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Effect of soil edaphic factors on the diversity and abundance of Collembola at Biodiversity Park, Ranchi, Jharkhand

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Abstract- Collembola are small apterygote insects that are commonly found upto a depth of 0-10cm. They are observed as one of the most important inhabitants of soil as they perform crucial role in pedo-ecosystem and also influence the decomposition process and soil mineralization. They also serve as an ideal bio-indicator for soil fertility and soil quality. To understand the impact of physicochemical properties, a study was conducted at two different sites of Biodiversity Park, Ranchi one having Natural Sal plantation (Site 1) and the other having Rose Plantation (Site 2). Soil physico-chemical properties such as temperature, moisture, soil organic carbon, pH and N, P, and K were taken into consideration. *Hypogastrura* sp. was recorded to be the most abundant species contributing 31.45% at site 1 and 29.38% at site 2. The collembolan diversity was higher at site 1 (1.6022) than at site 2 (1.5498). The highest seasonal diversity was observed during monsoon (1.6120) at site 1 and during post monsoon (1.5504) at site 2. The lowest seasonal diversity was recorded during summers at both the sites (1.5623, 1.4380) respectively. Soil temperature and soil moisture have significant role in seasonal diversity and distribution of Collembola. The organic carbon content and soil moisture played a pivotal role in controlling the Collembolan density and diversity as they showed high positive significant correlation with Collembolan population. Results indicate that the diversity of collembola was higher at site 1 than at site 2. At both the sites there was a decrease during summers and peak was observed during monsoon at site 1 and during post monsoon at site 2.

Keywords: Collembola, physicochemical parameters, species diversity, seasonal variation.

INTRODUCTION

Soil is a habitat for a multitude of organisms. The soil fauna, work as ecosystem engineers, and have crucial effects on the soil functioning and development system. Among soil fauna, Collembolans are considered ideal bio-indicators of soil fertility and soil quality because of their quick response towards various changes in the environment. Collembola, also known as springtails, are small wingless hexapods that measure 1-3mm in length. Approximately, 8767 described species of collembolans belonging to 694 genera and 33 families have been reported globally, whereas Indian Collembola fauna is represented by 342 species under 113 genera belonging to 20 families.[1] Collembolans are reported to feed on various dead organic matter and decaying plant materials. Some collembolans are also found to feed on various soil microorganisms, particularly on fungal hyphae and thereby play an important role in suppressing various fungal diseases in plants.[2,3] Collembola along with other soil arthropods such as Acari[4] are indispensable in accelerating the decomposition of organic matter, maintenance of soil physical structure, and efficient nutrient cycling. Soil physico-chemical factors play a pivotal role in the diversity and distribution of Collembolans. Among all the soil physico-chemical factors

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present, temperature, moisture, soil organic carbon, pH and N, P, K stand out as the most important ones in affecting the distribution and abundance of Collembola. Soil temperature and soil moisture have significant role in seasonal diversity and distribution of Collembola.[5-9] More humus and organic matter leads to greater diversity.

MATERIALS & METHODS

Study area

The Biodiversity Park is developed with an aim to conserve rare, imperative plants, trees and medicinal herbs. It is located in mauza Lalkhatanga and Garkhatanga in CD Block-Khijiri (Namkom) under Ranchi Sardar Sub-Division of Ranchi District. It is situated between 23 14' 40" N to 23 15' 37" N latitude and 85 19' 53" to 85 21' 30" E longitude on Tupudana - Namkom Ring Road. The various plantation sites in the park comprises of indigenous species zone, aquatic garden, bambusetum, medicinal garden, rose garden, grass zone, palm garden, exotic plants etc. and natural sal forest. The present study is done on Natural Sal plantation (site 1) and Rose plantation (site 2). The climate of Ranchi is sub-tropical type. Temperature ranges minimum 2-20°C during winter and 20°C to 39°C during summer. The annual rainfall is about 1530mm. From June to September the rainfall level is about 1100mm. These climatic conditions are well suited for the growth of many plants that are present in the park.

Collection of soil sample

Soil samples were collected from both sites once a month and placed in labelled zip-lock bags before being transported to the laboratory for extraction and analysis.

