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DIVERSITY AND DISTRIBUTION OF SOIL ARTHROPOD COMMUNITIES IN RELATION TO ALTITUDE AND EDAPHIC FACTORS OF DIFFERENT ALTITUDINAL ENVIRONMENTS OF DARJEELING HIMALAYAS, INDIA

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INTRODUCTION

The soil microarthropods in general and Collembola and Acari in particular play an important role in the decomposition of leaf litter to organic matter and its nutrient cycling (Scastedt and Crossley, 1981; Faber, 1992; Bardgett *et al.*, 1998). Various workers like Christiansen *et al.*, (1961), Yosii (1966), Crossley *et al.*, (1992), Badejo and Straallen (1993), Choudhuri and Roy (1967), Prabhoo (1976), Choudhuri and Pande (1979), Hazra and Choudhuri (1983), Mitra (1993), Hazra and Sanyal (1996), Ghosh and Roy (2004) in abroad and India have studied the soil arthropod population in relation to different biotic and abiotic factors particularly either in grassland, forest, cultivated, uncultivated fields or in a particular altitude in hilly region. So far no study has been undertaken in a consolidated way on the occurrence and ecology of soil arthropod fauna in different altitudinal ranges in Darjeeling Himalaya, India. To fill up these lacunae the present investigation has been undertaken with the objectives to determine what groups of soil arthropod communities inhabit in different altitudinal sites, a record of seasonal abundance of the groups in these areas, and to investigate distribution, dominance and diversity of different soil arthropod communities; to ascertain the effect of altitude and some important edaphic factors on the soil arthropod communities; and also to compare similarity and equitability of different group of soil arthropods in different altitudinal sites of Darjeeling Himalaya.

KEYWORDS : *Soil arthropods; Distribution; Diversity; Altitudes; Edaphic factors; Darjeeling Himalaya.*

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MATERIALS AND METHODS

Study sites :

The study was conducted at four different altitudinal sites (A, B, C, and D) of Darjeeling Himalaya (India). The sites are montane at an altitude 161–3636 m a.s.l. with an annual average precipitation in the region ranges from 300–400 cm. The entire area under investigation is made up of different types of metamorphic rocks, chiefly gneiss and soil was mixed with humus and grains of degraded rocks. All the sites were undisturbed, uncultivated and vegetated with herbs, shrubs and large woody plants. The site A (Sukna) was the foothill site of Darjeeling Himalaya with an approximate altitude of 161 m a.s.l. and was covered with *Shorea robusta* as the dominating tree. This site also contained trees like *Tectona grandis, Saraca indica, Bauhinia sp.* The soil was grayish black in color and loamy clay in texture. The site B (Kurseong) was at an approximate altitude of 1478 m a.s.l. The site was dominated by plant species like *Cryptomaria japonica, Betula alnoides, Phobea sp.* The soil was light brown in color and sandy clay in texture. The site C (Tiger Hill) was at an altitude of about 2573 m a.s.l. The site was well vegetated with a number of herbs and shrubs like *Pteris quadriaurita, Euphorbia sp., Anaphalis contorta,Rubus lineatus, Arsaema specioussum* and trees like *Pinus Longifolia* and *Cryptomeria japonica.* The soil was dark grayish in color and sandy loam in texture. The site D (Sandakphu) was at an approximate altitude of 3636 m a.s.l. and was characterized by evergreen oak forest with *Quercus lamellose, Q. pachyplla* along with *Engelhardia gardneri* and *Acer camllii. Rhododendron lepidotum* was very common in this site. In addition, mosses, ferns, herbs and shrubs were also present. The soil was moderate dark gray in color and sandy clay in texture. The soil characteristics of the sampling sites are presented in Table 1.

Table 1 : Soil characteristics of sampling sites A–D in Darjeeling Himalaya, India.

Characteristics	Sampling Sites			
	Site A	Site B	Site C	Site D
Coarse sand (%)	12.6	8.2	4.1	7.4
Fine Sand (%)	19.1	47.2	56.1	55.1
Silt (%)	45	17.8	21.1	22.1
Clay (%)	23.3	26.8	18.6	15.4
Mean pH	5.33	5.68	5.17	4.67
Mean Temperature (°C)	23.91	16.75	12.08	8.91

Sampling procedure and laboratory analyses :

Each site was divided into three quadrates (5m × 5m) and three soil samples were drawn per month at random from each quadrate for a period of 12 months (May, 2005–April, 2006). Altogether

432 soil samples were drawn by using a stainless steel corer (inner cross sectional diameter 8.5 sq. cm.) from a depth of 5 cm. The corers were then carried in polythene bags to laboratory and placed on the expedition type "Expedition Funnel Apparatus" modified by Macfadyen (1953). A 40 watt electric bulb was used for heat and light source. Collection jars (100 ml) with approximately 50 ml 70% ethanol plus 5% glycerin were attached below the funnels and the extraction period was 3 days. Specimens collected were identified to order level and quantified to estimate soil arthropods distribution and diversities of these sites.

