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STUDIES ON DIVERSITY AND DISTRIBUTION OF COLLEMBOLA IN THE MAN MADE FOREST ECOSYSTEM AT BIBHUTI BHUSHAN WILD LIFE SANCTUARY, PARMADAN, NORTH 24 PGS. DISTRICT, WEST BENGAL

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INTRODUCTION

The collembolans are small, entognathous, wingless insects possessing a spring-like forked jumping organ, the furcula underneath the fourth abdominal segment. They are minute in size (less than 6 mm in length); antennae primarily with 4 segments. The presence of antennae and absence of cerci distinguish them from the other entognathous hexapods. The collembolans have very diverse distribution occurring in all Zoo-geographical regions of the world inhabiting a wide range of ecological niche and climate. It includes a variety of habitats where they feed as scavengers on decaying vegetation and soil fungi even occurring in the vicinity of both south and north poles upto 83° south latitude in Antarctica. The collembolans are major components of terrestrial ecosystems (and particularly significant members of the soil communities), constituting a significant proportion of the animal biomass reaching densities of 200 to 1800 individuals per dm3, densities surpassed by the Acarine soil population (Handschin, 1955).

Diem (1903) was first attempt to study the soil fauna in the Alpine soil. There after a series of workers have published on ecology of collembola of different ecosystems in India and abroad *viz,* McAtee (1907), Agrell (1941), Gisin (1943 & 1955), Weis-Fogh (1948), Macfadyen (1952, 53 & 54), Murphy (1953), Haarlov (1955 &1960), Sheals (1956 & 1957), Chritiansen et al (1961 &1964), Choudhuri (1961-1983), Poole (1961), Dhilllon and Gibson (1962), Dunger (1962), Davis (1963), Clark (1965 & 1967), Hale (1967), Prabhoo (1967,71a,b,c & 76a,b), Rappoport (1967), Gujarathi (1968), Wallwork (1970), Mukherjee and Singh (1970), Curry (1971), Nijima (1971), Ashrof (1971), Singh and Mukherjee (1971 & 1973), Anderson and Healey (1972), Edwards and Lofty (1973), Choudhuri and Banerjee (1975), Singh and Pillai (1975), Gupta and Mukherjee, (1976), Crossley (1977), Singh (1978), Hazra *et al* (1976-2003), Mitra *et al* (1977-2002), Takeda (1978), Joose and Buker (1979), Bhattacharyya and Roychoudhuri (1979), Greenslade (1981), Hagvor (1982), Parkinson (1983), Bisht and Chattoraj (1986), Guru, Panda and Mahapatra (1988), Amelsovoort *et al* (1988), Veeresh (1990), Guru and Das (1991 & 91a), Sengupta and Sanyal (1991), Pal, Chottopadhyay and Roy (1992), Chakraborty and Bhattacharya (1992).

Added to this, there is growing evidence of interest from Indian workers as indicated by the proceedings of two national symposia *"Soil Biology and Ecology in India"* (Edwards & Veeresh, 1978) and *"Progress in* Soil *Biology and Ecology in India"* (Veeresh, 1981), followed by *"Applied Soil Biology and Ecology"* (Veeresh & Rajagopal, 1983) and *"Advances in Management and Conservation of Soil Fauna"* (Veeresh *et. al.* 1991), signaling the gradual maturity of soil faunal studies in India. These publications attempted to bridge the gap in the knowledge on soil biology and ecology in this country, which is, as yet insignificant compared to her vast landscape variation and severe pressures on fragile soils. Added to this venture was the launching of the *Indian Journal of Soil Biology and Ecology* in 1981.

Qualitative and quantitative studies of soil fauna, particularly the micro-arthropods from Indian soils began from the mid-sixties, although ecological studies were initiated much earlier (Trehan, 1945). However, major contributions have been from the agricultural fields, grasslands, abandoned fields and tea gardens, and very few from tropical rainforests. While the microarthropod studies from various forest floors

included those of Banerjee (1972), Hazra (1978), Annadurai *et al.* (1988), Reddy & Reddy (1996), Bisht & Chattoraj (1998). And reports from tropical forest soil and litter microarthropods are limited to the works of Singh & Singh (1975), Prabhoo (1976), Hazra (1982), Badejo & Straallen (1993), Straalen (1997), Hazra & Bhattacharyya (2003), Ghosh and Roy (2005), Hazra & Mandal (2007), Mandal *et al.* (2002, '04, '07, '09 & '10). Most of the recent literatures on Indian soil fauna are again from the agricultural fields.

From the above literature it was assumed that the research works on Soil-Biology have tried to assess the impact of different biotic and abiotic factors on the distribution and diversity of soil mesofauna with special reference to Collembola. The present project is taken to enrich the knowledge of Indian springtails and the role of edaphic factors like- Soil Temperature, Moisture, Hydrogen Ion Concentration (pH) and Organic Carbon on the distribution of soil micro-arthropod fauna specially Collembola in a forest ecosyetem.

OBJECTIVES OF THE STUDY

1. To inventories the below ground diversity of soil micro-arthropod fauna with special reference to Collembola.
2. To study the seasonal abundance and species diversity of Collembola fauna of that area.
3. To evaluate the role of edaphic factors like–Soil-Temperature, Moisture, Hydrogen Ion Concentration (pH) and Organic Carbon on the distribution of soil micro-arthropod fauna specially Collembola.
4. To know the relationship between soil parameters and soil micro-arthropod fauna especially Collembola will be analyzes statistically.

METHODS OF SAMPLING

Soil samples were collected at random at the rate of 3 samples per plot (in the four sampling site) every three month (Quarterly) during July, 2007 to December, 2009. Samples were drawn by using of a stainless steel corer (inner cross-section diameter 8.5 sq. /cm) from a depth of 5 cm. Separate soil samples units (500 gram) were taken from each site (2 packet from each site) for collection of collembolan and estimation of soil parameters like- moisture, pH, organic carbon etc. were kept immediately in sterile polythene packet in 4° C in the laboratory for estimations of soil parameters.

A total 96 sample units of core and 64 samples units of packet soil were collected and examined during the 30 months study period. All the samples collected were immediately transferred to polythene packets and labeled, taking as much as possible to prevent loss of moisture. The labeled samples were brought to the laboratory for extraction within 24 hours of their collection.

EXTRACTION OF COLLEMBOLA

Extraction of soil samples were carried out by "Expedition Funnel Apparatus" modified by Macfadyen (1953) with a 40-watt bulbs for providing heat and light. The extraction period varied from 36 hrs to 72 hours depending upon the moisture content of the soil sample (Plate 1 & 2).

ANALYSIS OF EDAPHIC FACTORS

Soil samples dried in a hot air oven at about 105°C for further bacterial action (some samples were kept separately for the estimation of soil moisture) were then allowed to cool and stored in a dessicator and dried soil was passed through the 2 mm sieve, mixed and fractionated before analysis.

Temperature

Soil-thermometer was put in use to record the temperature of the soil at 5cm depth and the temperature of air, one meter above ground level.

Moisture

Moisture of the soil sample measured by the 'Oven Dry Method' (Dowdeswell, 1959) and has been expressed in percentage of the weight difference before and after drying soil sample at 105°C for four hours.

Hydrogen Ion Concentration (pH)

A soil suspension was prepared in a glass bottle with stopper in which one part of soil was mixed with five parts of de-ionized double distilled water and was shaken in a mechanical shaker for one hour and the ratio was determined after CSIR (Piper, 1942) before taking the reading of the pH of the soil solution electronic pH meter, "WTW-pH 320" after standardizing the instrument each time with a standard Beckman buffer solution for avoiding the instrumental error.

Organic Carbon

Organic Carbon content of the soil was determined by 'Rapid Titration Method' (Walkely and Black, 1934). % C =3.951/g (1-TS). Organic matter of the soil (1 gm) was digested with excess 1 (N) K2Cr2O7 and conc. H_2SO_4 and the residual utilized dichromate is then titrated with 1(N) Fe (NH4)2SO4 using diphenyle amine indicator.

LOCATION OF STUDY AREA

Bibhutibhusan Wildlife Sanctuary is located at Parmadan in North 24 Parganas District of West Bengal. It is named after Bibhuti Bhushan Bandopadhyay, a great writer. Spread out over 640 hectares of forestland, the park lies on the banks of Ichhamati River. The highlight of the sanctuary is spotted deer. Monkeys and birds can also be seen. Children's park and the mini zoo are nearby. The sanctuary is also known as Parmadan Deer Park and is around 120 km north-east of Kolkata. It is about 30 km from Bangaon city of North 24 pgs. It is a man made forest named as Bibhuti Bhushan Wild Life Sanctuary (B.B.W.L.S), Parmadan.

LOCATION OF STUDY SITE

The total area of the Bibhuti Bhushan Wild Life Sanctuary (B.B.W.L.S) has been selected four sites, three sites are from core area which was surrounded by fencing and the core area was totally undisturbed. The other site is on the bank of Ichamoti River under the buffer area which was semi-disturbed. The names of these four sites are - Site I : 100 meters from main entry gate of the core area towards south near three Arjun tree. Site II : Beside three uprooted logs, path no.1, and 100 mts from site 1, towards East. Site III: Four way crossing path, 200mts from second site, towards Western side. Site IV : Embankment of Ichamoti River, Bibhuti Bhushan Sanctuary.

