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Research Article

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Effect of Ecological Factors on Population Density of Collembolan in Agra

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Abstract

Collembola are extremely abundant in soil and leaf litter and maintaining the agricultural ecosystem which is enriched by plant litter decomposition. This Present study is based on effect of ecological factor on Collembolapopulations in Agra regions. We have selected two different habitats in this investigation: Agricultural Area and A natural field. During study, Total 126 samples have been collected from different locations and soil collembolan extraction done by Modified Tullgren's funnel apparatus. We have found that Collembolans found highly frequent in entire community of soil collembolan, comprising up to 76.8% absolute frequency in natural site whereas 63.2% in Agricultural site. Population study of collembola for one calendar year was made in relation with temperature, moisture, and organic carbon and nitrogen contents of agricultural and natural site upto 0-10 cm. soil layer. Soil moisture content played important role and developed a significant correlation with the monthly population density of collembola. With increase carbon and nitrogen contents also observe increase population density indicating collembola's active participation in the release of these two nutrients from litter through decomposition and its incorporation in soil fertility.

Key Words: Collembola, Seasonal Diversity, Habitat Quality, Edaphic Factors

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Introduction

Collembola (commonly known as "springtails") arecurrently considered to be a monophyletic Class of thePhylum Arthropoda There are three main Orders ofCollembola. Members of the Arthropleona (about 6500species) have a more or less elongated body shape and range from highly active surface-dwelling species to thosethat live out all their lives in the depths of the soil.

These soil organisms play a significant role in mineralization and humification of organic matter (Coleman, 1985;Verma and Paliwal, 2010). Moreover, they are considered as the indicator organisms in studies of soil quality (Heisler,1995).

Agricultural intensification leads to alteration of soil pH which disrupts niches of soil fauna. Previous studies on effect of soil disturbances on the abundance and diversity of mites and Collembola showed that soil disturbance negatively affects their diversity have showed that molding and burning of surface plant litter reduces populations Collembolan (Verma and Paliwal, 2010). This study has baseline information against seasonal habitat disturbances in native soils because the dynamics of Collembola assemblages are extremely poor understood in Indian agricultural soils. Thus, under the progress of our research, a comparative study has been carried out from two selected sites at Agra which are different in locations and nature of vegetation. Hence, microclimatic conditions as well as field compositions and habitat quality with degree of disturbances have been studied thoroughly in this study.

Keeping a view about the above facts the present study has taken up to investigate the role of temperature , moisture, organic carbon and nitrogen contents of soil to the monthly population fluctuation of collembola in Agra regions. The present paper will also highlight that out of the four parameters taken which one is the most controlling factor of the collembolan population fluctuation.

Materials and methods

The present investigation was carried out for one year, fromApril 2013 to March 2014 in a two different sites of Agra regions. Soil samples were collected on monthly intervalsusing cylindrical core sampler of size 5.5 cm. in diameter and 10 cmin height having a surface area of 23.76 cm2 based on the principle of O'Conor (1957).

Site I selected an Agricultural area at Sewala Village that is situated at the outside of Agra city. Different crops considered within a year.

Site II a Selected a Natural Site that is located at Victoria garden which is situated at the heart of TajMahal, Agra. This field is approximately 2 acre in size without growing any crop.

Samples were taken every week regularly and brought to the laboratory for extraction of soil animals as soon as possible. Total, 126 samples have been taken from the both site. Modified Tullgren's funnel apparatus was used for extraction of soil microarthropods. All microarthropods were collected inside a beaker which contained 70 % alcohol with few drops of glycerol and they were mounted with DPX. All soil microarthropods were identified up to the level of their order or, family using a range of taxonomic keys (O' Connell and Bolger, 1994). A stereoscopic binocular microscope (Olympus Model CX 24B with digital camera) was used for identification of soil collembolan.

Out of the various physical factors only soil temperature, moisture content, total nitrogen and organic carbon content were considered for the present investigation. Soil temperature was measured by directly inserting the soil thermometer into the soil upto the required depth. The soil moisture content was analyzed by gravimetric method as given by Misra (1968). Soil total N and organic carbon were calculated by acid digestion kjeldalh procedure given by Anderson and Ingram (1993).Extraction was continued for seven days and extracted animals were collected and all the collembolans were sorted out and counted month wise.

Statistical Analysis

To study the diversity of soil microarthropods, the parameters considered were density, abundance, fractional population, relative density, and absolute frequency, Shannon Wiener diversity index (H) and Evenness (J) between the sites. Statistical analysis of the data was performed using the Statistical package (Statsoft, 2004). Correlation coefficient analysis was donebetween population of collembola and soil parameters.

Results and discussion

Quantitative analysis of Collembola population against different parameters showed in table 1.The species richness of Collembola was very low while the individual population was high in most of the sampling cases specifically in spring and winter season in both sites. The average abundance and density of collembolans was recorded 24.12 (ind/sample) and 14.97 (ind/sample) respectively in disturbed site. The highest (55.5%) collembolans recorded in Spring season while the lowest 5.5% in Rainfall in disturbed site.

