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Diversity and composition of co-existing soil micro-arthropods and association probability.

Diversity and composition of co-existing soil micro-arthropods and association probability

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ABSTRACT

The soil is at the interphase between the atmosphere and lithosphere and also with water bodies of fresh and salt. The organic matter of the soil was mixed up with minerals and derives energy. Soil organic matter is one of the major sources of nutrient element for plants. Organic matter in soil is a dynamic material and it changes continuously as a result of microbial activity. The soil faunas inhabiting the soil are active partners of plant tissues. In this study Population density, diversity, soil properties and species association of soil groups in general and species association of a soil isopod *Phyloscia javanensis* in particular was studied. It was observed that, in general grassland soil is more fertile than agriculture soil. The monsoon season has showed maximum soil animal group density and species association followed by post monsoon and summer season. The species with more significant positive association was observes as Collembola and Acari. The species under special study *Phyloscia javanensis* showed maximum association in monsoon in both ecosystems and least during summer.

Keywords: Isopod, soil fauna, species association, *Phyloscia javanensis*

RESUMEN

El suelo se encuentra en la interfase entre la atmósfera y la litosfera y también con masas de agua dulce y salada. La materia orgánica del suelo se mezcla con minerales y obtiene energía. La materia orgánica del suelo es una de las principales fuentes de nutrientes para las plantas. La materia orgánica del suelo es un material dinámico y cambia continuamente como resultado de la actividad microbiana. Las faunas del suelo que habitan el suelo son socios activos de los tejidos vegetales. En este estudio se estudió la densidad de población, la diversidad, las propiedades del suelo y la asociación de especies de grupos de suelos en general y la asociación de especies de un isópodo del suelo *Phyloscia javanensis* en particular. Se observó que, en general, los suelos de pastizales son más fértiles que los suelos agrícolas. La temporada de los monzones ha mostrado una densidad máxima de grupos de animales en el suelo y una asociación de especies, seguida de la temporada posterior a los monzones y del verano. Las especies con asociación positiva más significativa fueron Collembola y Acari. La especie bajo estudio especial *Phyloscia javanensis* mostró una asociación máxima durante el monzón en ambos ecosistemas y mínima durante el verano.

Palabras clave: isópodo, fauna del suelo, asociación de especies, *Phyloscia javanensis*.

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INTRODUCTION

The soil is a natural body of mineral and organic constituents differentiated into horizons of variable depth, which differs from the material below in morphology, physical makeup, chemical properties and composition and biological characteristics (Joffe, 1949). Soil is not only a factor of the environment of organisms, but is produced by them as well. In general soil may be considered as the net result of the action of climate and organisms especially vegetation on the parent material of the earth's surface. The texture and porosity of the soil are highly important characteristics and largely determine the availability of nutrients to plants and soil animals.

The organic matter of soil arise from the debris of green plants, animal's residues and excreta that are deposited on the surface and mixed to a variable extend with the mineral component (Russel, 1973). The dead organic matter is colonized by a variety of soil organisms most importantly microorganisms which derive energy for growth from the oxidative decomposition of complex organic molecules.

Climate, which is determined by temperature and rainfall, exerts a significant influence on the organic matter status of soil. Higher temperature stimulates microbial activity to a greater extent than plant growth. In cooler climates, the soils are several times richer in organic matter than those in warmer climate. The nitrogen, phosphorous and sulphur cycles emphasis the manner in which organic matter becomes a source of nutrient and a key substance in nutrient transformation in the soil (Allison, 1973). Organic matter plays an important role in improving soil physical conditions. It improves infiltration movement and retention of soil reaction, soil temperature and soil strength and root penetration. (Alexander, 1977). 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. The present study focuses on the species association of the soil isopod *Phyloscia javanensis.*

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 Alleppy District, of which four were grasslands and other four were agricultural land respectively. Samples were collected in three seasons viz monsoon (June-August), post monsoon (September- November) and summer (December – February) during 2010 June to 2011 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.

Soil Chemical Properties: The NPK value of the soil was determined. Total nitrogen content of the soil was analysed using Kjeldahl distillation method (Jackson, 1958). Phosphate content of the soil was determined by molybdate- stannous chloride method (Jackson, 1958). Potassium content was analysed by flame photometry method of ASA (1965). Exchangeable acid, exchangeable base, calcium and magnesium content were found out according to procedures of Jackson (1958).

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 > a then,

$$C = \frac{ad - bd}{(a+b)(a+c)}$$

If bc > ad and a > d then

$$C = \frac{ad - bc}{(b+d)(c+d)}$$

If ad > 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.

Statistical Analysis: Mean and standard deviation was calculated for the animal density estimation. One way ANOVA test was conducted to find out any significant difference in the soil properties at different sites of same community. 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.

RESULTS

1. Population density and diversity

a. 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

Orthopetera were least abundant. 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 ($F = 1.0668$, $P > 0.05$). (Table 1)

b. 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. 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 ($F = 1.419$, $P > 0.05$). (Table 2)

c. Agricultural land Community - Post Monsoon (September-November)

Only eight groups of soil animals were recorded from agricultural land community during post monsoon season. Isopetra, 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 Annellida were least represented. 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 ($F = 0.148$, $P > 0.05$).

d. 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. 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 ($F = 1.9365$, $P>0.05$).