Separate soil samples were taken in polythene bags from each site for the chemical analysis of soil parameters. The temperature of the soil was measured by a soil thermometer. The relative humidity of surface soil was recorded by using a dial hygrometer. Soil moisture was determined by an oven dry method (Dowdeswell, 1959). The electrical conductivity was measured by Conductivity Bridge. The pH of the soil in solution was measured by a glass electric pH meter. Organic Carbon content was estimated by the rapid titration methods of Walkley and Black (1934). International pipette method was employed for carrying out mechanical analysis of soil for the determination of soil texture.

Statistical treatments of data :

To analyze order wise dominance in distribution of soil arthropod communities in four altitudinal sites of Darjeeling Himalaya, index of dominance was used. The group wise index of dominance was calculated on the basis of relative abundance which is expressed as

$$RA = n_i / N \times 100$$

Where RA = relative abundance, n_i = number of individuals of ith group, N = total number of individuals of all the groups.

The Sorensen coefficient of similarity was used to compare soil arthropods diversity between different altitudinal sites of Darjeeling Himalayas. The formula is

$$C_s = 2a / (2a + b + c)$$

Where C_s is Sorensen coefficient, 'a' is the number of group C_s *s* common to both sites, 'b' is the number of groups in site second site but not in the first site, 'c' is the number of groups in the first site but not in the second site.

The diversity of soil arthropod group was calculated by the Shannon's equation (*e.g.*, Magurran, 1988). It was calculated by the following equation :

$$H' (G)_y = -\Sigma P_{gy} \ln P_{gy}$$

Where $H' (G)_y$ is the Group diversity per year, $P_{gy} = N_{gy} / N_y$ is the yearly proportion of individuals of each group per year, N_{gy} is the group abundance per year and N_y is the yearly arthropods abundance.

Regarding the uniformity of distribution of different orders of soil arthropods in different altitudinal sites, we compared a community's actual group diversity, $H'(G)_y$, to the maximum possible diversity, H_{max}, by using a measure called evenness index (E) :

$$E = H'(G)_y / H_{max}$$

Data pertaining to the soil factors and population density were subjected to statistical correlation with the number of soil arthropods in relation to each of six variables [*e.g.*, temperature, relative humidity (RH), pH, moisture, electrical conductivity (EC) and organic carbon] considered in this investigation.

RESULTS

Faunal composition :

A total of over 4079 soil arthropods were collected from 432 samples in the four different altitudinal environments belong to 11 orders and 4 classes were recorded throughout the survey period. Of which Sandakphu contained 851 individuals of soil arthropods belonging to 7 orders, Tiger Hill having 892 individuals represented by 8 orders, Kurseong having 1100 individuals represented by 9 orders and Sukna having maximum 1236 individuals with 10 orders. In all the sites order Acari had maximum dominance (47.04%), followed by Collembola (38.68%), Hymenoptera (3.40%), Coleoptera (3.3%), Diplura (1.81%), Diplopoda (1.49%), Isopoda (1.27%), Aranea (1.20%), Chilopoda (1.00%), Dermaptera (0.49%). The order Diptera had minimum dominance (0.26) [Table 3]. From a total of 1957 soil insects, over 84% belonged to the subclass Apterygota and remainder to the subclass Pterygota. The majority of apterygotes were Collembola and most of the pterygotes were endopterygotes. A total of 1938 arachnids were collected, over 98% belonged to the order Acari.

Monthly fluctuation of soil arthropods :

The total soil arthropod population showed fluctuations from month to month and from one site to other during the period of study. The peak of total soil arthropod population in all the sites was observed during March (12.38%) and minimum during May (4.43%). The soil arthropod population showed irregular trends of fluctuation in different altitudinal sites being maximum in December at site A and B and in March at site C and D and minimum in May at site A and B and in July at site C and D (Fig. 1). The faunal orders encountered in this study showed that only two orders namely Acari and Collembola had considerable population and occurred consistently in different month and from all the sites. Other orders had either low population or irregular occurrence (Table 2). The two predominant orders as stated above Acari and Collembola when analyzed their population fluctuation, the population of Acari in site A and B showed their peak in the month of December (1.59% and 1.44% respectively) and the peak population in the site C and D were in the month of March (1.27% and 1.44% respectively). The order Collembola had also population peak in the month of December in site A and B (1.44% and 1.22%respectively) and in March in site C and D (1.12% and 1.05% respectively).

Table 2 : Order wise index of dominance of soil arthropod population of Darjeeling Himalaya, India.