Physicochemical analysis of the soil

The soil physicochemical parameters were determined using standard procedures.[10,11]

Extraction of Soil arthropods

According to Crossley and Blair, (1991)[12], the Tullgren funnel is an integral part of the extraction process. The Tullgren funnel was invented by Berlese to gather soil arthropods from soil samples.[13] One 60- watt light bulb was utilized for 48-72 hours as a heat and light source. We gathered the separated species in vials, subjected them to 70% ethanol and a few drops of glycerol, and then examined them using compound microscope.[14]

Soil arthropod identification

The collected species were examined for basic identification using a Compound Microscope. The prepared slides were sent to the Zoological Survey of India for identification of species and categorized using a variety of taxonomic keys at the order or family level.

Statistical analysis

Shannon Weiner's Species Diversity was calculated using formula:-

$H' = -\sum p_i \ln(p_i)$ or H'= - "(Ni/N) × ln (Ni/N)

Where,

H' = The Shannon-Weiner Diversity Index

p_i= the relative abundance of each group of organisms

The index of evenness or equitability (J) were estimated using the formula as given by Krebs (1976).

$J = H'/H'_{max}$ when H'_{max} = LogS × 1/ Log 2

OBSERVATION

Table 1- Seasonal Collembolan diversity at both the sites

SEASONS	SITE 1	SITE 2
Summer	1.5537	1.4380
Monsoon	1.6655	1.5504
Post Monsoon	1.6257	1.5660
Winter	1.6159	1.5483

Table 2. Correlation between Collembolan population and various edaphic factors

CORRELATION BETWEEN FACTORS	SITE 1	SITE 2
Collembolan Population Vs Temperature	-0.5158	-0.5438
Collembolan Population Vs Moisture	0.9419	0.8613
Collembolan Population Vs Organic carbon	0.8671	0.7522
Collembolan Population Vs pH	-0.6625	-0.5435
Collembolan Population Vs Nitrogen	0.6579	0.6245
Temperature Vs Moisture	-0.3403	-0.4069
Moisture Vs Organic carbon	0.9056	0.8871

RESULT & DISCUSSION

The soil physicochemical properties viz. as temperature, moisture content, organic carbon content, and pH showed almost similar variations in both sites. The maximum temperature was recorded in the month of May having 35.2°C at site 1 and 36.9°C at site 2 while the minimum temperature was recorded in the month of January having 22.3°C at site 1 and in December having 20.6°C at site 2. The soil moisture was highest during August having 24.7% and 23.5% at both the sites while minimum was observed during May with a record of 10.2% at site 1 and 9.2% at site 2. The soil moisture could be seen to be more during monsoon months and less during summer months. A fluctuation in the Collembolan population was recorded as the soil moisture content varies. The soil pH was recorded to be between 6.3-6.5 at both the sites. The pH tends to decrease with an increase in moisture content of soil.

A total of 5130 Collembolans were collected, representing four families and six genera. At site 1, 2794.25 species were collected, while at site 2, 2403.45 species were collected. At site 1, *Hypogastrura* sp. (29.90%) is most abundant followed by *Proisotoma* sp. (22.39%), *Lepidocyrtus* sp. (20.79%), *Isotomurus* sp. (15.34%), while *Sminthurinus* sp. (7.39%) and *Entomobrya* sp. (4.16%) are least abundant. At site 2, *Hypogastrura* sp. (29.38%) and *Proisotoma* sp. (29.30%) were almost equally abundant followed by *Lepidocyrtus* sp. (21.21%), *Isotomurus* sp. (13.03%), *Sminthurinus* sp. (3.86%) and *Entomobrya* sp. (3.20%) is least abundant.

