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"STUDIES ON DIVERSITY AND DISTRIBUTION OF SOIL MICRO-ARTHROPODS FAUNA WITH SPECIAL REFERENCE TO COLLEMBOLA IN SAJNEKHALI WILD LIFE SANCTUARY, SOUTH 24 PGS, WEST BENGAL"

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INTRODUCTION

Sajnekhali Wild life Sanctuary which is under Sundarban delta situated a little south of Tropic of Cancer between the latitudes 21°31´ and 22°31´ North and 88°10´ and 89°51´ East longitudes in the District of 24 Parganas South, West Bengal. Sunderbans is an estuarine ecosystem with mangroves as the main flora. Mangroves are the plants which can survive, grow and propagate in loose muddy alluvial soil and saline water. These plants have highly specialized adaptations in the form of Stilt Root (for anchoring in loose soil), Pneaumatophores or Respiratory roots and Vivipary (germination while attached to mother tree).

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 micro-arthropod studies from various forest floors included those of Banerjee (1972), Choudhuri (1961 & 1962), Hazra (1978), Bisht & Chattoraj (1986 & 1998). And reports from tropical forest soil and litter micro-arthropods are limited to the works of Singh & Pillai (1975), Prabhoo (1967,'76a,b), Hazra (1976,'78,'82, '84 & 1987), Hazra *et al*. (1981,'83,'90,'96 & 2003), Mitra (1975,'76, '88 & 1993), Mitra *et al.* (1981, '83, '86, '99 & 2002), Guru *et al.* (1988 & 1991) Ghosh and Roy (2005), Hazra & Mandal (2007), Mandal *et al.* (2007a,b,c, '09, '10 & '11). 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. In India, Soil micro-arthropods fauna from Mangroove forest ecosyetem studies are very scanty. Hazra & Sanyal (1996), Hazra, Dey & Mandal (2005) studied ecology of Collembola in periodically inundated newly emerged alluvial island on the river Hooghly, West Bengal.

So far no consolidated research has not been conducted on this part of the Sundarban. Hence, the present investigation is taken up to know the impact of major soil factors on the distribution of soil micro-arthropod and specially the collembolan fauna. The relationship between the collembolan species and the soil parameters has also been analyzed statistically. The present paper deals with collembolan fauna, other micro arthropods fauna will be published somewhere else.

METHODS OF SAMPLING

Soil samples were collected at random at the rate of 3 samples per plot (in the two sampling sites) every three month (Quarterly) during April, 2011 to March, 2013. 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 4º C in the laboratory for estimations of soil parameters**.**

A total of 96 sample units of core and 64 samples units of packet soil were collected and examined during the 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.

ANALYSIS OF EDAPHIC FACTORS

Soil samples dried in a hot air oven at about 105 ºC for further bacterial action (some sample was kept separately for the estimation of soil moisture) were then allowed to cool and stored in a desiccators 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 Moisture meter.

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: Sajnekhali Wild life Sanctuary which is under Sundarban delta situated a little south of Tropic of Cancer between the latitudes 21°31´ and 22°31´ North and 88°10´ and 89°51´ East longitudes in the District of 24 Parganas South, West Bengal.

Sajnekhali Wild life Sanctuary has been selected two sites, one from core area of Sajnekhali Wild life Sanctuary which was surrounded by fencing. The other site is Sudanyakhali which was also under the Sundarban delta surrounded by fencing.

STATISTICAL ANALYSIS OF DATA

The statistical analysis of the complex soil faunal communities has been conducted to show the 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 and organic carbon) on each other in individual site were shown (Table 3-4). 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.

OBSERVATION

Site Wise Analysis Of Collembolan Fauna

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

Site I: SAJNEKHALI

Site II: SUDANYAKHALI

Site I: SAJNEKHALI

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. The site is located at 22°07´ 24.2´´ North and 88°49´ 45.8´´ East longitudes. Soil was humid alluvial in nature and sandy silt in texture. Although the region is situated south of the Tropic of Cancer, the temperature is equable due to its proximity to the sea. Average annual maximum temperature is around 35°C. Average annual rainfall is 1920 mm. Average humidity is about 82% which is more or less uniform throughout the year. The dominating mangroves are- Sundari (*Heritiera fomes*), Bain (*Avicennia spp*.), Passur (*Xylocarpus mekongensis*), Dhundul (*Xylocarpus granatum*), Golpata (*Nypa fruiticans*), Hental (*Phoenix paludosa*), Khalsi (*Aegiceras corniculatum*), Garjan (*Rhizophora apicata*), Garan (*Ceriops decandra*), Gnewa (*Exocaria agallocha*), Keora (*Sonneratia apetala*), Haragoja (*Acanthus ilicifolius*) and Dhanighas (*Porterasia coarctata*). 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 sandy silt in texture. Salinity of surface soil is high during dry season but is reduced to tolerable limits because dilution by the leaching effects of rainwater. Mechanical analysis of soil showed maximum percentage of medium silt 36.4% and more or less equal percentage of fine sand and fine silt. During summer, soil moisture content was 27% in 2011 and 29.5% in 2012. Maximum moisture content in soil (35.5%) was recorded in July, 2011 and 34.5% in the same period of 2012. During summer, other soil factors such as temperature, pH and organic carbon were found 33.5ºC, 5.8, 1.3%; 34ºC, 5.6, 1.5%; in 2011 and 2012 respectively. Mean values of others revealed more or less identical characteristics **(Tab. 1)**.