Classes	Orders	Site A	Site B	Site C	Site D	Total
Arachnida	Aranea	0.5	0.46	0	0.14	1.2
	Acari	13.28	12.62	10.39	10.73	47.04
Myriapoda	Chilopoda	0.39	0.61	0	0	1
	Diplopoda	0.41	0.34	0.51	0.22	1.49
Hexapoda	Coleoptera	1.12	1.1	0.56	0.51	3.3
	Collembola	10.93	10.24	8.89	8.6	38.68
	Dermaptera	0.22	0	0.26	0	0.49
	Diplura	0.95	0.49	0.36	0	1.81
	Diptera	0	0	0	0.26	0.26
	Hymenoptea	1.74	0.71	0.56	0.39	3.4
Crustacea	Isopoda	0.63	0.36	0.26	0	1.27

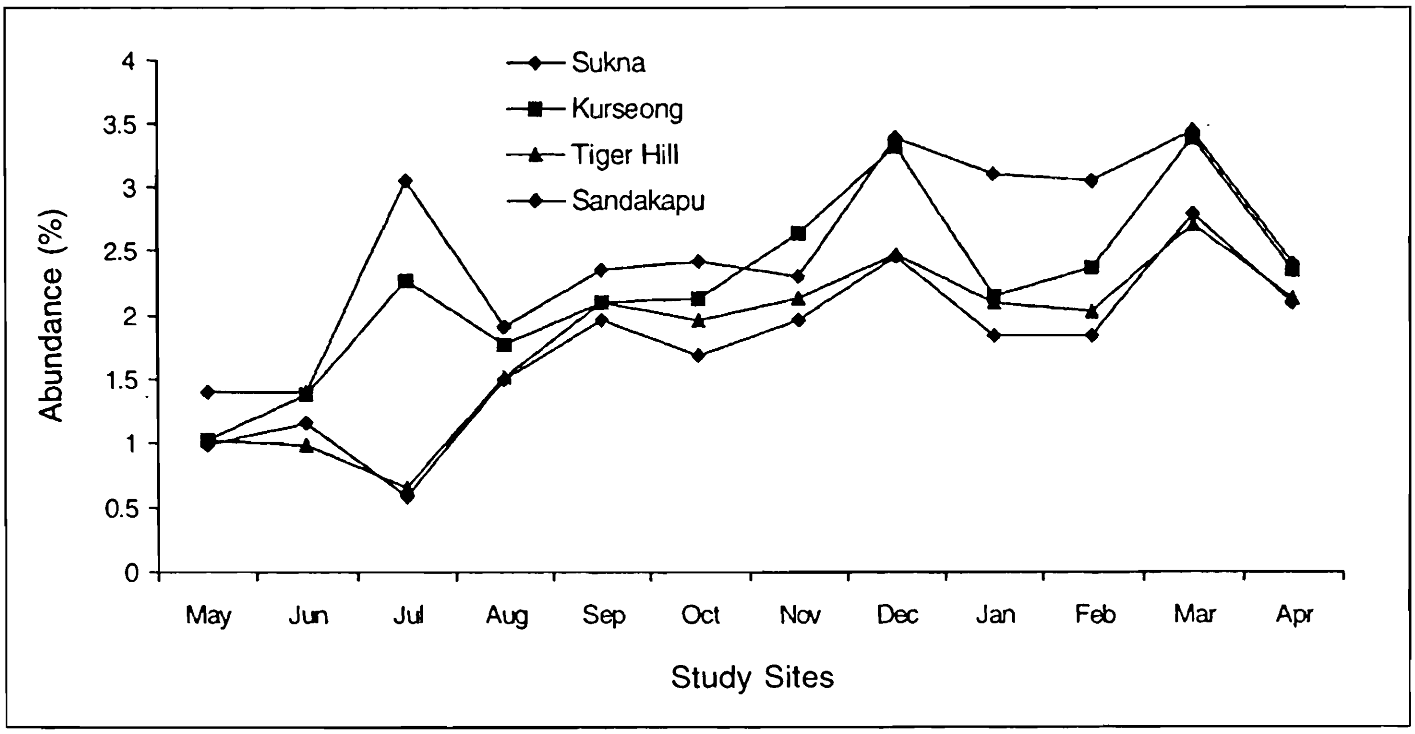

Fig. 1 : Showing the monthly variation of abundance (in %) of soil arthropod population in four altitudinal sites of Darjeeling Himalayas, India.

Table 3 : Monthly abundance (%) of soil arthropods fauna in four altitudinal sites of Darjeeling Himalaya, India.

(i) AT SITE A

Arthropod group	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Total
ARACHNIDA													
Aranea	–	–	0.14	0.02	0.02	0.04	0.07	0.02	0.12	0.02	–	0.09	0.58
Acari	0.63	0.73	1.1	0.83	0.88	1.05	0.98	1.59	1.44	1.39	1.49	1.12	13.28
MYRIAPODA													
Chilopoda	0.07		0.09		0.02	0.04	–	–	0.07	0.02	0.02	0.02	0.39
Diplopoda	–	–	0.17	0.02	0.12	–	0.02	0.04	–	0.02	–	–	0.41
HEXAPODA													
Coleoptera	–	0.02	0.19	0.02	0.17	0.04	0.07	0.14	0.07	0.29	0.02	0.04	1.12
Collembola	0.46	0.56	0.75	0.8	0.85	0.98	0.88	1.44	0.95	0.98	1.27	0.95	10.93
Dermaptera	0.02	–	0.02	–	–	–	0.09	–	–	0.04	–	0.02	0.22
Diplura	0.02	–	0.22	–	–	0.02	–	0.12	0.29	0.02	0.19	0.04	0.95
Diptera	–	–	–	–	–	–	–	–	–	–	–	–	–
Hymenoptera	0.12	0.07	0.29	0.17	0.22	0.09	0.14	0.02	0.09	0.22	0.19	0.07	1.74
CRUSTACEA													
Isopoda	0.04		0.04	0.02	0.04	0.12	0.02	–	0.04	0.02	0.24	–	0.63
TOTAL	**1.39**	**1.39**	**3.06**	**1.91**	**2.35**	**2.42**	**2.3**	**3.4**	**3.11**	**3.06**	**3.45**	**2.4**	**30.3**
(ii) AT SITE B													
ARACHNIDA													
Aranea	–	–	0.02	–	–	–	0.02	0.04	0.02	0.04	0.24	0.04	0.46
Acari	0.58	0.75	0.9	0.93	0.93	0.98	1.2	1.44	1.2	1.12	1.34	1.2	12.62
MYRIAPODA													
Chilopoda	–	–	–	–	0.02	0.02	0.26	–	0.04	0.02	0.22	–	0.61
Diplopoda	–	–	–	–	0.04	–	–	0.12	–	–	0.09	0.07	0.34

