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Temporal Variations in Population Dynamics of Soil Micro-Arthropods: Acarina and Collembola

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Abstract: In this study, we investigate temporal variations in population dynamics of soil micro-arthropods from some selected sites at Aligarh. We examine the variations of soil micro-arthropods. Among the soil micro-arthropods examined, we concentrate on mesofaunal group, specifically, acarina and collembola. To examine the variations of these species, we collect samples of soil from different sites-agriculture, vegetative and unarable land. The parameters that we examine are population, population density and abundance of soil micro-arthropods. We carried out experiments and observed that the total population of acarina in case of tomato is 3.58% smaller than that of collembola and the total population of acarina in case of brinjal is 10.67% smaller than that of collembola. Further, we found that the total population of acarina in maize is 4.10% larger than that of collembola and the total population of acarina in case of the natural site is 11.02% larger than that of collembola. Further, we compare the abundance and density of soil micro-arthropods found from different sites.

Key words: Temporal variations, population dynamics, micro-arthropods, acarina, collembola

INTRODUCTION

Soil micro-arthropods have significant role in the soil ecological system because they affect the productions due to their grazing activities and nutrient turnover by their roles as decomposer. The population of soil micro-arthropods may vary with time, place and several other parameters. The variations in the population of soil micro-arthropods with time are generally called as the population dynamics. The population dynamics of soil micro-arthropods may have a profound impact on the functional attributes of soil biodiversity and which may in turn enable one to decide about the soil fertility and soil quality.

There have been many studies reporting the impact of different categories of soil micro-arthropods on agricultural practices pertaining to cultivated and uncultivated or natural soils. Many of them focused on the population of mesofaunas in arable lands as well as unarable lands. For example, population of soil mites in uncultivated soil adjacent to crop fields in central Argentina is studied by Adren and Lagertof (1983). In Fox *et al.* (1996) and Pelletier (1999), the effects of mesofaunas on the biodiversity are studied. The effects of some physical factors and agricultural practices on the population of collembola in a multiple cropping programme is studied by Bandyopadhyaya *et al.* (2002) for the region West Bengal of India. Studies on soil mites from the point of view of their abundance and their effect on agriculture are presented by Behan-Pelletier (1999), Bedano *et al.* (2005). In Butcher *et al.* (1971), bio-ecology of collembola and acarina is presented. There are other researches such as those by Coleman *et al.* (1983), Cortet *et al.* (2002), Fonseca and Sarkar (1998), Natuhara *et al.* (1994), Noble *et al.* (1996), Pokarzhevskii and Krivolutskii (1997) and Whitford (1989) that present studies of soil micro-arthropods for different regions and different perspectives. Principles of sampling and enumeration for soil micro-arthropods are described by Coleman *et al.* (2004).

In this study, we wish to investigate the temporal variations in the population dynamics of soil micro-arthropods. Among many kinds of soil micro-arthropods mentioned above, we focus on the population dynamics of soil mesofaunas.

The parameters that we consider for evaluating the population dynamics are abundance and density of different species of soil mesofaunas. We study the effect of different environmental parameters such as moisture, relative humidity, temperature etc. on the population dynamics.

This study revealed temporal variations in the population dynamics of soil arthropods between three contrasting sites at Aligarh. In the study, we selected Aligarh because it provides a diversity of sites in terms of greeneries, agricultural, etc. We selected three different sites at Aligarh. The types of sites considered are arable, unarable and vegetative.

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MATERIALS AND METHODS

Here, we provide a brief overview of the sites for the present study and then we describe the sampling techniques used for the population dynamics.

Description of study sites: We took samples from three different sites at Aligarh, which are as follows:

Vegetative site: This site is situated at Zakir Bagh, which is at the heart of Aligarh Muslim University (AMU) campus. For this, we considered a kitchen garden. Tomato and Brinjal vegetables were grown in the very beginning of March 2008. After plantation of one month (when the plants were 5-10 cm long), soil samples were taken at regular intervals of time and from random points inside the kitchen garden.

Agricultural site: We selected a site at Quarsi village that is situated at the outskirts of Aligarh city and is a non-urban site. The crop that we considered was maize. The samples were taken regularly and from random points inside the field.

Unarable site: This site also belongs to the locality of Zakir Bagh situated inside the AMU campus with the difference that though the site is fertile, however, nothing is cultivated in an unarable site. It is a natural site without cultivation. For this site also, we did took samples from random points and at regular intervals of time.

Sampling: As mentioned earlier, for each of these sites, samples were taken every week regularly and the points selected within a site were distributed randomly. Specifically, we took 12 samples for each of these sites vegetative, agriculture and natural (unarable land). Among the vegetative site there were two vegetables brinjal and tomato. As a whole, there were 48 samples for all of these sites taken together. Each sample consists of soil up to a depth of 5 cm. In each sample, we counted the number of soil micro-arthropods. Further, for each sample, we recorded soil temperature, relative humidity and moisture content etc. Also, we recorded the rainfall for every month.

Apparatus used: For extraction of soil micro-arthropods, we used an apparatus that is generally called as Berlese-Tullgren Funnel. The apparatus consists of funnels, 5 cm corer, bulbs and base. The power of bulbs used was 60 Watts. The size of the corer varies with the amount of the soil examined. The micro-arthropods are collected inside a beaker which contained 70% alcohol and few drops of glycerol so that the micro-arthropods are not got dried. The instrument is on for period of 24-72 h so that the majority of micro-arthropods fall inside the beaker.