OBSERVATION

SITE WISE ANALYSIS OF COLLEMBOLAN FAUNA

The present investigation involves extraction of soil micro fauna from the sampling plots in four different sites such as :

Site I : 100 meters from main entry gate of the core area towards south near three Arjun tree.

Site II : Beside three uprooted logs, path no.1, and 100 mts from site 1, towards East.

Site III : Four way crossing path, 200mts from second site, towards Western side.

Site IV : Embankment of Ichamoti River, Bibhuti Bhushan Sanctuary.

SITE-I : 100 METERS FROM MAIN ENTRY GATE OF THE CORE AREA TOWARDS SOUTH NEAR THREE ARJUN TREE

Location and Characteristic of sampling site-I :

This locality was situated 100 meters from main entry gate of the core area of the sanctuary covered by fencing. Soil was humid and alluvial in nature. Annual rainfall of the site and its surroundings ranges from 77-84 cm and the forest comprises major trees like, *Terminalia arjuna, Shorea robusta, Tectona grandis, Ficus religiosa, Mangifera indica* and *Azadirachta indica* under growths like, *Sporobolus diander, Dichanthium annulatum, Eragrostis brachyphylla, Digitaria marginata, D. royleana, Euphorbia hirta and Lanatana camara.* The samapling site was

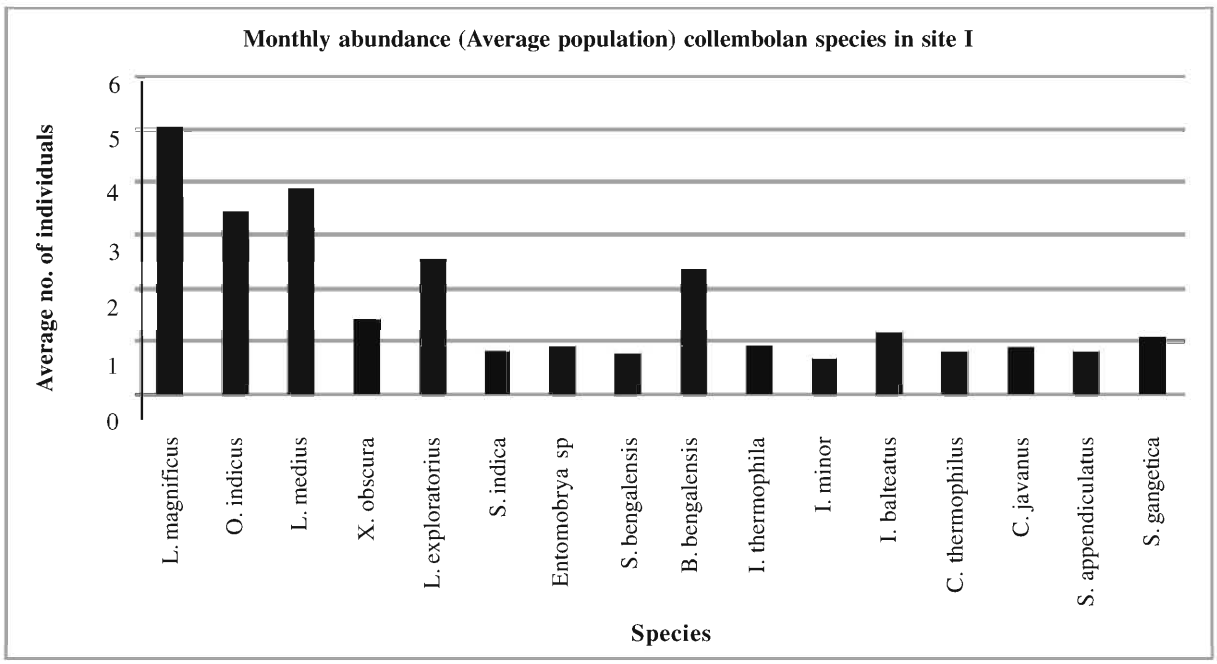

Fig. 1 : Monthly abundance (Average population) collembolan species in Site-I.

Table-1 : Values of edaphic factors per month (July, 2007- Dec, 2009) at site I, B.B.W.L.S, Parmadon

Year	Month	Temperature (0°c)	Moisture (%)	pH	Organic carbon (%)
2007	JUL	32.5	33	6.5	3.63
	AUG	30.5	35	6.1	3.95
	SEPT	31.2	33.5	6.5	3.66
	OCT	31	31.5	6.6	2.35
	NOV	29.5	30	6.4	3.52
	DEC	26	29	6.3	3.3
2008	JANU	19	28	6.4	3.4
	FEB	21	27.5	6.4	2.9
	MAR	26	29	6.3	2.7
	APRL	34	28	6.5	1.5
	MAY	35.5	25.5	6.9	1.3
	JUN	30	31.9	6.8	2.7
	JUL	30.5	33	6.2	3.9
	AUG	32	34.5	6.1	4
	SEPT	30	33	6.3	3.75
	OCT	28	31	6.5	3.2
	NOV	25	30	6.2	2.8
	DEC	23.5	28.5	6.1	3
2009	JANU	20	27.5	6.3	3.23
	FEB	21	27	6.5	3
	MAR	28	26.5	6.6	2.66
	APRL	33.5	27	6.8	2.2
	MAY	37	26.5	6.9	1.5
	JUN	33	26	6.5	2.3
	JUL	32	32	6.3	3.7
	AUG	30.5	35.5	6.1	3.95
	SEPT	31.2	33.5	6.5	3.6
	OCT	30	31.5	6.6	3.5
	NOV	28.5	29	6.4	3.6
	DEC	26	28	6.3	3.3

maintained with coverage of litter of the fallen leaves and dried twigs of the above trees.

Soil factors

Soils are alluvial, blackish brown in colour and sandy silt in texture. Mechanical analysis of soil showed maximum percentage of medium silt 33.6% and more or less equal percentage of fine sand and fine silt. During May, soil moisture content was 25.5% in 2008 and 26.5% in 2009. Maximum moisture content in soil (35.5%) was recorded in August, 2009 and 34.5% in the same period of 2008. During May, other soil factors such as temperature, pH and organic carbon were found 35.5°C, 6.9, 1.3%; 37°C, 6.9, 1.5%; in 2008 and 2009 respectively. Mean values of others revealed more or less identical characteristics (Table-1).

Collembolan Fauna

The Collembolan fauna obtained from this site belonged to 16 species in 14 genera. Amongst them, the species *Lepidocyrtus magnificus* was found most dominant and it was (18.5%) of the total fauna recorded from this site. The species *Lepidocyrtus medius* contributed (14.38%), *Onychiurus indicus* contributed (12.9%), *L. exploratorius* contributed (9.2%), *Xenylla obscura* contributed (5.16%), *Ballistrura bengalensis* contributed (7.5%), *Isotomurus balteatus* contributed (4.2%) and *Salina bengalensis* contributed (3.14%). Population of other species from this site was numerically low and highly irregular in distribution pattern in the sampling site. Percentage of springtails was found maximum in August in three consecutive years, which coincided with the maximum concentration

Table-2 : Values of edaphic factors per month (JULY, 2007- DEC, 2009) at site II, B.B.W.L.S, Parmadan

Year	Month	Temperature (0°c)	Moisture (%)	pH	Organic carbon (%)
2007	JUL	31.5	33.7	6.4	3.58
	AUG	30.9	36.5	6.1	3.95
	SEPT	31.2	34	6.3	3.66
	OCT	30	31.5	6.6	2.35
	NOV	28	30	6.4	3.52
	DEC	26.3	29	6.3	3.3
2008	JANU	19.8	27	6.5	3.1
	FEB	21	27.5	6.4	2.9
	MAR	26	29	6.3	2.7
	APRL	32.8	28	6.5	1.5
	MAY	34.5	25.5	6.9	1.3
	JUN	32	28.5	6.8	2.7
	JUL	30	33	6.2	3.9
	AUG	31	34.5	6.1	4.1
	SEPT	30	33	6.3	3.75
	OCT	28	31	6.5	3.2
	NOV	25.6	30	6.2	2.8
	DEC	24	28.5	6.1	2.9
2009	JANU	20.2	27.5	6.3	3.23
	FEB	21	27	6.5	3.12
	MAR	28	26.5	6.6	2.66
	APRL	33.5	27	6.8	2.2
	MAY	36.5	26.5	6.9	1.5
	JUN	34	27	6.5	1.9
	JUL	32	34.5	6.3	3.7
	AUG	30.5	36	6.1	3.9
	SEPT	31	33.5	6.5	3.6
	OCT	30	31.5	6.7	3.5
	NOV	28.5	29	6.4	3.6
	DEC	26	28	6.2	3.3

of soil factors like-moisture, organic carbon and other edaphic factors (Fig. 1).

Seasonal changes

Seasonal changes of each predominant species of Collembola obtained from this site revealed that *Lepidocyrtus magnificus, Lepidocyrtus medius* and *Onychiurus indicus* had reached at its peak in August in both the years, while *Lepidocyrtus exploratorius* showed maximum in January 2008 but 2009 the peak was shifted to December. It is apparently seen that, predominant forms of collembolan obtained from this site exhibited an irregular trend of fluctuation being minimum in April/May/June, slightly higher in December/January/February and higher in July/August/ Sept. In this field, the population peak of other genera/ species varied among the years as well as month of observation due to their irregular occurrence (Fig. 2).