Table 3 : *(Cont'd.).*

Arthropod group	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Total
HEXAPODA													
Coleoptera	–	–	0.12	–	0.14	0.12	0.09	0.22	0.04	0.22	0.09	0.02	1.1
Collembola	0.36	0.53	0.88	0.8	0.75	0.93	0.88	1.22	0.83	0.85	1.17	0.98	10.24
Dermaptera	–	0.02	–	–	–	0.04	0.07	0.19	–	0.07	0.07	–	0.49
Diplura	–	–	–	–	–	–	–	–	–	–	–	–	–
Diptera	–	–	–	–	–	–	–	–	–	–	–	–	–
Hymenoptera	0.04	0.02	0.34	–	0.09	–	0.04	0.02	–	–	0.09	0.02	0.71
CRUSTACEA													
Isopoda	0.02	0.02	–	0.02	0.09	0.02	0.04	0.04	–	0.02	0.04	–	0.36
Total	**1.02**	**1.37**	**2.27**	**1.76**	**2.1**	**2.13**	**2.64**	**3.33**	**2.15**	**2.37**	**3.4**	**2.35**	**26.96**
(iii) AT SITE C													
ARACHNIDA													
Aranea	–	–	–	–	–	–	–	–	–	–	–	–	–
Acari	0.49	0.58	0.34	0.71	0.85	0.93	0.95	1.2	1.1	0.98	1.27	0.95	10.39
MYRIAPODA													
Chilopoda	–	–	–	–	–	–	–	–	–	–	–	–	–
Diplopoda	0.02	–	–	–	–	0.02	0.09	0.17	–	0.02	0.09	0.07	0.51
HEXAPODA													
Coleoptera	0.07	–	–	0.07	0.12	0.02	0.09	0.12	–	0.04	–	–	0.56
Collembola	0.39	0.31	0.24	0.73	0.73	0.85	0.9	0.85	0.9	0.88	1.12	0.93	8.89
Dermaptera	–	0.02	–	–	0.04	0.04	0.04	0.04	–	–	–	0.04	0.26
Diplura	–	0.02	–	–	0.02	–	–	0.07	0.04	–	0.09	0.09	0.36
Diptera	–	–	–	–	–	–	–	–	–	–	–	–	–
Hymenoptera	0.02	0.02	0.07	–	0.31	0.04	–	–	0.02	0.02	0.02	–	0.56
CRUSTACEA													
Isopoda	–	–	–	–	–	0.02	0.02	–	0.02	0.07	0.09	0.02	0.26
Total	**1.02**	**0.98**	**0.66**	**1.51**	**2.1**	**1.96**	**2.13**	**2.47**	**2.1**	**2.03**	**2.72**	**2.13**	**21.86**

Table 3 : *(Cont'd.).*

Arthropod group	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Total
(iv) AT SITE D													
ARACHNIDA													
Aranea	0.02	0.02	–	–	0.04	–	–	0.02	–	–	–	0.02	0.14
Acari	0.58	0.68	0.26	0.8	0.83	0.9	0.95	1.1	1	1.05	1.44	1.07	10.73
MYRIAPODA													
Chilopoda	–	–		–	–	–	–	–	–	–	–	–	–
Diplopoda	–	–	–	–	0.09	–	–	0.09	–	–	–	0.02	0.22
HEXAPODA													
Coleoptera	–	–	–	–	0.02	0.02	0.17	0.24	–	–	0.02	0.02	0.51
Collembola	0.36	0.39	0.29	0.68	0.8	0.75	0.83	0.98	0.73	0.78	1.05	0.9	8.6
Dermaptera	–	–	–	–	–	–	–	–	–	–	–	–	–
Diplura	–	–	–	–	–	–	–	–	–	–	–	–	–
Diptera	–	0.04	–	–	0.02	–	–	–	0.09	–	0.09	–	0.26
Hymenoptera	–	–	0.02	–	0.12	–	–	–	–	–	0.17	0.07	0.39
CRUSTACEA													
Isopoda	–	–	–	–	–	–	–	–	–	–	–	–	–
Total	**0.98**	**1.15**	**0.58**	**1.49**	**1.96**	**1.69**	**1.96**	**2.45**	**1.83**	**1.83**	**2.79**	**2.1**	**20.86**

