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Research Article

SEASONAL DIVERSITY OF COLLEMBOLA ASSEMBLAGES IN TWO DIFFERENT HABITATS OF ALIGARH

***Mohammad Jalaluddin Abbas**
Department of Zoology, Aligarh Muslim University, Aligarh-202002
** Author for Correspondence*

ABSTRACT
Present study is based on seasonal diversity of Collembola assemblages in two different habitats of Aligarh. The two different habitats selected in this study are agricultural (disturbed) and a natural (undisturbed) field. Four questions are addressed in this study. (i) Do local Collembola assemblages showed a consistent response to disturbances? (ii) Can particular species or functional group be identified that may reliable indicator of ecological change? (iii) To what extent do responses of collembola merely reflect those of vegetation covered? And (iv) What affect of seasonal changes on diversity of collembola? Total 96 samples have been collected from two different habitats with respect to the degree of change. All soil microarthropods extracted with the help of Tullgren's funnel apparatus. Among the soil microarthropods collected, Collembolans found highly frequent in entire community of soil microarthropods, comprising up to 70.8% absolute frequency in natural site whereas 68.8% in disturbed site. There was no significant difference in species diversity of sites investigated. However, multivariate analysis demonstrated a strong correspondence between Collembola composition and degree of habitat disturbance. We observed that both, vegetation covered and assemblages of Collembola showed a consistent but apparently meaningful differentiation among disturbed as well as undisturbed sites.

Key Words: *Microarthropods, Collembola, Seasonal Diversity, Bio-Indicator, Habitat Quality, Disturbance*

INTRODUCTION
Collembola is a dominant group with in entire community of soil microarthropods and it is linked to fungal based food habits in native agricultural soils. Their high diversity, functional importance, sensitivity to disturbance and easy of sampling, makes them potentially useful bio-indicators for land management practices. These soil organisms play a significant role in mineralization and humification of organic matter (Coleman, 1985; Huhta *et al.*, 1988; Czarnecki, 1989; Striganowa, 1992). Moreover, they are considered as the indicator organisms in studies of soil quality (Heisler,1995; Kopszki, 1997).
Microarthropods are abundant in most agricultural soils but their importance is often overlooked (Crossley *et al.*, 1992). Differences in frequency distribution (abundance) of soil microarthropods may also serve as strong variables to make them for ecosystem conditions and environmental suitability whereas the impact of disturbance on abundance and diversity of soil microarthropods due to changes in land use practices. Land use practices are other tasks for development and implementation as effective measures and to preserve biodiversity of such microarthropods especially that of collembolans because some numerous researchers also stated that vegetation covers influence the activities of diverse soil organisms including collembolans (Hansen, 2001) whereas, alteration of soil animal species depends on the climatic variations (Parwez *et al*., 2011).
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 Aligarh 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.

MATERIALS AND METHODS

Area of Study

The area selected for study is situated at Aligarh. It is a flat topographical area, located in western part of UP at latitude 27-54'N, longitude 78-05E' and altitude 187.45 meter above sea level. It is a subtropical zone with fluctuating climatic conditions consisting of four different seasons characterized by extreme winter and summer followed by medium to heavy rainfall during monsoon months and a post monsoon sweet spring. In hot dry summer, the temperature rises up to 48 ºC, while in winter-cold, the temperature down up to 2 ºC. Relative humidity also fluctuates with the sudden change of environmental temperature and with rainfall patterns. Such widely varying climatic conditions provide a variety of ecological niche to soil dwelling organisms and interesting for soil ecological studies in this region.

(A) Study Sites

(I) Agricultural (Disturbed) Site

We selected a site at Quarsi village that is situated at the outskirts of Aligarh city. It is a non urban site approximately 3 km. from AMU Campus. Different crops considered with in a year such as Maize (*Zea mays*), Indian Jwar and Wheat (*Triticum aestivum*) etc.

The soil of this site is course textured a mixture of sand, silt and clay, high enough to hold water and plant nutrients. In addition of organic substances in soil increases the fertility and water holding capacity of this soil, so that it keeps sufficient moisture especially in wheat crop. This soil is more fertile and able to produce more crops. Every crop was well managed by its farmer in terms of ploughing, irrigation and care taking during the crop standing time. Thus the site is continuously disturbed by tilling the land mechanically as well as human interference.