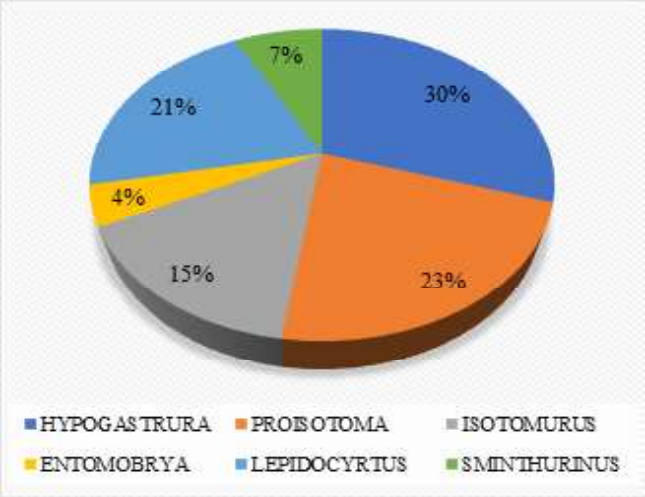

Fig 1. Relative abundance (%) of collembolans at site 1

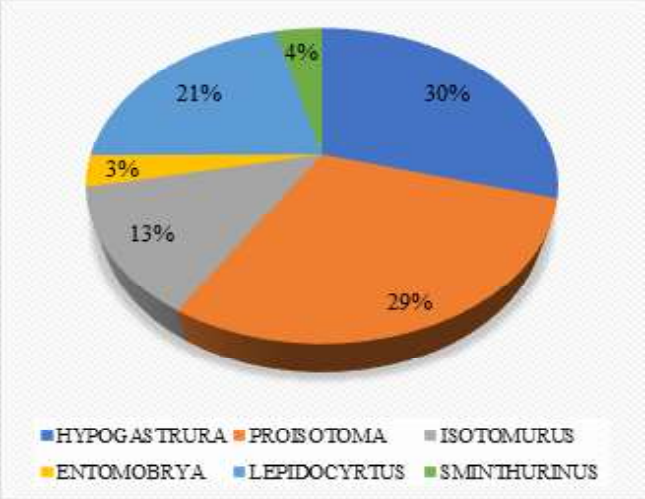

Fig 2. Relative abundance (%) of collembolans at site 2

Though, a strong positive correlation coefficient was seen between the Collembolan population and soil moisture content at both sites, site 1 had higher correlation coefficient of 0.9419 than site 2 having 0.8613. The reason is that site 1 is undisturbed land where the microhabitat is not affected by any anthropogenic activities while at site 2, regular tillage disrupts the microhabitat and obstructs the growth and diversification of organisms. A highly significant positive correlation was observed between Collembolan population and soil moisture as given.

The present finding corroborates with the findings of Bhattacharya and Ray Choudhuri (1979)[15]. The soil moisture plays a crucial role in the development and growth of collembolans and has strong positive correlation with the collembolan population and its seasonal fluctuations.[16] The soil moisture directly influences the humification thereby stimulating the soil microbial flora and fauna. A negative correlation between Collembolan population and temperature was observed measuring -0.5159 at site 1 and -0.5438 at site 2.

The organic carbon content and soil moisture played a pivotal role in controlling the collembolan density and diversity as they showed high positive significant correlation with collembolan population. More humus and organic matter leads to greater diversity of collembolans.[17] Due to an increased concentration of organic matter and presence of sufficient amount of moisture, almost 85-90 percent of Collembola congregated in the top layers of soil that provides them a healthy ecological niche and also served as a source of sufficient food.[18] The maximum Collembolan population was recorded during August month (362.5, 349) at both the sites followed by July (391, 334.45). The minimum population was recorded during May (53.75, 36.75 numbers/sq.m) at both sites respectively. The present findings are also in accordance with the work of Mandal and Suman (2014)[19] who found that July month had the maximum percent of Collembolans. This was due to the high correlation coefficient of collembolan population with soil moisture as well as organic carbon content.

Collembolan diversity was found to be higher at site 1 (1.6352) than at site 2 (1.5498). Among the seasons present, the seasonal species diversity was maximum during monsoon at site 1 (1.6655) and during post monsoon at site 2 (1.5660). Minimum species diversity was found during summer at site 1 (1.5537) and site 2 (1.4380). The number of Collembola declines during the dry season and then increases during the wet season.[20,21] This is due to the fact that Collembolans are very sensitive to any change in the soil environment.[22]

The density and diversity of collembola were greatly affected by changes in physical and climatic conditions.

The overall density and diversity of collembola was found to be higher at site 1 as compared to site 2. This may be due to the higher intensity of disturbance at site 2 as compared to site 1 by ways of regular tillage, irrigation and addition of fertilizers which alter the soil structure and its chemical nature, lowering the existing resources and making the soil less habitable and conducive for the sustenance and growth of soil fauna.[20] Also, the addition of fertilizers kills the Collembola directly or indirectly by changing the specific fungal food resources.[24-27]

CONCLUSION

The present study revealed that the density and species diversity of Collembola was higher at site 1 than at site 2. Moreover, from the findings, it can be concluded that it is the cumulative impact of various soil physicochemical parameters that are responsible for the density, diversity and distribution of Collembola. However, among all the physicochemical parameters present, soil moisture and organic carbon content play a very crucial role in determining the Collembolan diversity as they have a strong positive correlation coefficient with the Collembolan population.

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