SITE II : BESIDE THREE UPROOTED LOGS, PATH NO.1, 100 MTS FROM SITE 1, TOWARDS EAST.

Location and Characteristic of sampling site-II :

This locality is situated about 100 meters from the previous locality towards south of the core area of the sanctuary. There are few uprooted logs present in that area and underneath the logs large nos. of fungal combs were growth. The locality was also covered with large numbers of tall trees along with some herbs and shrubs. Soil was humid and large nos. of decomposed leaves was present.

Soil factors

Soils of the plots were alluvial in nature, blackish brown in colour and sandy silt in texture. Mechanical analysis of soil showed maximum percentage of medium silt 35.6% and more or less equal percentage of fine

sand and fine silt. During May, soil moisture content was 25.5% in 2008 and 26.5% in 2009. The month of August in sampling year showed maximum moisture content in soil (36.5% in 2007, 34.5% in the same period of 2008 and 36% in 2009. During May, other soil factors such as temperature, pH and organic carbon, were found 34.5°C, 6.9, 1.3%; 36.5°C, 6.9, 1.5%; in 2008 and 2009 respectively. Mean values of others revealed more or less identical characteristics (Table-2).

Collembolan Fauna

The Collembolan fauna obtained from this site belonged to 14 species under 12 genera. The species *Xenylla obscura* was the most dominant with 16.4% of the total fauna recorded from this site. The species are, *Lepidocyrtus medius, Onychiurus indicus, Lepidocyrtus exploratorius, Ballistrura bengalensis* and *Isotomina thermophila* which represented 13.58%, 12.94%, 10.76%, 8.97%, and 6.15% respectively. Population of other species from this site was

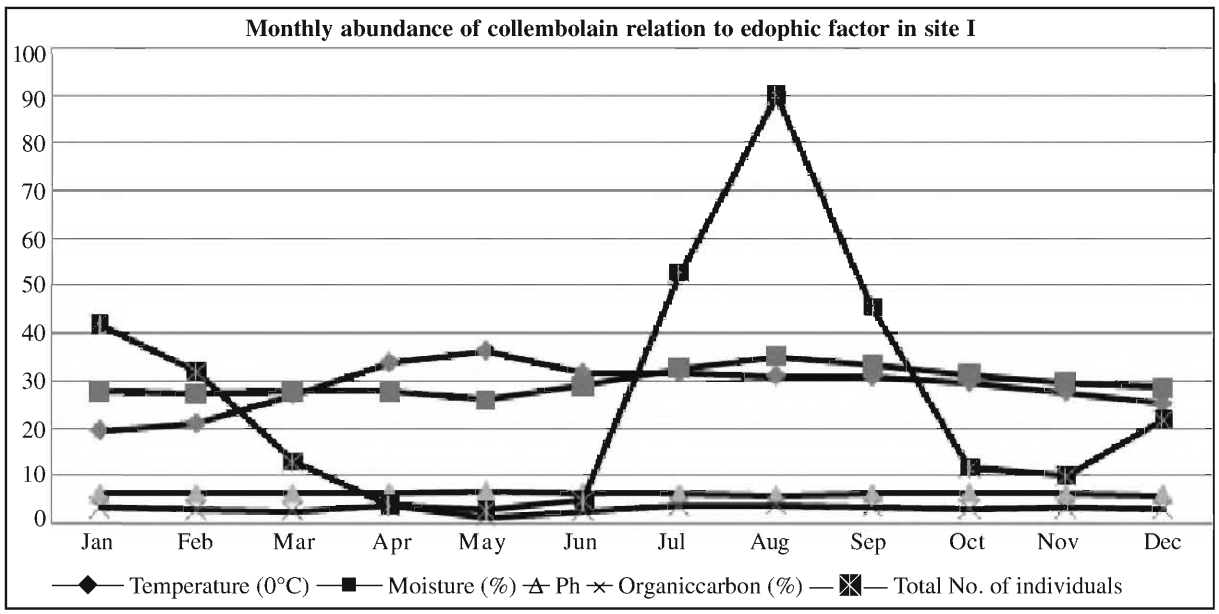

Fig. 2 : Monthly abundance of collembola in relation to edaphic factor in site-I.

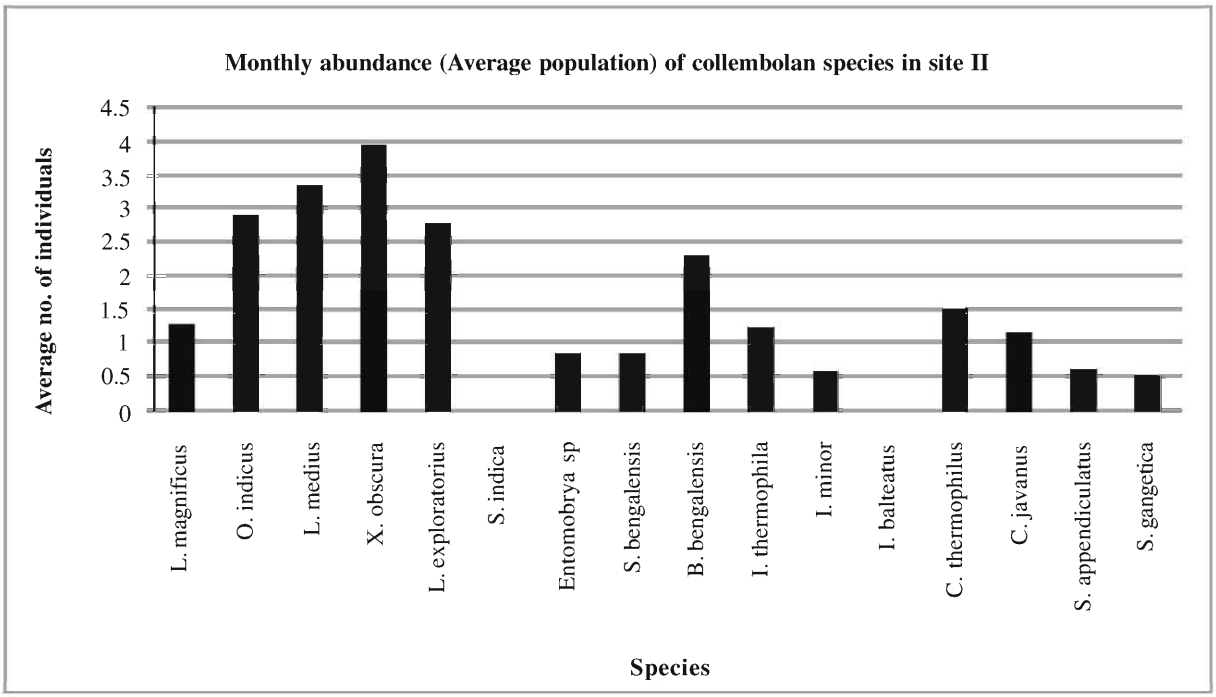

Fig. 3 : Monthly abundance (Average population) collembolan species in Site-II.

numerically low and highly irregular in distribution pattern. The population of collembola was found maximum in the month of August in both the year, which coincided with the maximum concentration of soil factors like moisture, pH and organic carbon. Partial increase in population in December- January as obtained in this site might be due to prevalence of winter maxima resulting from increased population of some species of collembolan as evident (Fig. 3).

Seasonal Changes

Number of each predominant species of collembolan insects obtained from this site revealed that *Xenylla obscura* and *Onychiurus indicus* indicating single peak in August in both the year (2008 and 2009) while *Lepidocyrtus medius* showed its peak in December, 2008 but in 2009 the peak shifted to February. *Lepidocyrtus exploratorius* and *Ballistrura bengalensis* exhibited highest peak in January (2008 & 2009) in both the year. It became apparently evident that predominant formed of collembolan obtained in this site exhibited an irregular trend of fluctuation The population maxima of other genera and species varied during the years as well as months of observation due to their irregular occurrence in this field (Fig. 4).

SITE III : FOUR WAY CROSSING PATH, 200 MTS FROM SECOND SITE, TOWARDS WESTERN SIDE.

Location and Characteristic of sampling site-III :

This locality was situated in the four way crossing path of the core area of the sanctuary. The locality was also covered with large numbers of tall trees but not thickly populated. The area also covered with large nos. of tall grasses. The soil was semi-dry and alluvial in nature. The sampling site was maintained with coverage of litter of the fallen leaves and dried twigs of the above trees.

Soil factors

Soils are alluvial, blackish brown in colour and clayey silt to silty in texture. Mechanical analysis of soil showed maximum percentage of coarse to medium silt 36.4% and more or less equal percentage of fine sand and fine silt. During May, soil moisture content was 25.5% in 2008 and 25% in 2009.The month of August in each sampling year showed maximum moisture content in soil (34.5% in 2008 and 35% in 2009). During May, other soil factors such as temperature, pH and organic carbon were found 35°C, 6.9 & 1.3%; 37°C, 6.8 & 1.5% in 2008 and 2009 respectively. The mean values of other factors revealed more or less identical characteristics (Table-3).