Fluctuation of edaphic factors :

Soil factors in the study sites exhibited fairly wide range of variation during different months of the year (Fig. 2). The lowest soil temperature was 1°C during January at Sandakphu and highest was 27°C during May and September at Sukna. The relative humidity (%) of these study sites varies from 58% to 89%. The maximum relative humidity was recorded during the month of July at Sandakphu and minimum in the month of January at Sukna. The moisture content of soil being maximum (56.51%) in July at Sandakphu and minimum (10.62%) in February at Sukna. The electrical conductivity (EC) of soil varied from 0.22 in November at Sukna to 0.96 in November at Kurseong. The soil pH varied from varied from 5.97 in January at Kurseong to 4.18 in April at Sandakphu. The content of soil organic carbon (%) varied from 2.69 to 5.01. The content of soil organic carbon (%) was maximum in December at Kurseong and was minimum in July at Sandakphu.

DISCUSSION

The soil arthropods collected in this study shows that the Arachnida population (48.23%) was maximum followed by Hexapoda (47.96%) and lowest population was found in case of Crustacea (1.27%). All the four classes of soil arthropod fauna showed their gradual decrease of number with the increase of altitude except class Arachnida which exhibit their minimum populations in the site C (Table 4).The soil insects are highly abundant at lower altitudinal site than the sites at higher altitude (Fig. 3).

It is also observed that sites A, B, C and D of Darjeeling Himalaya represented respectively by 30.3%, 26.96%, 21.86% and 20.86% individuals of the total soil microarthropods community (Fig. 4) and gradually their abundance (%) decreases with the increase of altitude. The minimum and maximum abundance (%) of soil arthropods varied from one altitudinal site to another altitudinal site as well as varied with the months. In the site A and B minimum population were observed in the month of May when moisture content and organic matter were also low and similar results were also obtained by Hazra and Choudhuri (1983), Mitra *et al.*, (1977) in plains of West Bengal, India. The population maxima were obtained from these two sites in the month of December when the soil parameters were found to be optimum condition. In the month of December population maxima was also obtained by Hazra and Sanyal (1996) in an alluvial island in West Bengal, India. The population minima in the site C and D were in the month of July. These two sites are on high hill slopes and due to high precipitation rate resulting to drainage of soil nutrients. As a result values of edaphic factors like organic carbon were also at lower level during this period. The population maxima in the Site C and D were in the month of March when temperature was not so cold and other edaphic factors were also present in optimum level. These results coincide with the finding of Mukherjee and Banerjee (1993), Ghosh and Roy (2004).