Collembolan Fauna: The Collembolan fauna obtained from this site belonged to 10 species in 9 genera. Amongst them, the species *Lepidocyrtus curvicollis* was found most dominant and it was (32.5%) of the total fauna recorded from this site. The species *Axelsonia nitida* contributed (18.9%), *Isotoma* sp contributed (16.2%), *Lepidocyrtus caeruleicornis* contributed (12.4%), *Sminthurides appendiculatus* contributed (5.16%), *Sinella curviseta* contributed (5.5%) and *Cyphoderus javanus* contributed (4.14%). 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

Table 1. Values of edaphic factors from April, 2011- March, 2013 at Sajnekhali

Month & Year	Temperature (°C)	Moisture (%)	pH	Organic carbon(%)
April,2011	33.5	27	5.8	1.3
July,2011	31	35.5	6.4	2.38
October,2011	29.5	34	6.0	2.4
January,2012	25	27.5	6.4	2.3
April,2012	34	29.5	5.6	1.5
July,2012	30.5	34.5	6.1	2.7
October,2012	29	31.5	6.2	2.4
January,2013	24.8	28.5	6.4	2.1
March, 2013	34.5	28.5	5.5	1.8

maximum in July in two consecutive years, which coincided with the maximum concentration of soil factors like-moisture, organic carbon and other edaphic factors.

Seasonal changes: Seasonal changes of each predominant species of Collembola *Lepidocyrtus curvicollis*, *Lepidocyrtus caeruleicornis* and *Axelsonia nitida* obtained from this site revealed that had reached at its peak in July in both the years, while *Isotoma* sp showed maximum in January 2011 but 2012 the peak was shifted to October. It is apparently seen that, predominant forms of collembolan obtained from this site exhibited an irregular trend of fluctuation being minimum in summer months, slightly higher in winter months and higher in monsoon months. 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**.**

SITE II: SUDANYAKHALI

Location and Characteristic of sampling site II: This locality is situated at Sudhynakhali of Sundarban delta. The site is located at 22°06'4.8"North and 88°48' 3.9"East longitudes. The main forest species are Goran, Passur, Keora, Bain, Garjan, Tora and Hental (local name).

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 37.6% and more or less equal percentage of fine sand and fine silt. During summer, soil moisture content was 26.8% in 2011 and 27.5% in 2012. The month of July in sampling year showed maximum moisture content in soil (36.4% in 2011, 37.2% in the same period of 2012. During summer, other soil factors such as temperature, pH and organic carbon, were found 34.5ºC, 5.2, 1.3%; 34ºC, 5.5, 1.4%; in 2011 and 2012 respectively. Mean values of others revealed more or less identical characteristics **(Tab. 2)**.

Collembolan Fauna: The Collembolan fauna obtained from this site belonged to 6 species under 6 genera. The species *Axelsonia nitida* was the most dominant with 24.9% of the total fauna recorded from this site. The species are, *Lepidocyrtus curvicollis, Isotoma* sp., *Entomobrya sp, Sminthurides appendiculatus* and *Cyphoderus javanus* which represented 20.36 %, 19.84%, 13.76%, 10.90%, and 10.25% respectively. The population of collembola was found maximum in the month of August in both the year, which

Table 2. Values of edaphic factors from April, 2011-March, 2013 at Sudanyakhali

Month & Year	Temperature(°C)	Moisture (%)	pH	Organic carbon(%)
April,2011	34.5	26.8	5.2	1.3
July,2011	32	36.4	6.1	2.4
October,2011	29	33.7	5.9	2.1
January,2012	26	28.5	5.8	1.9
April,2012	34	27.5	5.5	1.4
July,2012	30.2	37.2	6.1	2.6
October,2012	29.3	30.6	6.1	2.1
January,2013	24.9	28.7	5.9	1.8
March, 2013	34.5	26.2	5.4	1.2

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.