2. Species association

a. 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 3)

b. 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 Pauropoda and by chance association with Hymenoptera and Isoptera. Diplopoda has negative association with Gastropoda and Pauropoda and by chance association with Isoptera, Orthoptera and Coleoptera. Isopoda has negative association with Orthoptera and Gastropoda and by chance association with Isoptera and Pauropoda. Annelida and Colembola 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 Pauropoda. Orthoptera has positive association with Isoptera, Coleoptera and Pauropoda. Coleoptera has negative association with only Acari. Gastropoda has positive association with Annelida and Collembola. Pauropoda has negative association with Acari and Diplopoda.

c. 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 30). Negative association was found only between Collembolan and Pauropoda; Hymenoptera with Isoptera and Orthoptera; Isoptera with Hymenoptera, Orthoptera and Pauropoda; Orthoptera with Hymenoptetera, Isoptera and Pauropoda; Coleoptera with Pauropoda and Pauropoda with Collembola, Isoptera, Orthoptera and Coleoptera.

d. 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 Pauropoda; Collembola with Orthoptera, Gastropoda and Pauropoda; Hymenoptera with Orthoptera; Isoptera with Gastropoda, Coleoptera with Pauropoda and Gastropoda with Pauropoda.(Table 4)

e. Species association in the Agricultural Soil- Post monsoon.

In the Post monsoon season by chance association was more prevalent among different groups than negative association. Twenty six positive associations, 16 by chance association and 13 negative associations were seen between 11 groups identified.

f. 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 associations, 12 by chance association and 8 negative associations was found between 11 groups of soil animals isolated.

3. Species association with *Phyloscia javanensis*

a. 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.

b. 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.

DISCUSSION

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. Swarupanandan (1995) reported that the young leaves of grasses are the prime food of Diplopodans.

Post-monsoon temperature of soil favours the reproduction and multiplication of soil micro arthropods (Sanal Kumar and Sujatha, 1996). 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 may be 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 may be 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 un disturbances 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.

Grassland soil is more fertile than the agricultural soil as revealed by OC %, pH, EA% and EB% but the luxuriant vegetation is lacking in the soil due to the high content of calcium, magnesium and sand content. Increase in sand content and level of calcium and magnesium above optimal had retarded effect on plant growth (Sankar, 1994). The one way Anova conducted to find any significant different in the chemical properties of soils of different sites of same community showed a negative difference and even leaching of minerals from the soil (Balagopal, 1980). The increase in the nitrogen and phosphorous content of agricultural soil is because of the addition of chemical fertilizers to the soil during agricultural operations.

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 (Thomas, 1992). 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 (Sanal and Swarupanandan, 1995). 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 (Thomas, 1992).

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 (Sanal and Sujatha, 1996). This may be 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.

Table 1. Density and diversity of soil organisms at different sites in the grassland community during monsoon, post monsoon and Summer season. (Mean + SD per m2).

Species	Monsoon				Post monsoon				Summer			
	Site I	Site II	Site III	Site IV	Site I	Site II	Site III	Site IV	Site I	Site II	Site III	Site IV
Acari	11.85 ± 1.65	10.54± 1.732	14.45 ± 134	13.36 ± 2.081	16.45 ± 2.516	14 .47± 2.465	20.33 ± 1.732	17.74± 1.66	16.45 ± 2.516	14 .47± 2.465	20.33 ± 1.732	17.74± 1.66
Diplopoda	18.54 ± 1.55	7.65 ± 0.09	10.74 ± 1.732	11.22± 2.56	12.33 ± 1.01	16.87 ± 1.527	19.14 ± 1.01	10.47 ± 1.732	12.33 ± 1.01	16.87 ± 1.527	19.14 ± 1.01	10.47 ± 1.732
Isopoda	13.74 ± 2.081	8.45 ± 2.645	5.54 ± 189	10.45 ± 1.56	9 .36± 3.605	15.45 ± 1.45	12.78 ± 1.03	11.65 ± 2.25	9 .36± 3.605	15.45 ± 1.45	12.78 ± 1.03	11.65 ± 2.25
Annelida	9 .65± 2.645	11.66± 1.65	7.96 ± 1.41	12.14± 1.98	8 .41± 3.214	13.54 ± 1.527	14 .47± 2.645	17.85 ± 1.45	8 .41± 3.214	13.54 ± 1.527	14 .47± 2.645	17.85 ± 1.45
Collembola	26.47± 2.081	24.48 ± 1.33	30.47± 2.645	20.65± 2.081	35.69 ± 4.358	34.98 ± 3.605	32.99 ± 2.645	31.85 ± 1.65	35.69 ± 4.358	34.98 ± 3.605	32.99 ± 2.645	31.85 ± 1.65
Hymenoptera	10.56 ±1.732	8.56 ± 3.605	12.54 ± 2.56	14 ± 1.527	4 .36± 1.02	8 .99± 2.01	7.74 ± 1.45	6.45 ± 1.66	4 .36± 1.02	8 .99 ± 2.01	7.74 ± 1.45	6.45 ± 1.66
Isoptera	6.98± 2.645	4 .78± 1.732	3.54 ± 2.645	7.87 ± 1.732	7.17 ± 1.732	3 .69± 1.33	4.25 ± 0.25	9.89 ± 1.732	7.17 ± 1.732	3 .69 ± 1.33	4.25 ± 0.25	9.89 ± 1.732
Orthoptera	1.89± 1.98	3.56 ± 1.732	0	0	1 .36± 0.36	0	3.36 ± 0.21	1.45 ± 1.732	1 .36± 0.36	0	3.36 ± 0.21	1.45 ± 1.732
Coleoptera	2.56± 1.732	0	1.45 ± 1.732	1.98 ± 0.89	1.58 ± 1.01	2 .58± 1.732	0	1 .88± 1.66	1.58 ±1.01	2 .58± 1.732	0	1 .88 ±1.66
Gastropoda	4 .78± 1.98	6.45 ± 3.605	3.87 ± 1.732	5.56 ± 2.645	3.88 ±1.732	2.98 ±2.002	3.36 ±1.45	6.87 ± 2.645	3.88 ±1.732	2.98 ±2.002	3.36 ±1.45	6.87 ± 2.645
Pauropoda	7.67 ± 3.98	4 .78± 1.89	3.89 ± 1.32	5.65 ± 1.732	4 .47± 1.65	3.65 ± 2.645	5.89 ± 2.645	6.98 ± 1.732	4 .47± 1.65	3.65 ± 2.645	5.89 ± 2.645	6.98 ± 1.732