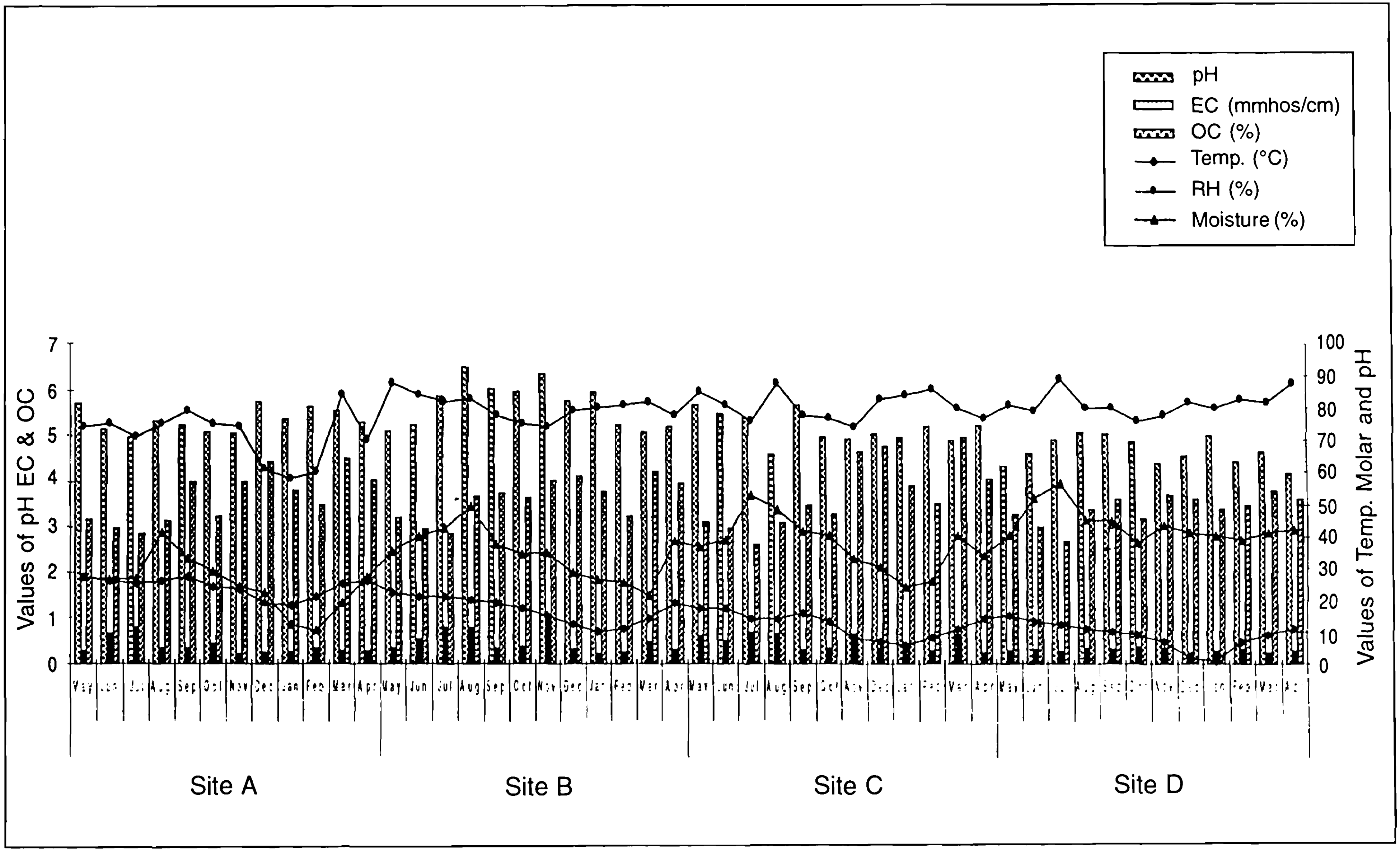

Fig. 2 : Monthly fluctuation of edaphic factors at four different altitudinal sites of Darjeeling Himalaya, India.

Table 4 : Class wise abundance (%) of soil arthropods in four altitudinal sites of Darjeeling Himalaya, India.

Classes	Sites [altitude]			
	A [161 m]	B [1478 m]	C [2573 m]	D [3636 m]
Arachnida	13.87	13.09	10.39	10.88
Hexapoda	14.97	12.55	10.66	9.78
Myriapoda	0.8	0.95	0.51	0.22
Crustacea	0.63	0.36	0.26	0

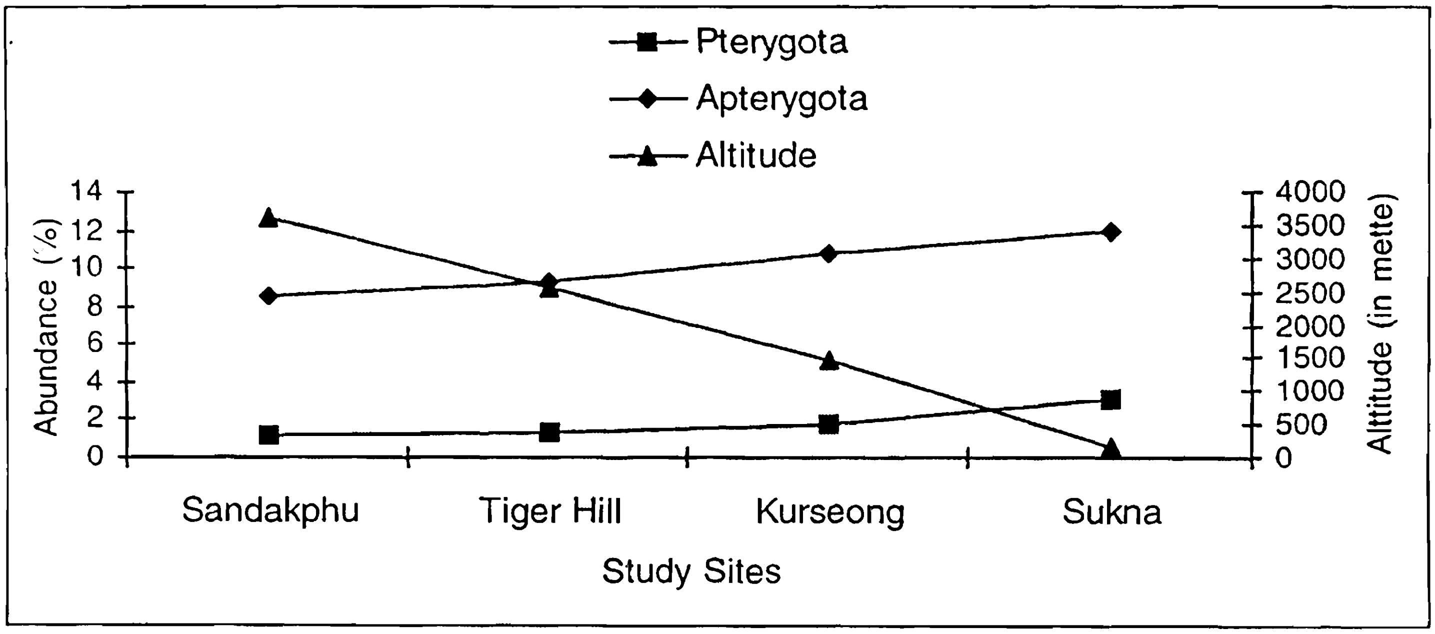

Fig. 3 : Showing the abundance (%) of the subclass Pterygota & Apterytoga in relation to altitude of four altitudinal sites of Darjeeling Himalayas, India