Seasonal Changes: Number of each predominant species of collembolan insects obtained from this site revealed that *Axelsonia nitida* and *Lepidocyrtus curvicollis* indicating single peak in July in both the year (2011 and 2012) while *Isotoma* sp. showed its peak in January, 2012 but in 2013 the peak shifted to March. *Sminthurides appendiculatus* and *Cyphoderus javanus* exhibited highest peak in October (2011 & 2012) 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.

Table. 3. Correlation(r value) between individual collembolan species with edaphic factors at Site-I

Name of the species	Temperature	Moisture	pH	Organic carbon
Hypogastrura sp	-0.180147846	0.828530719	-0.652997651	0.652985415
Lepidocyrtus curvicollis	0.109146027	0.872077366	-0.476077623	0.565049206
Lepidocyrtus caeruleicornis	0.11233319	0.740633265	-0.583840341	0.498988274
Sinella curviseta	-0.1471323	0.6677209	-0.568348	0.5597715
Entomobrya sp	-0.4904062	0.1977307	-0.6556189	0.4604979
Axelsonia nitida	-0.0113091	0.5849276	-0.6844386	0.479076045
Lobella maxillaris	0.073256903	0.6271018	-0.5098721	0.469072044
Isotoma sp	0.1328547	0.760909	-0.6889775	0.5749779
Cyphoderus javanus	-0.5243741	0.0777475	-0.371506	0.2472246
Sminthurides appendiculatus	-0.4010517	0.2774619	-0.6175193	0.427766

Table 4. Correlation(r value) between individual collembolan species with edaphic factors at Site- II

Name of the species	Temperature	Moisture	pH	Organic carbon
Entomobrya sp	-0.160745935	0.786287817	-0.702520498	0.775227292
Lepidocyrtus curvicollis	0.010067725	0.846771521	-0.645910627	0.749046149
Axelsonia nitida	-0.713751666	0.235595549	-0.726386647	0.640066048
Isotoma sp	0.030307095	0.711675122	-0.590427574	0.603337027
Cyphoderus javanus	-0.641062164	0.118584114	-0.562758953	0.435401949
Sminthurides appendiculatus	-0.023930549	0.634964027	-0.540389791	0.612977051

ANALYSIS OF VARIANCE (ANOVA): ONE WAY ANALYSIS

A univariate analysis of variant with the month as a factor has been carried out whether any significant seasonal fluctuation exists or not in the population of individual species of collembolan in the four sampling sites. The results of analysis are represented in the tables 5-6.

Table 5. 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*
Hypogastrura sp	152.86	0.000	250.17	0.000	3.20	0.088	0.31	0.582
Lepidocyrtus curvicollis	173.97	0.000	329.54	0.000	1.57	0.224	3.16	0.089
Lepidocyrtus caeruleicornis	152.86	0.000	250.17	0.000	3.20	0.088	0.31	0.582
Sinella curviseta	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
Axelsonia nitida	179.63	0.000	316.20	0.000	5.77	0.025	0.09	0.771
Lobella maxillaris	348.82	0.000	997.90	0.000	170.54	0.000	22.17	0.000
Isotoma sp	152.86	0.000	250.17	0.000	3.20	0.088	0.31	0.582
Cyphoderus javanus	310.76	0.000	788.52	0.000	69.34	0.000	7.08	0.014
Sminthurides appendiculatus	239.51	0.000	499.66	0.000	18.04	0.000	0.30	0.587

* < 0.05 significant

Table. 6. 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*
Entomobrya sp	260.30	0.000	482.12	0.000	19.35	0.000	0.02	0.891
Lepidocyrtus curvicollis	380.08	0.000	866.15	0.000	211.63	0.000	22.15	0.000
Axelsonia nitida	347.78	0.000	743.91	0.000	98.11	0.000	8.69	0.007
Isotoma sp	404.57	0.000	969.96	0.000	564.53	0.000	51.88	0.000
Cyphoderus javanus	340.48	0.000	708.68	0.000	83.05	0.000	8.11	0.009
Sminthurides appendiculatus	358.59	0.000	755.07	0.000	110.49	0.000	14.98	0.001

*<0.05 significant

DISCUSSION

The ecological studies of this investigation were based on the sample survey of two sites from Sajnekhali Wild Life Sanctuary, Sundarban Biosphere Reserve, South 24 Parganas, West Bengal over a period of 24 months (April, 2011 to March, 2013). Salinity of surface soil is high during dry season but is reduced to tolerable limits because dilution by the leaching effects of rainwater. The general natures of the soil of two sampling sites were more or less identical.

The Collembolan fauna of the two study sites belonged to 10 species under 9 genera of 6 families: Hypogastruridae, Neanuridae, Isotomidae, Entomobryidae, Cyphoderidae and Sminthuridae (Table 7).