Collembolan Fauna

The Collembolan fauna obtained from this site belonged to 12 species under 10 genera. Amongst them, the genus *Lepidocyrtus exploratorius* was found most dominant and it was (23.3%) of the total fauna recorded from this site. The species *Lepidocyrtus medius* was recorded the second dominant (15.94%) of the total fauna recorded from this site. The species *Lepidocyrtus magnificus* represented 12.46%, *Xenylla obscura* represented 12.17%, *Ballistrura bengalensis* represented 9.56%, *Salina bengalensis* was 6.23% and *Cyphoderus javanus* 4.63%. Population of other species from this site was numerically low and highly irregular in distribution pattern in the sampling site. The percentage of springtails was found maximum in August in both the years, and second highest in the month of January in each year which coincided with the maximum concentration of soil factors like-moisture, organic

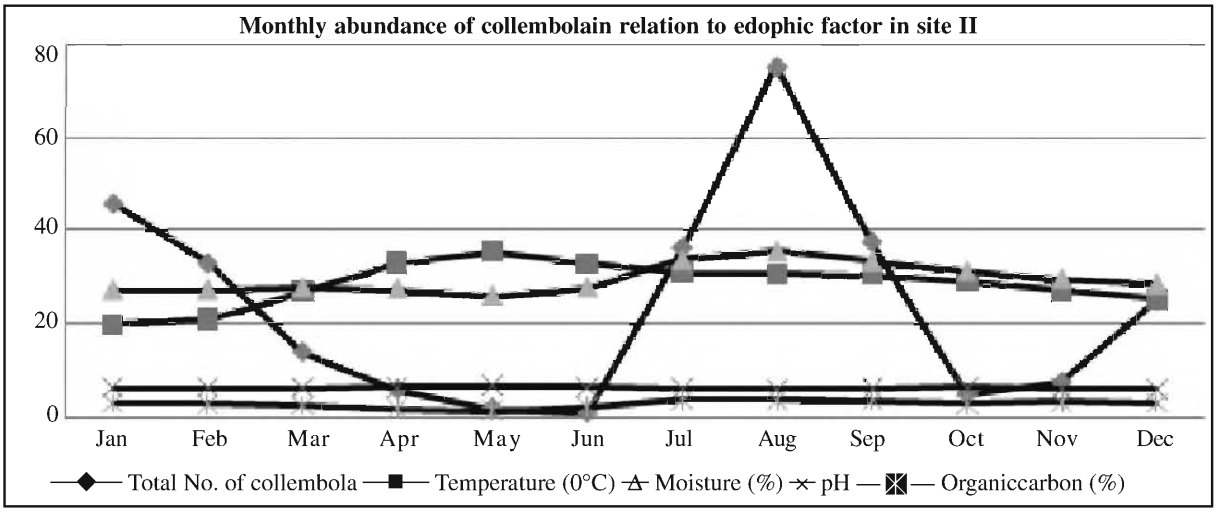

Fig. 4 : Monthly abundance of collembola in relation to edaphic factor in site-II.

Table-3 : Values of edaphic factors per month (JULY, 2007- DEC, 2009) at site II, B.B.W.L.S, Parmadan

Year	Month	Temperature (0°c)	Moisture (%)	pH	Organic carbon (%)
2007	JUL	31.8	32.8	6.5	3.63
	AUG	30.5	34.5	6.1	3.95
	SEPT	31.2	33.5	6.5	3.66
	OCT	31	31.5	6.6	2.35
	NOV	29.5	30	6.4	3.52
	DEC	26	28.5	6.3	3.3
2008	JANU	19	27.8	6.4	3.4
	FEB	21	27.5	6.4	2.9
	MAR	26	29	6.3	2.7
	APRL	34	28	6.5	1.5
	MAY	35	25.5	6.9	1.3
	JUN	30	31.9	6.8	2.7
	JUL	30.5	33	6.2	3.9
	AUG	32	34.5	6.1	4.1
	SEPT	30	33	6.3	3.8
	OCT	28	31	6.5	3.2
	NOV	25	30	6.2	2.8
	DEC	23.5	28.5	6.1	3.1
2009	JANU	20	27.5	6.3	3.23
	FEB	21	27	6.5	3
	MAR	28	26.5	6.6	2.7
	APRL	33.5	27	6.8	2.2
	MAY	37	25	6.8	1.5
	JUN	33	26	6.5	2.3
	JUL	32	32	6.3	3.7
	AUG	30.5	35	6.1	3.95
	SEPT	31.2	33.5	6.5	3.6
	OCT	30	31.5	6.6	3.5
	NOV	28.5	29	6.4	3.6
	DEC	26	27.5	6.3	3.3

carbon and minimum value of Ph and temperature (Fig. 5).

Seasonal changes

The seasonal changes in number of each predominant species of Collembola as observed in this site have been shown in figure. The most dominant species *Lepidocyrtus exploratorius* had reached at its peak in August in both the years. *Lepidocyrtus medius* showed its peak in August, 2008 but the year 2009 peak shifted to January. The population density of *Xenylla obscura* was maximum in January 2008 and it remained high during December-January in each year. *Ballistrura bengalensis* and *Isotomina thermophila* showed highest population peak during January in each year where as *Entomobrya sp*, *Cyphoderus javanus* and *Sphyrotheca gangetica* showed highest population peak during August in each year. It became apparent that predominant forms of this site exhibited an irregular trend of fluctuation being minimum in May-June slightly higher in December/January and higher in August-September. The population peak of other genera/species varied among the years as well as month of observation due to their irregular occurrence in this field (Fig. 6).

SITE IV : EMBANKMENT OF ICHAMOTI RIVER, BIBHUTI BHUSHAN SANCTUARY.

Location and Characteristic of sampling site-IV :

This locality was periphery of the river Ichamoti. This site was chosen as an experimental site for collection of soil micro-arthropods fauna because it is semi disturbed by human population. This area is under the buffer zone where large number of tall trees, herbs and shrubs were present. Soil was moist and alluvial in nature.

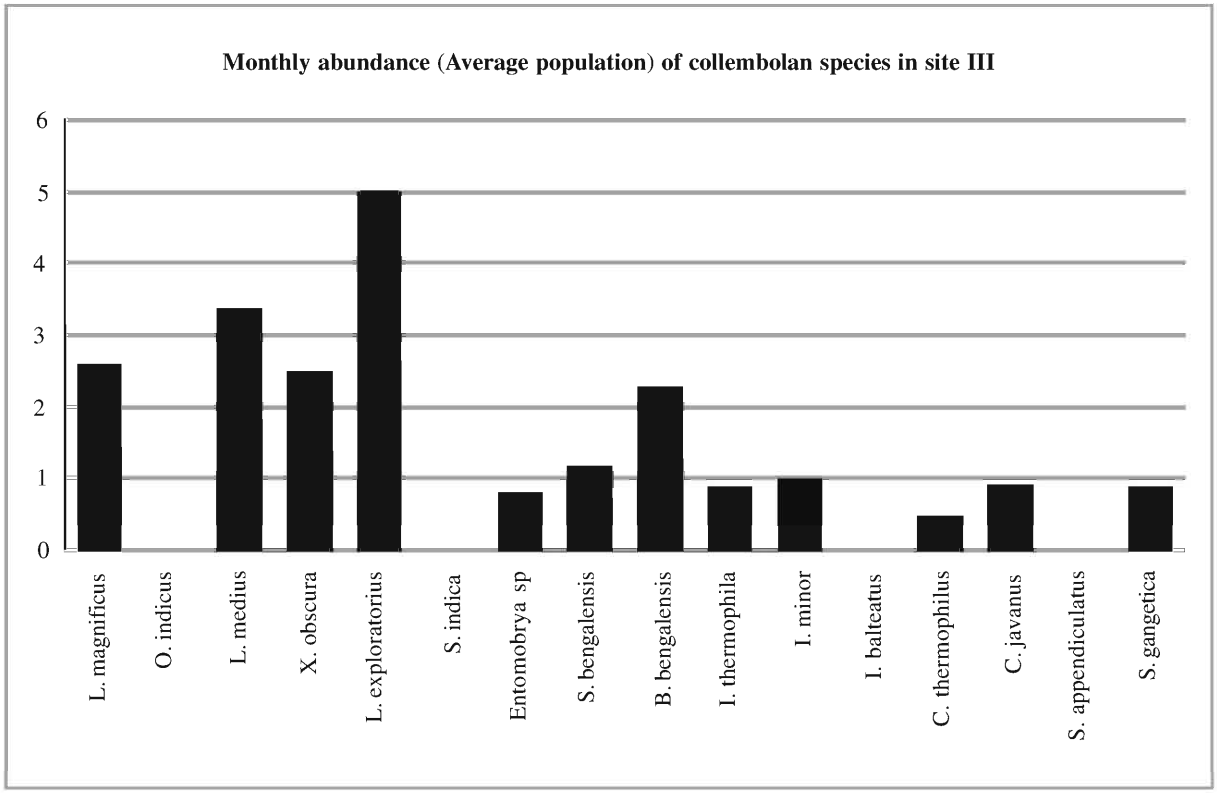

Fig. 5 : Monthly abundance (Average population) collembolan species in Site-III.