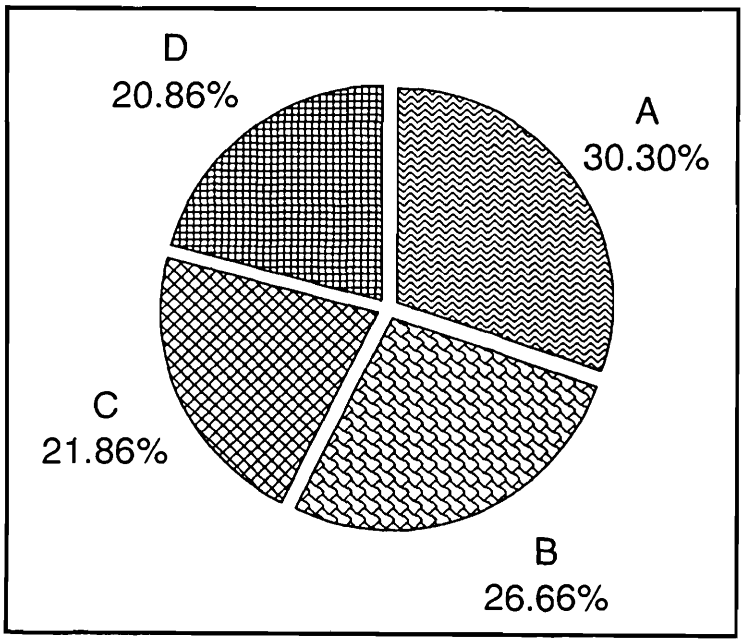

Fig. 4 : Distribution of soil arthropod community in different altitudinal sites of Darjeeeling Himalayas, India.

It is evident from the Table 5 that group diversity increases with the decrease of altitude when group diversity index as determined by Shannon's method is applied. This is substantiated by the occurrence of different number of groups (orders) in these sites and the group diversity index increases with the addition of groups and with increasing evenness. Only 7 orders of soil arthropods were found in Sandakhphu [$H'(G)_y$ = 1.0124] and 8 orders of soil arthropods found in Tiger hill site [$H'(G)_y$ = 1.1734] and 9 orders of soil arthropods found in Kurseong [$H'(G)_y$ = 1.2926] and 10 orders of soil arthropods found in Sukna site which showed higher diversity index value [$H'(G)_y$ = 1.421] (Table 4). β-diversity between the sites suggested that site A and B had maximum similarity of the soil arthropod fauna and minimum similarity between site C and D (Table 6). This might be due to changes in micro climatic conditions in different altitudes of Darjeeling Himalaya.

Table 5 : Group diversity index of soil arthropods, measured by $H'(G)_y$, the Shannon index, increases with the addition of groups and with increasing evenness, measured as $H'(G)_y/H_{max}$ in four altitudinal sites of Darjeeling Himalaya, India.

Sites	$H'(G)_y$	H_{max}	E
A	1.421	2.30259	1.6204
B	1.2926	2.1972	0.5882
C	1.1734	2.07944	0.5642
D	1.0124	1.945356	0.5204

Table 6 : Sorenson's coefficient of similarity of soil arthropods diversity between different altitudinal sites of Darjeeling Himalaya, India.

Sites	B	C	D
A	94.73	88.88	70.58
B		82.35	75
C			66.66

Different soil factors like temperature, relative humidity (RH), pH, moisture, organic carbon (OC) and electrical conductivity (EC) in the study sites exhibited fairly wide range of variation during different months of the study period (Fig. 4). Throughout the period of study the average temperature of soil in these four sites exhibited a decline with increase of altitude (Table 7). In this study the population density of soil arthropods in higher altitudinal sites attained their peak during March when the temperature was moderate. The soil temperature showed a negative significant correlation with the soil arthropod population (Table 7). This result also coincided with the earlier result of Hazra and Choudhuri (1983), Ghosh and Roy (2004).

The mean moisture content of soil in each site showed wide range of variation and exhibited a higher value with altitude (Table 7). In plain areas moisture played a positive correlation with the soil arthropod population as reported by earlier workers like Hazra and Choudhuri (1983) and Mitra (1993). But in this present investigation of the study a negative correlation between the soil

Table 7 : Showing the mean and correlation of soil factors with the soil arthropods in four study sites of Darjeeling Himalaya, India.