The number of genera occurring in two different sampling sites also varied, maximum extracted from the site-I (10 species under 9 genera) and from the site-II (6 species under 6 genera). Out of the 9 genera, the predominant genera were *Lepidocyrtus* (2 species), *Axelsonia* (1 species), *Isotoma* (1 species), *Cyphoderus* (1 species), *Entomobrya* (1 species), *Sinella* (1 species), *Sminthurides* (1 species) *Lobella* (1 species), *Hypogastrura*(1 species) mentioned in order of dominance.

The genus *Lepidocyrtus* were represented by 2 species like, *Lepidocyrtus curvicollis* and *Lepidocyrtus caeruleicornis.* The genus *Lepidocyrtus* was found to be widely distributed in all sampling plots comprising 22.9% 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 curvicollis* 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 July.

The second predominant genus was *Axelsonia* with single species *nitida,* comprising 21.9% 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.

Table 7. Taxonomic status of the Collembolan species from the Sajnekhali Wild life Sanctuary.

FAMILY	HYPOGASTRURIDAE
	Hypogastrura sp
FAMILY	NEANURIDAE,
	Lobella maxillaris Yosii,1966
FAMILY	ISOTOMIDAE
	*Axelsonia nitida (*Folsom) Borner,1906
	Isotoma sp
FAMILY	ENTOMOBRYIDAE
	Sinella curviseta Brook,1882
	Lepidocyrtus curvicollis Bourlet,1839
	Lepidocyrtus caeruleicornis Bonet, 1930.
	Entomobrya sp
FAMILY	CYPHODERIDAE
	Cyphoderus javanus Borner,1906
FAMILY	SMINTHURIDAE
	Sminthurides appendiculatus Imms, 1912

The third numerical dominant genus *Isotoma* sp. represented by single species was extracted in maximum number (18%) from all the sampling sites though the insects were maximum in number in October.

Another dominant genus *Sminthurides* and *Cyphoderus* extracted from both the sites and comprised 8.1% and 7.19% of total population occupying fourth position in dominance.

The other important genera collected there were, *Entomobrya, Sinella, Lobella* and *Hypogastrura* constituting 5.5%, 5.4%, 3.2% and 1.9% respectively.

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 summer months in all sites. Moreover, a general pattern of fluctuation with maximum in monsoon and minimum in pre-monsoon (April), which in agree 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.

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, the predominant species *Lepidocyrtus curvicollis, Lepidocyrtus caeruleicornis Axelsonia nitida* and *Isotoma* sp. attained maximum population in July and two species, *Cyphoderus javanus* and *Sminthurides appendiculatus* in January. *Entomobrya sp*. reached its peak in October followed by in March while *Sinella curviseta* and appeared largest population in the month of August. Individuals of other species like*, Hypogastrura* sp, *Lobella maxillaris* were numerically low in summer months 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 (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, 1997). 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 25°C and 34.5°C (Table 1-2). Collembolan population indicated negative correlation with temperature in both sites which confirm the study of 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 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 (36.4%) and minimum (26.2%) respectively in all 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 both the sites (Table 3-4). Mukherjee and Singh (1970), Choudhuri and Roy (1967), Hazra and Choudhuri (1983, 90) and Guru *et al*. (1988) found positive but not significant correlation between the soil organisms and moisture. Choudhuri 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), 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 2.6% and exhibited strong positive correlations with the population densities of Collembola in all the sampling sites (Table 1-2). 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 5.2 and maximum of 6.4 (Table.1-2). However, its average value in both the 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 both the 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.

It may be concluded from the present investigation that the organic carbon and moisture are key factors which controlling fluctuations of collembolan population. However, the factors considered here and other biotic and abiotic factors not considered at present may also play an important role for the seasonal variation and fluctuation of collembolan fauna.

SUMMARY

The fauna of the experimental sites belong to 10 species of 9 genera of 6 families: Hypogastruridae, Neanuridae, Isotomidae, Entomobryidae, Cyphderidae and Sminthuridae. Maximum species diversity came in view from the Site-I with 10 species in 9 genera and the Site II with 6 species in 6 genera.

The number of genera occurring in two different sampling sites also varied, maximum extracted from the site-I (10 species under 9 genera) and minimum from the site-II (6 species under 6 genera). Out of the 9 genera, the predominant genera were *Lepidocyrtus* (2 species), *Isotoma* (1 species), *Axelsonia* (1 species), *Entomobrya* (1 species), *Sinella* (1 species), *Sminthurides* (1 species), *Cyphoderus* (1 species), *Lobella* (1 species), and *Hypogastrura* (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 mangrove 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 July, August & September). Soil factors viz, moisture, organic carbon, also showed

significant positive correlation with the Collembolan population in two sites while negative correlation was observed in respect to temperature and pH.

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