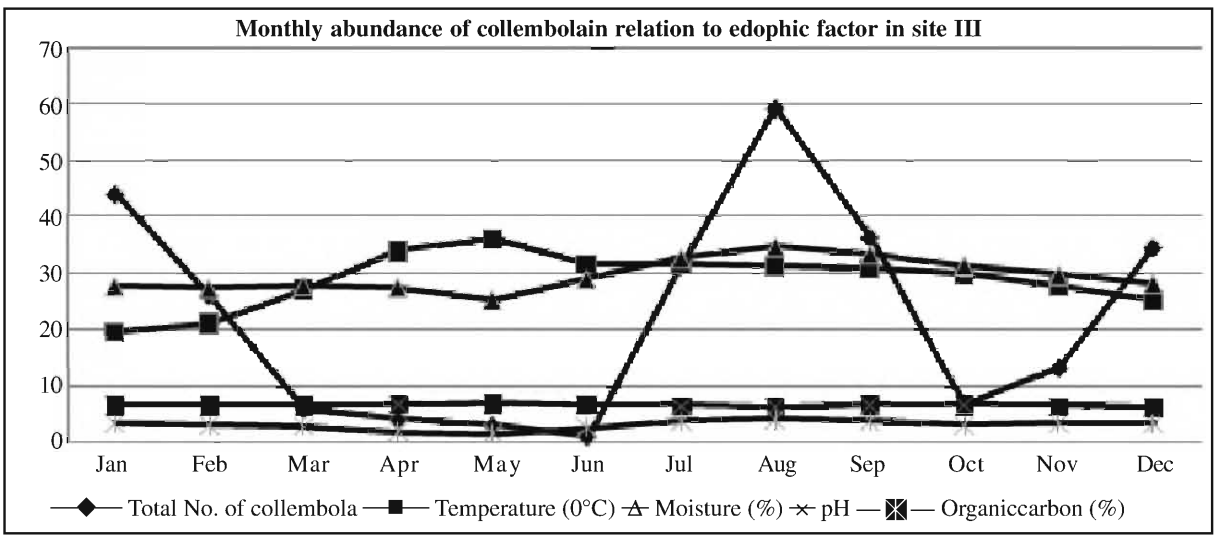

Fig. 6 : Monthly abundance of collembola in relation to edaphic factor in site-III.

Soil factors

Soils of this plot was alluvial in nature, brownish in colour and clayey silt to silty in texture. Mechanical analysis of soil showed maximum percentage of fine silt, the amount being 44.5%. During May, soil moisture content was 25.5% in 2008 and 25% in 2009. Maximum moisture content in soil (35.5%) was recorded in August, 2008; 35% and 34.8% in the same period of 2007 and 2009. Other factors like-organic carbon was found to be maximum in 4% in November, 2009, 3.95% in August, 2007 and 3.8% in the same period of 2008. Mean values of others revealed more or less identical characteristics (Table-4).

Collembolan Fauna

The Collembolan fauna obtained from this site belonged to 10 species under 9 genera. The species *Lepidocyrtus medius* was found most dominant form with 18.46%. The species *Lepidocyrtus magnificus* was

Table-4 : Values of edaphic factors per month (JULY, 2007-DEC, 2009) at site IV, B.B.W.L.S, Parmadan

Year	Month	Temperature (0°c)	Moisture (%)	pH	Organic carbon (%)
2007	JUL	32	33	6.3	3.5
	AUG	30.5	35	6.1	3.95
	SEPT	31	33.5	6.5	3.66
	OCT	30.5	31	6.4	3.5
	NOV	29.2	30	6.3	3.5
	DEC	26	29	6.5	3.3
2008	JANU	20	28	6.4	3.3
	FEB	21	27.5	6.7	2.92
	MAR	29.5	29	6.9	2.2
	APRL	34	28	6.9	2.1
	MAY	34.5	25.5	6.8	1.5
	JUN	32.5	27	6.2	1.3
	JUL	30.5	32	6.1	2.75
	AUG	32	35.5	6.5	3.8
	SEPT	30	33.5	6.6	3.6
	OCT	28	31	6.4	3.75
	NOV	26	30	6.3	3.2
	DEC	22.5	29	6.4	2.8
2009	JANU	21	28	6.4	3
	FEB	22	27	6.5	2.9
	MAR	28.5	29	6.9	3
	APRL	35	28	6.8	2.8
	MAY	37.5	25	6.2	1.6
	JUN	33.5	29.5	6.1	1.3
	JUL	32	33	6.3	2.7
	AUG	30	34.8	6.5	3
	SEPT	31.2	34	6.2	3.9
	OCT	28	31	6.3	3.95
	NOV	27.5	30	6.2	4
	DEC	22.5	28	6.1	3.2

recorded the second dominant 17.69% of the total fauna recorded from this site. The species *Isotomiella minor* contributed 12.11% followed by *Isotomina thermophila* contributed 10.38%, *Ballistrura bengalensis* contributed 9.23%, *Xenylla obscura* contributed 8.07%, *Entomobrya sp* contributed 6.9%, and *Cyphoderus javanus* contributed 6.3%, Maximum percentage of collembolan population was obtained in August of both the years followed by December-January which coincided with the maximum concentration of soil factors like-moisture, organic carbon and low concentration of soil pH (Fig. 7).

Seasonal changes

The month wise changes in abundance of individual predominant species of Collembola recorded from this site have been shown in Fig. Maximum population density of the most dominant species *Lepidocyrtus medius* was December in both the year. The second dominant species *Lepidocyrtus magnificus* exhibited its peak in August in both the years, while the highest population density of *Isotomiella minor* was in February 2008 & 2009. *Isotomina thermophila* showed population peak in November of both the year, where as *Ballistrura bengalensis* exhibited its peak in January of both the year. It became apparent that predominant forms of the site exhibited an irregular trend of fluctuation being minimum in May, slightly higher in December/January/ February and higher in August-September. The peak of population of other genera / species varied among the years as well as month of observation due to their irregular occurrence (Fig. 8).

STATISTICAL ANALYSIS OF DATA

The statistical analysis of the complex soil faunal communities has been conducted to show the

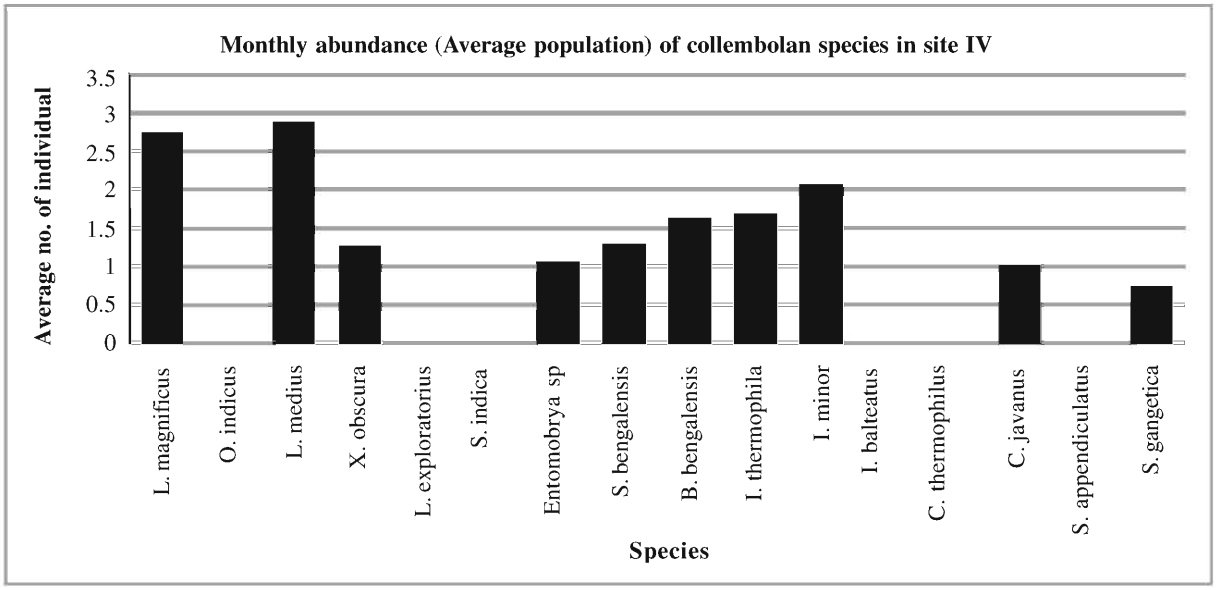

Fig.7. Monthly abundance (Average population) collembolan species in Site-IV.