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Table 2. Population density and diversity of different soil animals at different sites of agricultural land community during monsoon, Postmonsoon and Summer Season (Mean + SD Per m2).

Species	Monsoon				Post monsoon				Summer			
	Site I	Site II	Site III	Site IV	Site I	Site II	Site III	Site IV	Site I	Site II	Site III	Site IV
Acari	11.11 + 1.65	13.45 + 1.527	9.14 + 1.32	14.96+ 1.23	12.54 + 2.645	15 .54+ 2.54	13 .98+ 2.081	10.88 + 3.12	7.25 + 1.732	9.47 + 1.05	6 .87+ 1.21	8.65+ 3.01
Diplopoda	7.45 + 1.732	5.47 + 1. 732	3.74 + 1.21	7.47 + 1.732	8.33 + 1.732	10.87 + 2.32	13.58 + 3.785	9.87 + 2.645	6 .65+ 1.732	5 .98+ 1.10	7 .25+ 2.645	6.98 + 2.645
Isopoda	6 .32+ 2.02	4.85 + 1.732	7.01 + 1.25	8 .85+ 2.14	8.41+ 2.645	7.87 + 1.732	9.25+ 2.33	4.84 + 2.645	4.47+ 2.47	3.98 + 3.35	2.65+ 1.732	4.74 + 1.25
Annelida	3.87 + 1.36	2.22 + 1.02	3.98+ 1.732	4.74 + 1.21	3.45 + 1.22	5.32 + 2.645	2.04+ 1.21	7 .98+ 2.01	2.25 + 1.02	2.85 + 2.645	3.85+ 1.01	1.47 + 1.01
Collembola	18.87 + 2.645	14.47 + 2.32	13.78 + 0.54	12.54 + 1.36	12.47+ 2.645	11.96 + 2.01	10.78 + 2.645	13.87 + 3.055	10.89+ 1.732	13 .36+ 1.732	9.87 + 2.645	12.58 + 5.567
Hymenoptera	6.78 + 1.12	4.88 + 1.02	5.87 + 1.732	5.47 + 2.645	6.85 + 2.32	4 .25+ 1.04	0	5.07 + 2.04	6.98 + 1.04	8.32 + 2.645	4.47+ 1.732	7.87 + 1.32
Isoptera	0	0	0	0	0	0	0	0	0	0	0	0
Orthoptera	0	1.87 + 1.98	0	2 .99± 2.01	0	0	0	0	0	0	0	0
Coleoptera	0	0	0	0	0	0	0	0	0	0	0	0
Gastropoda	3.89 + 1.732	4.47 + 2.21	2.74+1. 732	4.45 + 1.36	0	2.99 + 1.732	1.87 +1.01	0	0	0	0	0
Pauropoda	3.45 + 2.645	3.01 + 4.358	6.56 + 1.732	4 .12+ 2.54	3.48 + 3.605	1.45 + 1.01	2.05 + 1.732	3.47 + 1.732	0	2 .45+ 1.21	1.32 + 0.05	1 .74+ 0.02

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Table 3. Species association coefficient between different animal groups in the grass -land soil during monsoon, post monsoon and summer season.

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

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

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

Table 4 Species association coefficient between different animal groups in the agriculture soil during post monsoon.

	Acari	Diplo	Isopoda	Anne	Collem	Hymeno	Isopte	Ortho	Coleo	Gast	Pauro
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
Pauropoda	-1	0	-1	0	0	+1	-1	0	-1	+1	

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