(II) Natural (Undisturbed) Field

Another site that we selected was natural that is located at Zakir Bagh, which is situated at the heart of University. This field is approximately 2 acre in size without growing any crop (undisturbed). However, the moisture is keeping regularly due to water from masjid that is situated in between the mid part of the field investigated. The samples were collected from the back site of masjid to avoid the any of disturbances because no human interference was recorded at the back site field.

(B) *Sampling and Extraction of Soil Microarthropods*

As mentioned earlier, samples were taken every week regularly and the points selected within the plots were distributed randomly. Total, 96 samples have been taken for site study during the investigation period from both sites. Each sample consists of 4 corers of 5 cm. size. 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.

(C) *Identification*

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 binocular stereo-microscope was used to identify soil microarthropods.

(D) *Analysis of Edaphic Factors*

Temperature of the soil was measured by directly inserting the thermometer into the soil up to the required soil depth and Relative Humidity was determined by Dial hydrometer. Soil Moisture has been determined by using the gravimetric method as described by Dowdswell, (1959). Soil pH, Organic Carbon, and Nitrogen, all were examined by standard laboratory methods.

(E) *Statistical Analysis*

To study the diversity of soil microarthropods, the parameters considered were density, abundance, (Abbas and Parwez, 2009) fractional population, relative density, and absolute frequency, Shannon Wiener diversity index (H) and Evenness (J) between the sites. ANOVA was used to determine the correlation between population of soil microarthropods with reference to various edaphic and soil chemical parameters.

RESULTS

Sampling revealed a hitherto unexpected abundance and diversity of Collembola. 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 19.6 (ind/sample) and 13.5 (ind/sample) respectively in disturbed site. The highest (53.5%) collembolans recorded in Spring season while the lowest 4.3% in Rainfall in disturbed site.

In soil dwelling Apterygotes, more than 96% collembolans have been recorded however, peak population of collembolans recorded in spring (60.5% and the least population (3.9%) in rainfall season. The mean average of density and abundance of Collembolans were recorded 13.2 (ind/sample) and 18.6 (ind/sample) respectively (Table 1) in natural site. The highest abundance and density of collembolans recorded in the month of February (41.3%) while in June and August, collembolans were totally absent in natural site.

In agriculture (disturbed) site, the total organic carbon recorded during the investigation period which was higher (0.25%) in the month of January and minimum was in June (0.18%. In case of natural site, the maximum total organic carbon (0.33%) content found in the month of November while the minimum recorded in the month of December (0.16%). Soil temperature ($r = -0.932$) and pH ($r = -0.708$) were negatively correlated with reference to Collembola populationin disturbed site as well as in natural site (soil temperature, $r = -0.867$ and pH, $r = -0.790$) at 5 % level of significance (Table 3). Available nitrogen always found significantly positive with reference to soil microarthropods population (Figure A).

Among the soil microarthropods collected, Collembola was the dominant group and absolutely frequent up to 70.8 % in natural site followed by 68.8 % 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). The peak population of Collembola has been recorded in Winter while sharp decline in Summer months in both study sites. Similar trend of population fluctuation have been recorded in both sites (Table 2).

Table 1: Quantitative analysis of Collembola population against different parameters

Parameters	Disturbed site	Natural site
Mean Density	13.54	13.20
Abundance	19.69	18.64
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

Table 2: Mean ± SD of seasonal population dynamics of Collembola at Aligarh

Season	Disturbed site	Natural site
Summer	9.67±15.99	12.00±12.53
Fall	9.33±6.11	8.33±10.41
Winter	81.67±49.66	63.00±29.05
Spring	116.00±87.16	128.00±38.59

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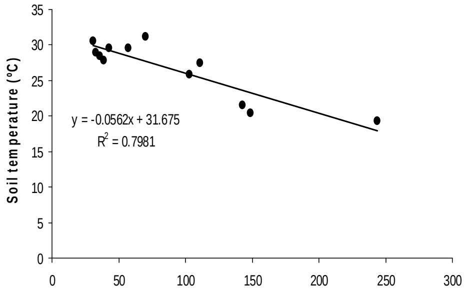

