in monsoon at both grassland and agriculture soil and least association during post monsoon and summer.

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