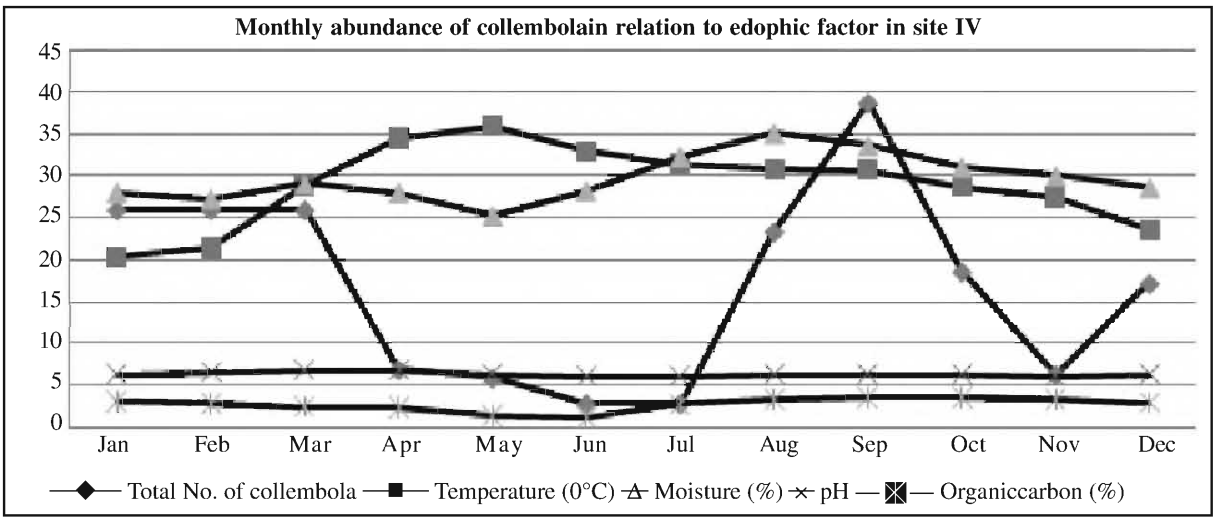

Fig. 8 : Monthly abundance of collembola in relation to edaphic factor in site-IV.

relationship between the soil factors and Collembola. The application of LINEAR CORRELATION and ANOVA (One way analysis) were undertaken in the present study involving the data of soil factors and collembolan population densities of soil separately for each site. All the analysis has been carried out by using MINITAB statistical software.

LINEAR CORRELATION

The correlation coefficient ('r' value) of each variable (i.e. total population of Collembola and four edaphic factors (temperature, moisture, pH, organic carbon) on each other in individual site were shown (Table 5-8). The correlation revealed identical relationship between the biotic variables in four sites. The correlation coefficient data mentioned in the above table broadly indicated that the edaphic factors like moisture, organic carbon with the biotic variables showed strong positive correlation in almost four sites. The correlation coefficient ('r' value) in respect of other variables like - temperature and pH with the biotic variables was found to be negatively significant correlated in all four sampling sites with the population densities of Collembola.

ANALYSIS OF VARIANCE (ANOVA) : ONE WAY ANALYSIS

An univariate analysis of variant with the month as a factor have been carried out whether any significant seasonal fluctuation exist or not in the population of individual species of collembolan in the four sampling sites. The results of analysis are represented in the tables 9-12.

Table-5 : Correlation(r value) between individual collembolan species with edaphic factors at Site-I

Name of the species	Temperature	Moisture	pH	Organic carbon
L. magnificus	-0.180147846	0.828530719	-0.652997651	0.652985415
O. indicus	0.109146027	0.872077366	-0.476077623	0.565049206
L. medius	0.11233319	0.740633265	-0.583840341	0.498988274
X. obscura	-0.1471323	0.6677209	-0.568348	0.5597715
L. exploratorius	-0.4904062	0.1977307	-0.6556189	0.4604979
Seira indica	-0.0113091	0.5849276	-0.6844386	0.479076045
Entomobrya sp	0.073256903	0.6271018	-0.5098721	0.469072044
S. bengalensis	0.1328547	0.760909	-0.6889775	0.5749779
B. bengalensis	-0.5243741	0.0777475	-0.371506	0.2472246
I. thermophila	-0.4010517	0.2774619	-0.6175193	0.427766
I. minor	-0.4397747	0.1281827	-0.3908345	0.2303874
I. balteatus	-0.2558236	0.5459557	-0.6186606	0.5190585
C. thermophilus	-0.2035165	0.2805958	-0.1707681	0.144376
C. javanus	0.312443	0.5646476	-0.2376556	0.1216208
S. appendiculatus	0.1261598	0.6036843	-0.5247406	0.372721
S. gangetica	-0.0889385	0.2606868	-0.04174	0.2815279

Table-6 : Correlation(r value) between individual collembolan species with edaphic factors at Site-II

Name of the species	Temperature	Moisture	pH	Organic carbon
Xenylla obscura	-0.160745935	0.786287817	-0.702520498	0.775227292
O. indicus	0.010067725	0.846771521	-0.645910627	0.749046149
L. medius	-0.713751666	0.235595549	-0.726386647	0.640066048
L magnificus	0.030307095	0.711675122	-0.590427574	0.603337027
L. exploratorius	-0.641062164	0.118584114	-0.562758953	0.435401949
Entomobrya sp	-0.023930549	0.634964027	-0.540389791	0.612977051
S. bengalensis	0.010436281	0.737650625	-0.746756504	0.663690309
B. bengalensis	-0.600913827	0.160241109	-0.485428386	0.449267921
I. thermophila	-0.196002606	0.600050933	-0.616270704	0.618689652
I. minor	-0.0505153	-0.175735766	0.112915938	-0.154284743
C. thermophilus	-0.178304138	0.447560095	-0.49987309	0.485600752
C. javanus	-0.270770226	0.325937808	-0.502561668	0.417739981
S. appendiculatus	0.062358655	0.5653906	-0.476560067	0.41675546
S. gangetica	-0.165588862	0.415864006	-0.337913016	0.440254448

DISCUSSION

The ecological studies of this investigation were based on the sample survey of four sites from Bibhuti Bhushan Wild Life Sanctuary (B.B.W.L.S), Parmadan, over a period of 30 months (July, 2007 to December, 2009). Three sampled sites from undisturbed core area of forest floor site and remaining one from the disturbed area of buffer zone of the sanctuary were chosen for the study. All the sites were in Gangetic plains exposed to tropical climate with humidity and temperature were comparatively low during winter months. The general natures of the soil of four sampling sites were more or less identical.

The Collembolan fauna of the four study sites belonged to 16 species under 14 genera of 5 families :

Table-7 : Correlation(r value) between individual collembolan species with edaphic factors at Site-III

Name of the species	Temperature	Moisture	pH	Organic carbon
L. exploratorius	-0.19972168	0.759832386	-0.64782442	0.766060986
L. medius	-0.22345409	0.675319364	-0.79656544	0.822330775
L magnificus	-0.46728373	0.312762165	-0.82608251	0.663508738
Xenylla obscura	-0.36449774	0.208942839	-0.63706734	0.485379347
Entomobrya sp	0.314452079	0.616396327	-0.44285257	0.454654867
S. bengalensis	0.04499953	0.614285487	-0.788804907	0.673644188
B. bengalensis	-0.573729409	0.052634449	-0.366712885	0.376901917
I. thermophila	-0.404695465	0.252999771	-0.622044443	0.537796337
I. minor	-0.374934492	0.013236549	-0.240146053	0.232201029
C. thermophilus	-0.103092716	0.276730841	-0.034946384	0.24640714
C. javanus	0.052437799	0.397337724	-0.553073922	0.388962368
S. gangetica	-0.431735679	0.129699091	-0.113793406	0.30733033

Table-8 : Correlation(r value) between individual collembolan species with edaphic factors at Site-IV

Name of the species	Temperature	Moisture	pH	Organic carbon
L. magnificus	-0.1769545	0.7930076	-0.1552162	0.6441762
L. medius	-0.5412866	0.3043318	-0.3977079	0.5057319
X. obscura	-0.0129628	0.7109205	-0.1085984	0.4338867
Entomobrya sp	-0.0682902	0.5641524	-0.2329746	0.3258003
S. bengalensis	-0.2913997	0.5334357	-0.1288971	0.45457
B. bengalensis	-0.6259028	0.0705465	-0.0677042	0.2411919
I. thermophila	-0.3531079	0.196177	-0.4460732	0.4604439
I. minor	-0.7241513	0.1795067	-0.1223435	0.1866484
C. javanus	-0.1208675	0.4982095	-0.0322146	0.3499985
S. gangetica	-0.2927487	0.30753	-0.1950678	0.3256444

Hypogastruridae, Onychiuridae, Isotomidae, Entomobryidae and Sminthuridae (Table-13).

The number of genera occurring in four different sampling sites also varied, maximum extracted from the site-I (16 species under 14 genera) and minimum from disturbed area of buffer zone of the sanctuary (10 species under 9 genera). Out of the 14 genera, the predominant genera were *Lepidocyrtus* (3 species), *Onychiurus*(1 species), *Xenylla* (1 species), *Cyphoderus* (1 species), *Cryptopygus* (1 species), *Ballistrura* (1 species), *Isotomina* (1 species) and *Salina*(1 species) *Sphyrotheca* (1 species) and *Sminthurides*(1 species) mentioned in order of dominance.

The genus *Lepidocyrtus* were represented by 3 species like, *L. exploratorius, L. medius* and *L. magnificus*. The genus was found to be widely distributed in all sampling plots comprising 31.8 % of total population of collembola and being numerically dominant over other forms. The wide distribution range and numerical dominance suggest capability of this genus to dwell in varying ecological conditions. The species, *Lepidocyrtus magnificus* was seen the most dominant taxon of this genus and occupied first position in order of dominance in respect to the total number of collembola indicating maximum genera and species in the month of August.