Sites	Parameters	Mean	*r'* value of microarthropods	Remarks
A	Temperature (°C)	23.91	−0.645583971	*
	Moisture (%)	24.88	−0.583717762	*
	RH (%)	71.33	−0.369615209	ns
	pH	5.33	0.240817238	ns
	EC (mmhos/cm)	0.375	−0.176646705	ns
	OC (%)	3.63	0.57947287	**
B	Temperature (°C)	16.75	−0.649963102	*
	Moisture (%)	34.41	−0.576778652	*
	RH (%)	80	−0.617493204	*
	pH	5.68	0.0395285	ns
	EC (mmhos/cm)	0.478	−0.031929639	ns
	OC (%)	3.55	0.737868705	**
C	Temperature (°C)	12.08	−0.620260423	*
	Moisture (%)	36.76	−0.56273687	*
	RH (%)	80.75	−0.063855101	ns
	pH	5.17	−0.443703159	ns
	EC (mmhos/cm)	0.474	−0.449621281	ns
	OC (%)	3.67	0.736948296	**
D	Temperature (°C)	8.91	−0.577009981	*
	Moisture (%)	43.70	−0.623833061	*
	RH (%)	81.58	−0.147758561	ns
	pH	4.67	−0.15677827	ns
	EC (mmhos/cm)	0.31	−0.303788862	ns
	OC (%)	3.39	0.886686806	***

* = $P < 0.05$; ** = $P < 0.01$; *** = $P < 0.001$; ns = not significant

arthropod population and moisture contents was noticed in the study sites (Table 7). Such a negative correlation was earlier witnessed by Dhilon and Gibson (1962), Hazra (1978), Mukherjee and Banerjee (1993), Ghosh and Roy (2004). As altitude increases, the requirement of moisture from the soil of these arthropods is reduced due to cold climatic condition.

In this study, the soil EC did not exhibit wide range of variation with the change of season and possibly did not have a significant impact on population fluctuation.

The soil pH has been found to be strongly associated with soil arthropod distribution (Van Straalen and Verhoef, 1997 and Loranger *et al.*, 2001). In the present study, as expected from the nature of the parent rock (mainly granite or gneiss), the soil pH of all the samples was very low. In general acidity of the soil led to differentiation of humus type and thus the occurrence of Collembola and other soil arthropods has often been related to humus form (Schaefer and Schauermann, 1990). The occurrence of soil arthropods in slightly acidic soil as observed in this study confirmed to the earlier reports made in relation to mites (Chaudhuri and Pande, 1979).

Though the average RH (%) of each study site increased with the increase of altitude, but except in site B, the RH did no show any significant correlation with soil arthropods in these altitudinal sites (Table 7).

The organic carbon (%) exhibits a strong positive correlation with the soil arthropod population (Table 7). The soil organic matter not only served as a source of food for soil arthropods but also influenced the amount of living space required by them. The increase in soil arthropod population with the increase in organic matter of soil as encountered here as reported by Haarlov (1960), Christiansen *et al.*, (1961), Hazra (1978), Hazra and Choudhuri (1983), Mukherjee and Banerjee (1993), Ghosh and Roy (2004).

It can be concluded from the present investigation that low altitude, optimum quantity of rain fall, relatively higher soil temperature and less acidic soils perhaps the important reasons for supporting a diverse group of soil fauna in Sukna [$H'(G)_y$ = 1.421] than in high altitudinal sites like Kurseong [$H'(G)_y$ = 1.2926] Tiger Hill [$H'(G)_y$ = 1.1734] and Sandakhphu [$H'(G)_y$ = 1.0124]. However, the definite role of altitude on the population structure of soil fauna in the Darjeeling Himalayas can only be made when each species will be studied in laboratory condition which is under progress.

SUMMARY

The soil arthropod fauna in four different altitudinal sites, A (161m), B (1478 m), C (2573 m) and D (3636 m) in the Darjeeling Himalaya, West Bengal, India have been studied. The aim of the present study was to investigate the distribution, dominance and diversity of soil arthropod communities in these altitudinal sites; to observe the altitudinal variation in faunal composition and obtain a record of their seasonal abundance; to ascertain the impact of altitude and some important edaphic factors on the soil arthropod communities; and also to compare similarity and equitability of different groups of soil arthropods in different altitudinal sites. A total of 4079 examples of soil arthropod fauna belonging to 4 classes and 11 orders have been recorded. From a total of 1957 soil insects, over 84% belonged to the subclass Apterygota and remainder to the subclass Pterygota. The majority of apterygotes are Collembola and most of the pterygotes are endopterygotes. Among 1938 examples of arachnids, over 98% belonged to the order Acari. The abundance of soil arthropods belonging to order Acari (47.04%) followed by Collembola (38.68%) are found to be maximum in all the sites. The order Diptera has minimum dominance (0.26%). The site A shows maximum richness in faunal diversity in comparison to other three sites. The soil arthropod population shows irregular trends of fluctuation in different altitudinal sites during one year study, being maximum in December (in site A and B) and March (in site C and D) and minimum in May (in site A and B) and July (in site C and D). Of the six edaphic factors studied only organic carbon shows positive correlation, while soil temperature and moisture exhibit negative correlation with soil arthropod population in all the sites. Group diversity index analyzed indicate a more diverse soil arthropod community in site A and group diversity increases with the decrease of altitude. â-diversity between the sites indicate that site A and B had maximum similarity of the soil arthropod fauna and minimum similarity between site C and D. The over all observation reveals that the order wise faunal abundance, diversity and distribution of soil arthropods decrease with the increase of altitude.

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