In soil dwelling Apterygotes, more than 95.8% collembolans have been recorded however, peak populationof collembolans recorded in spring (61.7% and the least population (3.2%) in rainfall season. The mean average of density and abundance of Collembolans were recorded 14.25 (ind/sample) and 22.09 (ind/sample) respectively (Table 1) in natural site.

Collembola was the dominant group and absolutely frequent up to 76.8 % in natural site followed by 63.2 % in disturbed site. Thus, the variation among the Collembola population was not varying significantly; however, Shannon's diversity (H) indicated that the natural site was less diversified than the disturbed site comparatively (Table 1).

Table 1: Quantitative analysis of Collembola population against different parameters

Parameters	Site I	Site II
Mean Density	14.97	14.25
Abundance	24.12	22.09
Relative Density (%)	61.38	60.15
Absolute Frequency (%)	68.78	70.83
Diversity Index (H)	1.10	1.15
Evenness (E)	0.28	0.28

The monthly population fluctuations of collembola for the two study sites were illustrated in Table-2. Highest population densities of 224 $\times 10^2$ m^{-2} and 246$\times 10^2$ m^{-2} were recorded during the month of August in site-I and site-II respectively.

Table 2. Population Density of Springtails recorded of two study sites at 0-10cm soil depth (Numbers x 102 m^{-2})

	Site 1	Site 2
Apr	139±1.5	109±2.5
May	202±2.9	109±2.5
June	158±1.9	140±2.2
July	215±7.8	245±11.7
Aug	206±21.5	237±1.5
Sep	206±21.5	237±1.5
Oct	198±12.1	179±1.2
Nov	170±4.6	186±4.1
Dec	54±1.7	98±1.5
Jan	77±3.2	71±2.1
Feb	71±2.3	63±1.2
March	185±4.3	165±1.5

Site I: Agricultural Area; Site II: Natural Area

During this investigation, we observed an increase in the population of collembolans during monsoon months and their decline during hot summer and extreme winter months. The potential use of soil inhabiting Collembola can be evaluated because of their utility of plant promoting nature. Among soil Collembola investigated, Collembola found a highly diversified group in native agricultural soils (approximately 73 % in both study sites) as well as highly sensitive to disturbance in its habitat. However, they are functionally vital for growth and support of plants as well as fertility of soils for their agricultural utilities.

Table 3: Correlation coefficient between Collembola population and soil parameters

	Variables	Soil Layers	Correlation	Slope	Significance
Site I	Soil Temp.	0-10	-0.895	-0.042	>0.05
	Soil Moisture	0-10	0.568	0.007	>.0.01
	Organic carbon	0-10	0.452	0.001	>0.05
	Nitrogen	0-10	0.545	0.209	<0.05
Site II	Soil Temp.	0-10	-0.801	-0.064	>0.05
	Soil Moisture	0-10	0.389	0.004	>.0.01
	Organic carbon	0-10	0.401	0.002	>0.01
	Nitrogen	0-10	0.798	0.219	<0.05

There was considerable seasonal variation in the population of Collembola and this may perhaps due to the strong influence of temperature. Thus, seasonal changes of Collembola abundance were shaped by the dry and wet seasons under the monsoon climatic conditions. Therefore, temperature and moisture contents are the precursor of community distribution of Collembola. Among the soil microarthropoids, Collembolans are likely to be more dependent on temperature and availability of water (soil moisture) than on food supply as they have cosmopolitan diet (Hopkins, 1997).

Soil temperature (r = -0.895were negatively correlated with reference to Collembola population in site-I as well as in site II (soil temperature, r = -0.801) at 5 % level of significance (Table 3).Temperature plays an important role in seasonal variation of these microarthropods specially collembolans and diplurans which had also been reported earlier by Sinha et al., (1988). We studied a low population of Collembola in winter that corresponded well with consistent decrease in soil and atmospheric temperature. The reason for this low population of Collembola at low temperature could be that during low soil temperature, the moisture content of the soil is also very less (20ºC, 4.98%) which is unfavorable since soil microarthropods flourish well in moist conditions. In dry and desiccated soil the fungal growth is negligible and fungus being the main food of the collembolans, their population show a declining trend during this period. Yet another reason of low collembolan population at low temperature could be that the arrest in reproduction and higher adult mortality. It has also been observed that many collembolans species undergo hibernation (Joose, 1981).

Soil moisture content was found to play the most vital role among the three parameters of the soil for the present investigation in the distribution and fluctuation patterns of soil collembola population specially collembola. In the present study the soil moisture content recorded at 0 – 10 cm soil layer exhibited high significant positive correlations with collembolan population density (p > 0.01) Table 2. Hazra (1978) andReddy (1984) were also observed a positive correlation of soil moisture with collembola and acarina. In thepresent investigation, maximum soil moisture content (July, Aug) recorded falls during rainy months corresponded with the maximumpopulation densities of collembola were of the same opinion withNiijima (1971) and Verma and Paliwal (2010) and Badejo et al. (1998).