The second predominant genus was *Xenylla* with single species *obscura,* comprising 10.45% of the total population in all the sites. The species was recorded in maximum from the sampling site II reaching its peak in January-February.

The third numerical dominant genus *Cyphoderus* represented by single species *javanus* was extracted in maximum number (9.83%) in February from all the

Table-9 : ANOVA (One way analysis) of the collembolan species in relation to the edaphic factors in Site-I

Species	Temperature		Moisture		pH		Organic carbon	
	F value	P value*	F value	P value*	F value	P value*	F value	P value*
L. magnificus	173.97	0.000	329.54	0.000	1.57	0.224	3.16	0.089
O. indicus	179.63	0.000	316.2	0.000	5.77	0.025	0.09	0.771
L. medius	152.86	0.000	250.17	0.000	3.2	0.088	0.31	0.582
X. obscura	310.76	0.000	788.52	0.000	69.34	0.000	7.08	0.014
L. exploratorius	239.51	0.000	499.66	0.000	18.04	0.000	0.3	0.587
S.indica	358.05	0.000	1056.63	0.000	228.95	0.000	30.13	0.000
Entomobrya sp	334.22	0.000	892.93	0.000	110.23	0.000	15.25	0.001
S.bengalensis	363.33	0.000	1096.81	0.000	288.55	0.000	36.65	0.000
B. bengalensis	218.78	0.000	415.82	0.000	14.44	0.001	0.45	0.507
I. thermophila	348.82	0.000	997.9	0.000	170.54	0.000	22.17	0.000
I. minor	372.73	0.000	1162.82	0.000	454.92	0.000	54.16	0.000
I. balteatus	337.98	0.000	945.8	0.000	132.69	0.000	15.22	0.001
C. thermophilus	364.58	0.000	1111.76	0.000	319.44	0.000	38.87	0.000
C. javanus	358.58	0.000	1068.68	0.000	245.6	0.000	30.8	0.000
S. appendiculatus	324.08	0.000	818.59	0.000	86.02	0.000	13.01	0.002
S. gangetica	342.08	0.000	966.67	0.000	146.49	0.000	17.53	0.000

* < 0.05 significant

Table-10 : ANOVA (One way analysis) of the collembolan species in relation to the edaphic factors in Site-II

Species	Temperature		Moisture		pH		Organic carbon	
	F value	P value*	F value	P value*	F value	P value*	F value	P value*
X. obscura	218.3	0.000	383.15	0.000	6.77	0.016	1.12	0.301
O.indicus	221.66	0.000	372.88	0.000	11.19	0.003	0.000	0.995
L. medius	243.83	0.000	445.81	0.000	12.73	0.002	0.27	0.611
L magnificus	339.52	0.000	710.28	0.000	82.44	0.000	7.36	0.013
L. exploratorius	260.3	0.000	482.12	0.000	19.35	0.000	0.02	0.891
Entomobrya sp	380.08	0.000	866.15	0.000	211.63	0.000	22.15	0.000
S. bengalensis	381.7	0.000	873.42	0.000	223.54	0.000	23.24	0.000
B. bengalensis	246.93	0.000	430.23	0.000	18.31	0.000	0.36	0.553
I. thermophila	347.78	0.000	743.91	0.000	98.11	0.000	8.69	0.007
I. minor	404.57	0.000	969.96	0.000	564.53	0.000	51.88	0.000
C. thermophilus	359.39	0.000	813.46	0.000	148.56	0.000	9.34	0.006
C. javanus	340.48	0.000	708.68	0.000	83.05	0.000	8.11	0.009
S. appendiculatus	358.59	0.000	755.07	0.000	110.49	0.000	14.98	0.001
S. gangetica	400.56	0.000	942.44	0.000	386.96	0.000	42.87	0.000

* < 0.05 significant

sampling sites though the insects were maximum in number in March.

Another dominant genus *Ballistrura* & *Onychiurus* extracted from both the sites and comprised 8.69% and 7.28% of total population occupying fourth position in dominance.

The two genera of collembolan species, *Isotomiella minor* (6.20% of the total population) and *Salina*

Table-11 : ANOVA (One way analysis) of the collembolan species in relation to the edaphic factors in Site-III

Species	Temperature		Moisture		pH		Organic carbon	
	F value	P value*	F value	P value*	F value	P value*	F value	P value*
L. exploratorius	175.22	0.000	399.49	0.000	1.7	0.205	3.39	0.079
L. medius	210.63	0.000	580	0.000	9.04	0.006	0.16	0.693
L magnificus	263.53	0.000	475.51	0.000	25.5	0.000	0.2	0.66
Xenylla obscura	239.21	0.000	882.23	0.000	18	0.000	0.23	0.634
Entomobrya sp	342.42	0.000	879.72	0.000	121.22	0.000	14.93	0.001
S. bengalensis	341.45	0.000	910.86	0.000	132.7	0.000	12.45	0.002
B. bengalensis	223.81	0.000	416.25	0.000	15.47	0.000	0.38	0.546
I. thermophila	353.06	0.000	961.22	0.000	171.69	0.000	18.86	0.000
I. minor	335.71	0.000	855.75	0.000	106.81	0.000	11.98	0.002
C. thermophilus	371.36	0.000	1044.6	0.000	265.82	0.000	34.3	0.000
C. javanus	340.46	0.000	880	0.000	118.72	0.000	13.66	0.001
S. gangetica	338.96	0.000	868.28	0.000	113.49	0.000	13.37	0.001

* < 0.05 significant

Table-12 : ANOVA (One way analysis) of the collembolan species in relation to the edaphic factors in Site-IV

Species	Temperature		Moisture		pH		Organic carbon	
	F value	P value*	F value	P value*	F value	P value*	F value	P value*
L. magnificus	285.08	0.000	692.14	0.000	34.96	0.000	0.03	0.872
L. medius	269.22	0.000	617.08	0.000	24.95	0.000	0.000	0.972
X. obscura	339.15	0.000	898.81	0.000	112.73	0.000	8.83	0.007
Entomobrya sp	353.03	0.000	971.68	0.000	159.75	0.000	14.20	0.001
S. bengalensis	352.08	0.000	991.22	0.000	175.57	0.000	12.49	0.002
B. bengalensis	295.25	0.000	674.91	0.000	45.36	0.000	2.66	0.117
I. thermophila	330.99	0.000	885.95	0.000	100.99	0.000	5.02	0.036
I. minor	306.35	0.000	764.50	0.000	56.41	0.000	1.58	0.222
C. javanus	362.15	0.000	1033.59	0.000	221.85	0.000	19.03	0.000
S. gangetica	381.72	0.000	1155.10	0.000	523.70	0.000	41.45	0.000

* < 0.05 significant

bengalensis (4.80% of the total population) was taken out in maximum numbers of all the sites in August.

The other important genera collected there were, *Entomobrya, Isotomina, Cryptopygus, Seira, Isotomurus, Sphyrotheca and Sminthurides* constituting 3.52%, 3.48%, 3.44%, 2.86%, 2.72%, 2.57%, and 1.95% respectively.

The aforesaid variations of the faunal components might be due to the differences in the ecological conditions with some genera being wide spread occurring regularly in different sampling sites because they could tolerate wide variety of habitats and were aptly called "Ubiquist" or "ecological generalized groups". On the other hand, some forms were localized or restricted to ecological specialized group.

The nine genera of collembolans, *Xenylla, Lepidocyrtus, Salina, Entomobrya, Cyphoderus, Ballistrura, Isotomiella, Isotomina* and *Sphyrotheca* seemed to have wider tolerance to different encountered during the present discourse and they were 'Ubiquists" (Table-14.).

Addison (1980) remarked that such faunal groups had the capacity to utilize different food sources and microhabitat for their survival while five genera namely, *Onychiurus, Seira, Isotomurus, Cryptopygus* and

Sminthurides were said to be restricted and as such they were "Stenocious".

Hazra & Choudhuri (1990) studied the distribution pattern of soil arthropod particularly Collembola and Acari of 14 kinds of ecosystems of West Bengal and found 2 "ubiquists" genera *Lepidocyrtus* and *Cyphoderus* and 23 "Stenocious"species. In another observation Hazra and Sanyal (1996) recorded 4 "ubiquists" species and 11 "Stenocious" species from a deciduous reserve forest floor as well as two mangrove areas (one natural & another artificially raised) in a silt deposited island in the river Hooghly.

In the present study, the total population of collembolan of all the sampling sites showed numerical variation with the change of season with minimum in May in all four sites. Moreover, a general pattern of fluctuation with maximum in monsoon and minimum in pre-monsoon (May), which in agreement with Hazra and Choudhuri (1990) and Hazra & Sanyal (1996).

Mitra *et al.*, (1977) and Hazra and Choudhuri (1990) showed that, surface soil vegetations exert an indirect influence on the collembolan population through its effect on the porosity of soil, humus formation and soil moisture in spite of different vegetation in most of the sampling sites.

According to Wallwork (1970), the Collembolan fauna of certain locality was determined by a complex factor of both ecological and historical. Therefore, the author is of the view that the degree of similarity in species composition between two sites could be used as an index of overall ecological similarity and the influence of vegetation type indirectly exert through its effect on soil type, micro floral composition or soil moisture.