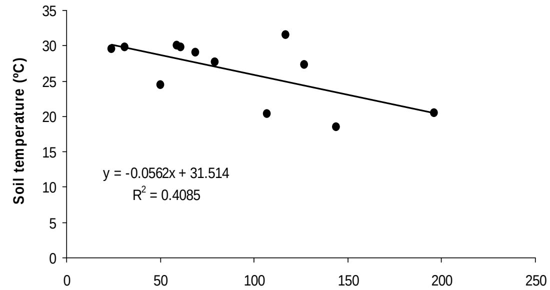

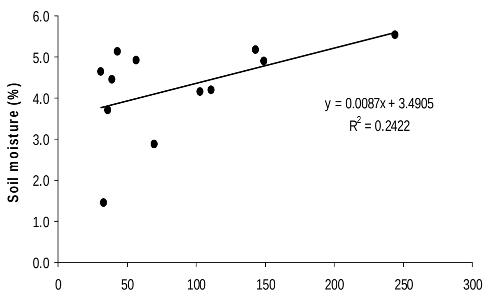

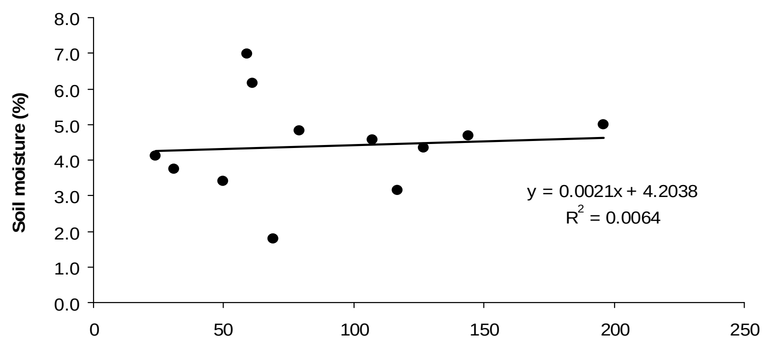

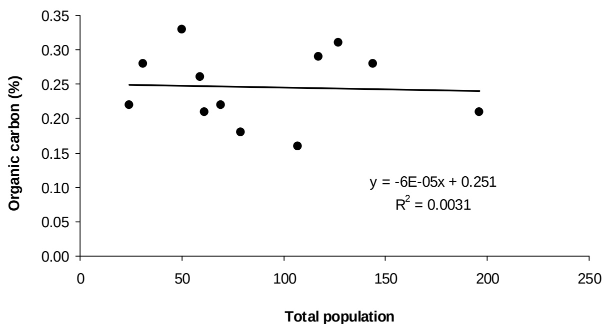

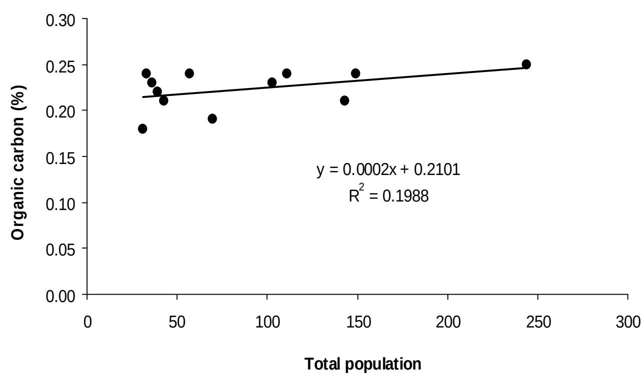

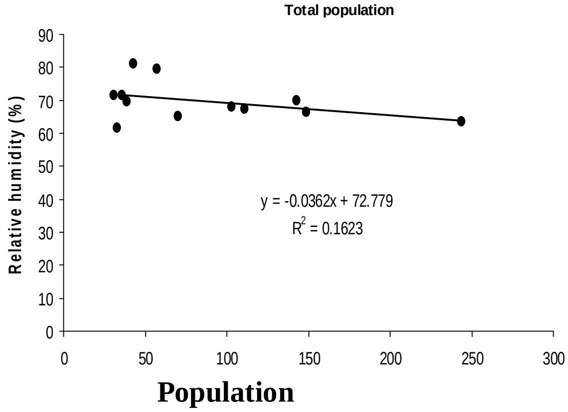

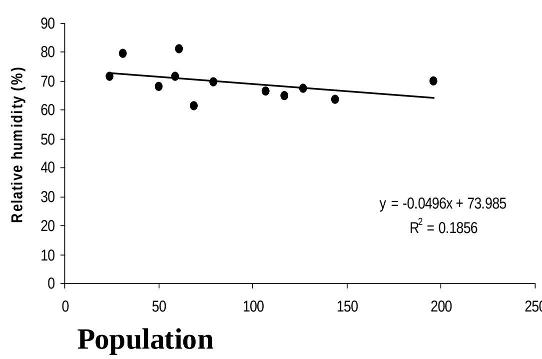

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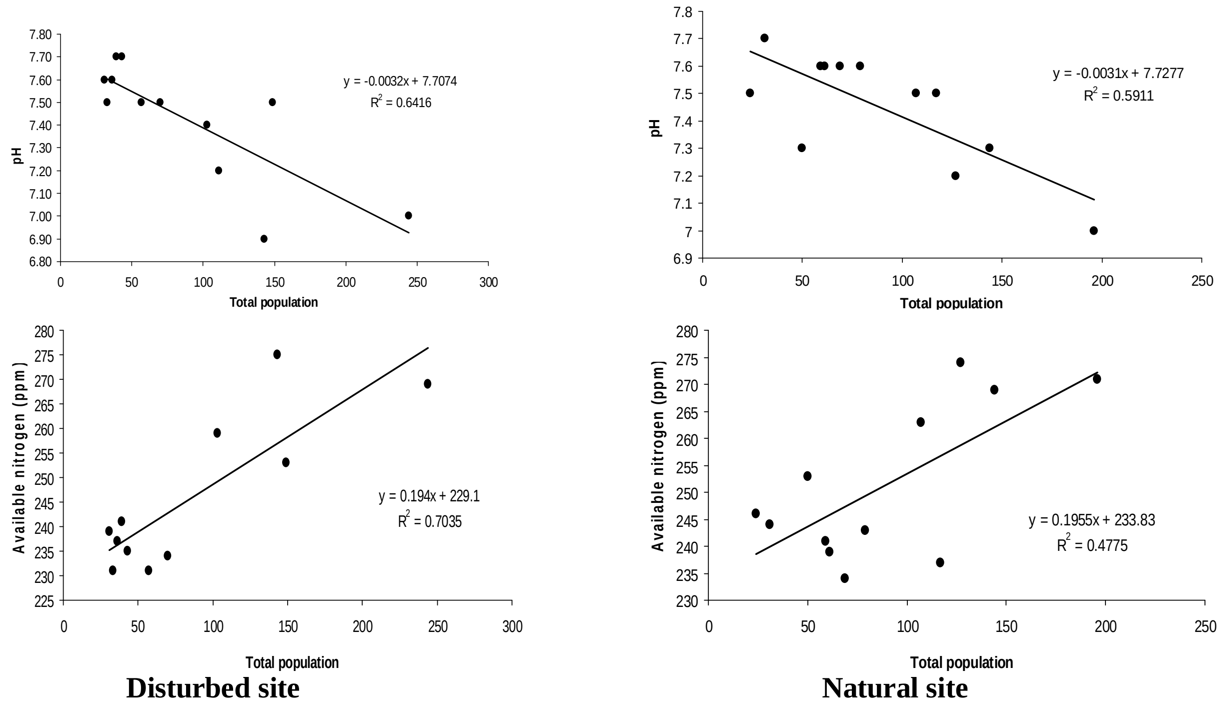

Figure 1: Regression analysis between soil parameters and total microarthropods population in two different sites at Aligarh

Table 3: Correlation between Collembola population and soil properties

Variables	(A) Disturbed site			
	Correlation	**Slope**	**Intercept**	**Significance**
Soil Temperature	-0.932	-0.059	29.90	S
Soil Moisture	0.502	0.009	3.78	
RH	-0.404	-0.036	71.55	
pH	-0.708	-0.003	7.58	S
Organic carbon	0.412	0.001	0.22	
Available Nitrogen	0.656	0.183	238.87	S
(B) Natural site				
Soil Temperature	-0.867	-0.070	30.24	S
Soil Moisture	0.118	0.003	4.24	
RH	-0.357	-0.038	71.58	
pH	-0.790	-0.003	7.61	S
Organic carbon	-0.189	0.000	0.26	
Available Nitrogen	0.847	0.221	239.51	S

DISCUSSION

The potential use of soil inhabiting microarthropods can be evaluated because of their utility of plant promoting nature. Among soil microarthropods investigated, Collembola found a highly diversified group in native agricultural soils (approximately 70 % 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.