The soil organic carbon contents of the two study sites werecomparatively more or less similar. Soil organic carbon contents were recorded maximum during July and August i.e. during wet rainy months and minimum were recorded during dry winter months in all the two study sites (fig-2). This may be due to higher percentage of moisture and other favorable microclimatic conditions which enhance the decomposition rate during rainy months. Soil organic carbon contentexhibited a strong positive correlation with collembolan population (p> 0.01).

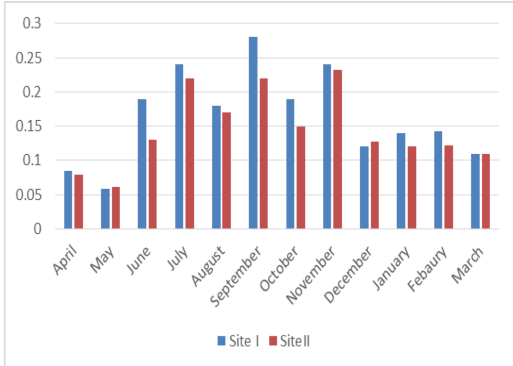

Fig 1. Soil moisture content (%) of the three study sites at 0-10cm layer during different months of the study period

The quantitative increased of population with increased concentration of organic carbon has been reported by Verma and Paliwal (2010) Banerjee &Sanyal (1991), Sanyal et al (1999) etc. in different ecosystems. It is highly probable that the total concentration potential of food as measured by the percentage of organic matter was ofprofound importance in controlling the distribution of soil microarthropodsespecially of collembola. In the present investigation the total nitrogen content showed a positive non-significant correlation in site-Iand site – II relationship were maintained with collembolan population. It may be suggested that

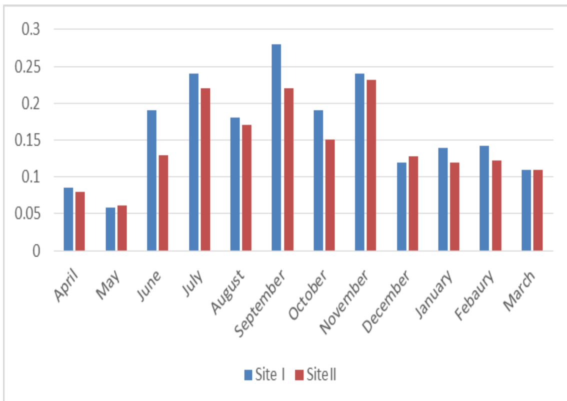

Fig 2. Soil organic carbon content (%) of the two study sites at 0-10cm layer during different months of the study period.

some species of collembola were using the same available niche in the soil with other soil fauna and when other species dominant,collembola could not maintain a positive correlation with totalnitrogen available in that particular microhabitat and microclimatic conditions.

The results revealed that the Collembola populations showed apparently meaningful differentiation among disturbed site whereas high population of Collembola due to cool temperature and low humidity in Winter and Spring months and sharp decline in Summer as well as in Monsoon months due to high temperature (dryness) along with high humidity. Thus, seasonal and climatic variations directly affected the density and abundance of soil Collembola including Collembola. Interestingly, stable soil moisture and medium temperature regimes are critical source for high density buildup of soil Collembola because this may lead to the reproduction.

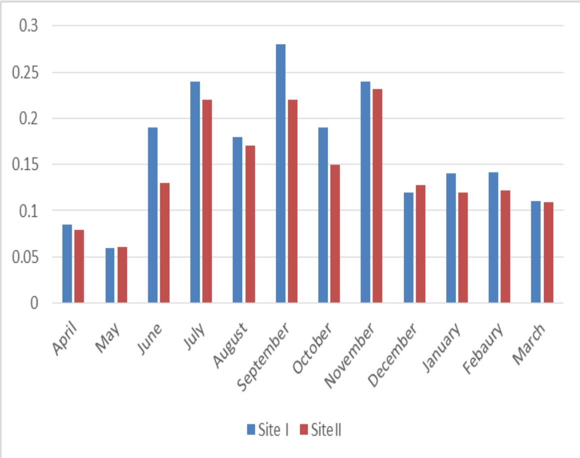

Fig 3. Soil Nitrogen content (%) of the two study sites at 0-10 soil layer during different months of the study period.

Conclusion

This important group of soil collembola is also affected by variety of edaphic factors namely, atmospheric and soil temperature, humidity, soil moisture content and pH which are independently correlated with collembolan population. We are concluded that he above findings it can be pointed out that out of the four parameters soil temperature, moisture content and organic carbon content played similar important roles in controlling the population densities of collembola as they showed high significant correlation with collembola population. However, number of collembolan increased with increased carbon content and nitrogen content of the present study clearly indicated their active participation in litter decomposition and hence soil fertility.

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