Hagvar (1982) observed increase of number of springtails with the increase of soil fertility in coniferous forest floor but the species diversity and number appeared maximum in medium rich soil. He also measured the fertility-scale in accordance to vegetation types and noted that the soil moisture,the vegetation would better indicate Collembolan fauna in more extreme environmental condition.

Hazra and Sanyal (1996) found increase of the diversity of collembolan members in artificially raised mangrove forest of an island of the river Hooghly (West Bengal) and also said that the number increased with high concentration of moisture and nitrate.

According to Curry (1971) the maximum and minimum population were confined to a particular month or season of the years of observation in particular site which appears similar to the observations of workers in different parts of world. Study of maximum population in all sampling site in August and minimum in May tally with Mukherjee and Singh (1970).

During this investigation, only three predominant species *Lepidocyrtus magnificus, L. medius* and *Isotomurus balteatus* attained maximum population in August and two species, *Xenylla obscura* and in February. *Entomobrya* sp. reached its peak in January followed by *Lepidocyrtus exploratorius, Seira indica, Isotomiella minor, Cryptopygus thermophilus, Cyphoderus javanus* in March while *Sinella curviseta* and appeared largest population in the month of August. Individuals of other species like *Ballistrura bengalensis, Onychiurus indicus, Salina bengalensis, Isotomina thermophila* were numerically low in May with a very irregular trend of fluctuation and these were altogether absent in many of the sampling months. Thus, most of the predominant forms considered here were found to exhibit a single peak in a year.

According to Straalen (1997) some species had a sharp peak of collembolan community in respective months whereas others tend to fluctuate gradually throughout the year. Existence of single peak suggested the probability of single generation per year (Bellinger, 1954 and Hale (1966).

The role of edaphic factors on the distribution and population pattern of different groups of soil inhabiting micro fauna and flora might be assumed that the factors so far analyzed in this study exerted both significant and insignificant effects either singly or in cumulative way depending on the nature of the site. The population was maximum when the factors like moisture, organic carbon were significantly high and other conditions were optimum.

Temperature and soil moisture appeared as the main driving variables for seasonal fluctuation of micro-arthropod population especially in temperature climate with dry summer period (Straalen, 1985, Satamou *et al.*, 1993). In the summer month's soil temperature was significantly high and yielded minimum population on account of lesser water content and physical stability of the humus layer in this type of climate in West Bengal.

Of the edaphic factors studied, temperature showed wide variation with the change of season, ranging between 19°C and 37.5°C (Table-1-4). Collembolan population indicated negative correlation with temperature in all four sites which confirm the study of

Table-13 : Taxonomic status of the Collembolan species from the four study sites of B.B.W.L.S, Parmadon.

ORDER	COLLEMBOLA
Suborder	Arthropleona
Family	HYPOGASTRURIDAE, Borner, 1913
Subfamily	Hypogastrurinae
Genus/species	*Xenylla obscura* Imms, 1912
Family	ONYCHIURIDAE, Borner, 1901
Subfamily	Onychiurinae
	Onychiurus indicus Choudhury & Roy, 1965
Family	ISOTOMIDAE, Borner, 1913
	Cryptopygus thermophilus (Axelson, 1900)
	Ballistrura bengalensis Yosii, 1966
	Isotomurus balteatus (Reuter, 1876)
	Isotomiella minor (Schaeffer, 1898)
	Isotomina thermophila (Axelson, 1900)
Family	ENTOMOBRYIDAE, Tomosvary, 1882
Subfamily	Entomobryinae
	Lepidocyrtus exploratorius Carpenter, 1924
	Lepidocyrtus medius Schaeffer, 1898
	Lepidocyrtus magnificus Carpenter, 1924
	Entomobrya sp
	Seira indica (Ritter, 1911)
Subfamily	Cyphoderinae
	Cyphoderus javanus Borner, 1906
Subfamily	Paronellinae
	Salina bengalensis Mitra, 1966
Sub order	Symphypleona
Family	Sminthuridae
	Sminthurides appendiculatus Imms, 1912
	Sphyrotheca gangetica Yosii, 1966

Pal *et al.* (1992) and Guru *et al.* (1988). Takeda (1978) also found both positive and negative correlation between temperature and different species of springtails. Hazra & Choudhuri (1983) commented that direct influence of temperature on the distribution pattern of Collembola was difficult to evaluate because collembolan are known to withstand a wide range of temperature, as low as -50°C (Paclt, 1956) and as high as 55°C (Dunger, 1964) and made a conclusion that temperature alone did not show significant correlation. Thus it might be noted in this connection that the direct influence of temperature on the distribution pattern of soil arthropods was difficult to evaluate. The actual influence of temperature on the soil-organisms could be evaluated in conjunction with the effect of moisture which recorded minimum in summer thereby yielding low population.

Moisture content was recorded maximum (36%) and minimum (27%) respectively in all four sites and thus a range of variation was observed in two different seasons. The value of correlation of collembola with moisture was highly significant in all four sites (Table 5-8). Mukherjee and Singh (1970), Choudhuri and Ray (1972), Hazra and Choudhuri (1983, 90) and Guru *et al.* (1988) found positive but not significant correlation between the soil organisms and moisture. Choudhuri

Table-14 : UBIQUITUS & STENOCIOUS species of Collembola from the study sites

STENOCIOUS Species (restricted to)			**UBIQUITUS Species (present in all sites)**
SITE I	**SITE II**	**SITE III**	**SITE IV**
Seira indica	*Onychiurus indicus*	*Cryptopygus*	*Lepidocyrtus magnificus*
Isotomurus balteatus	*Sminthurides*	*thermophilus*	*L. medius*
	appendiculatus		*Xenylla obscura*
			Entomobrya sp
			Salina bengalensis
			Ballistrura bengalensis
			Isotomina thermophila
			Isotomiella minor
			Cyphoderus javanus
			Sphyrotheca gangetica

and Roy (1972) and Singh and Pillai (1975) affirmed that soil humidity put its influence on micro-arthropods and collembolan in particular. Highly significant positive correlation with collembola and its monsoon population peak in all sampling sites was similar to Agrell (1941), Poole (1961), Knight (1961), Christiansen *et al.* (1961), Davis (1963), Gupta and Mukherjee (1976), Mitra *et al.*(1977), Hazra and Choudhuri (1981, '83). Haarlov (1960) considered either moisture or organic matters as an important ecological factor in the life of collembola in Danish soil. However, Choudhuri and Roy (1967) and Nijima (1971) reported significant influence of organic matter and soil moisture on the population of Collembola.

According to Singh and Pillai (1975), the ecological parameters like soil temperature, moisture, organic matter and CaCo3 content of soil influence composition of soil fauna either individually or in combination with other. Hazra (1978a, b) and Hazra & Choudhuri (1990) suggested that organic matter and water content of soil together exerted direct or indirect influence on the microbial floral and faunal population by (i) maintaining soil reaction, (ii) controlling humification and (iii) stimulating the growth of micro-macro-flora.

The content of organic carbon varied between 1.3% and 4.1% and exhibited strong positive correlations with the population densities of Collembola in all the sampling sites (Table 5-8). The concentration of large population of flora and fauna in the litter and humus layer suggested their affinity to organic matter. The high temperature and low moisture in the soil seemed to influence the amount of organic carbon as was evident here in summer during when soil contain less amount of organic because of low moisture level and ready oxidation of organic matter.

Another important variable affecting the population fluctuation of soil biota was the soil pH which read minimum of 6.1 and maximum of 6.9 (Table.1-4). However, its average value in four sites did not differ much and was more or less neutral. The statistical analysis showed strong negative correlation with the population densities of Collembola and pH at all four sites which agreed with the findings of Agrell (1941), Bellinger (1954), Choudhuri *et al.* (1978) and Pal *et al.* (1992). According to Hazra and Choudhuri (1983), more or less neutral pH was favorable to soil organisms while Dhillon and Gibson (1962) opined for very little or no direct effect of soil pH on the floral and faunal make up.

SUMMARY

The fauna of the experimental sites belong to 16 species of 14 genera of five families: Hypogastruridae, Onychiuridae, Isotomidae, Entomobryidae and Sminthuridae. Maximum species diversity came in view from the Site-I with 16 species in 14 genera and the minimum in the Site IV with 10 species in 9 genera.

The number of genera occurring in four different sampling sites also varied, maximum extracted from the site-I (16 species under 14 genera) and minimum from disturbed area of buffer zone of the sanctuary (10 species under 9 genera). Out of the 14 genera, the predominant genera were *Lepidocyrtus* (3 species), *Onychiurus* (1 species), *Xenylla* (1 species), *Cyphoderus* (1 species), *Ballistrura* (1 species), *Cryptopygus* (1 species), *Isotomina* (1 species) and

Salina (1 species), *Sphyrotheca* (1 species) and *Sminthurides* (1 species) mentioned in order of dominance.

Soil factors like temperature, moisture, hydrogen ion concentration, organic carbon and the roles of these edaphic factors of soil on the distribution of collembola in the man made forest ecosystem were taken into consideration in the study.

The peak of population also varied from site to site being minimum in pre monsoon (summer months) and maximum population during monsoon (in the month of August & September). Soil factors viz, moisture, organic carbon, also showed significant positive correlation with the Collembolan population in all the sites while negative correlation was observed in respect to temperature and pH.

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