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). However, the factors determining the prevalence of a particular species in a local community are still unknown (Sleptsova and Reznikova, 2006). Thus, real disturbances cannot be proved because of density, abundance and survival of soil microarthropods along with concomitant changes with edaphic conditions is still undergoes dynamic changes of climate. Unfortunately, physical factors such as soil temperature and moisture being interlinked and are perhaps inseparable in natural conditions.

We observed that both, vegetation covered and assemblages of Collembola showed a consistent but apparently meaningful differentiation among disturbed as well as undisturbed sites. Higher density and abundance of Collembola found in disturbed site directly support the positive relationship between soil fauna and floral densities and this favors of agricultural management practices but having minimum disturbances. Because the degree of disturbances directly pronounced to the negative affect on the population density and abundance of soil microarthropods. However, agricultural management practices sharply regenerated the population via support in reproduction and food availability for their growth. Thus, higher degree of disturbance such as mechanical tillage and sudden changed environmental conditions (rising temperature with humid conditions) directly affect the Collembola population. Vegetation covers also influence the activities of diverse soil organisms including collembolans (Hansen, 2001).

From the view of our results, we can assume that the response of Collembola community can be varying consistently against the site disturbance, yet it may positive (mostly) or, negative (rare) but not continuously after every disturbance. This may refer to the answer of my first question. However, edaphic and weather conditions may be more pronounced to the direct affect on the diversity of living beings in an ecosystem. So, that their developmental rate is directly climatic and edaphic dependent.

We can identify a functional group of potential use that may reliable indicator of ecological change rather than a single species because the fitness of an indicator is directly dependent on the biotic potential (functional part) of the vegetation occupying the site specific productivity (Knoepp *et al*., 2000). And because of single species cannot perform the all functional conditions, so the reliability of it may be doubtful. Perhaps it is due to the ecological change that is so much complex in order to interlink between climate, soil properties and bio productive capacity of an ecosystem environment. Soil microarthropods act as buffer energy source both for soil and plants, and they also act as an indicator of soil conditions. Thus, microarthropods can be used for soil diagnosis (Chaudhary and Roy, 1967). This may refer to the answer of my second question.

We observed from our results that, Collembola assemblages respond to disturbance associated with human land use and these responses do not simply reflect those of plants. Therefore, they participate in soil matter decomposition processes and nutrient recycling. Thus, they favor in increasing plant diversity and play an important role indirectly in plant growth, soil fertility and food productivity. Collembolans are therefore potentially useful bio-indicators of ecological change in an agro- ecosystem (disturbed). It may refer to the answer of my third question.

The results revealed that the Collembola assemblages 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 microarthropods including Collembola. This may refer to a simple answer of my fourth question.Interestingly, stable soil moisture and medium temperature regimes are critical source for high density buildup of soil microarthropods because this may lead to the reproduction rate of soil biota along with their fecundity and adaptability to such favorable climatic conditions. Hence, Winter and Spring both are the favorable seasons for growth of soil Collembolans in agricultural soils (Abbas and Parwez, 2012). Ultimately, soil food productivity is affected via their functional approach. This shows the density dependent nature of an ecosystem. Hence, this study clearly establishes that higher biodiversity favors the higher reliability and an evidence for long term functional approach of an agro-ecosystem.

It is clearly hypothesized that densities of Collembola may vary at regional or local level even it depends on various parameters such as food availability, nature of concern vegetation, structure & matrix of soil, habitat quality and weather conditions along with local disturbances in an agro-ecosystem. This study provides a baseline data source for making difference accurately and to assess the impact of seasonal changes on applied management practices.

Conclusions

Following are the contributions of this study that-Diversity indices of both sites indicate that no site differentiation has been recorded significantly and both sites are normal to achieve the goal of land use regimes.

The survival growth of Collembola is often temperature dependent. Therefore, Collembolans are more survival in winter months than compare to summer and rainy season.

Edaphic properties and weather conditions may be more pronounced to the direct affect on the diversity of soil microarthropods in an agro-ecosystem.

Thus, stable soil moisture and medium temperature regimes are critical source for high density buildup of soil microarthropods and this may lead to soil productive capacity.

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