We took care of the instrument so that it was not overheated during the extraction period. After that all animal material was collected into glass vials. These vials contain either picric acid (2, 4, 6 tri nitro phenol) or lactic acid as a preservant for the population of micro-arthropods. Micro-arthropods were separated and mounted in Henze's medium.

Identification: The soil micro-arthropods are identified from the slides prepared during the process of extraction. We are interested in the population dynamics of soil micro-arthropods. All micro-arthropods were identified up to the level of their order using a range of taxonomic keys (O'Connell and Bolger, 1997). For identifying them, we used stereomicroscope.

RESULTS AND DISCUSSION

For each site and for each sample, we identified and quantified soil micro-arthropods. We are interested in the population dynamics of soil micro-arthropods. Specifically, we considered the population of soil micro-arthropods (mesofauna) in terms of acarina, collembola and miscellaneous. The soil micro-arthropods that are in addition to the acarina or collembola are taken to be in the miscellaneous category for the sake of simplicity.

Statistical parameters: To study the population dynamics of soil micro-arthropods, we considered the following parameters: population, population density and abundance.

The abundance is defined as the ratio of the total population of individual species and the number of samples in which the species was present. In other words, the abundance is as follows:

$$a = \frac{\sum_{i=1}^{|S|} p_i}{|S_p|}$$

Where:

a = The abundance

p_i = The population of an individual species

|S| = The total number of samples examined

$|S_p|$ = The number of samples in which the species was found

The population density is defined to be the ratio of the total population of an individual species and the total number of samples examined. In other words, the population density is as follows:

$$d = \frac{\sum_{i=1}^{|S|} p_i}{|S|}$$

Experimental results: In this subsection, we present results obtained through experiments. We classify the results into two categories. The first category contains the results pertaining to the environmental parameters as these parameters affect the population of soil micro-arthropods. The second category contains the results regarding the population of soil micro-arthropods.

Environmental parameters: The parameters that we measure are temperature of the soil, moisture, relative humidity and rainfall. The temperatures that we measure are that of air, soil surface and at the depth of 5 cm.

Figure 1 shows the temperatures of air, soil surface as well as at the depth of 5 cm in degree centigrade. We observe that the air temperature and the temperature of soil surface increase from the beginning of the April till the first week of May and thereafter these temperatures decrease and then become almost constant. In the month of April, the temperature increased due to an increasing intensity of the sunshine The reason for the decrease afterwards is that from the beginning of the second week of May, raining started due to that the temperature of air as well as the temperature of soil decreased. Intensity of the sunshine increases from April to June; however, increased rains maintained a balance in the temperature. We observe that the temperature at the depth of 5 cm does not vary significantly.

Figure 2 shows the moisture content of the soil for different sites. We observe that the moisture content increases with time. The reason is that as the time passes, the rainfall increases, thereby increasing the moisture. The moisture content across different sites is almost the same.

Figure 3 shows the relative humidity in percent. We observe that the relative humidity first increases in the months of April-May and then decreases and again increases. The reasons for this can be related to the raining and the variations in the temperature.

Figure 4 shows the rainfall per 10 days of a month as well as per month. In the month of April there is no rainfall at all in first 20 days and there is very little rainfall in the last 10 days. In the month of May, the rainfall increases and in June there was a significant amount of rainfall. The rainfall affects the air temperature, the temperature

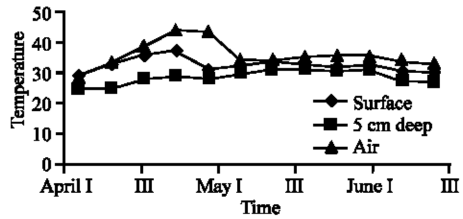

Fig. 1: Variations in temperature of soil as a function of time

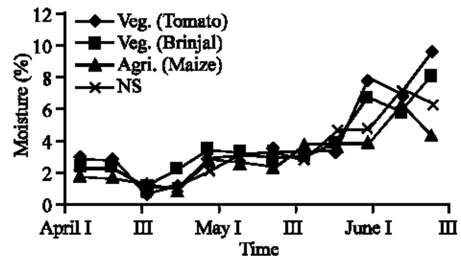

Fig. 2: Moisture contents of soil as a function of time in different sites

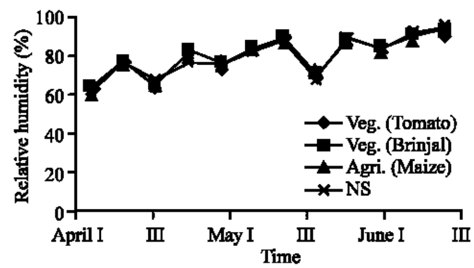

Fig. 3: Relative humidity as a function of time in different sites

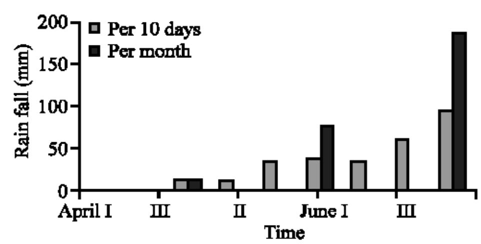

Fig. 4: Rainfall (mm) as a function of time

of the soil surface and other parameters such as moisture contents of the soil and relative humidity. In fact, the moisture contents of the soil and the relative humidity increases with an increase in the rainfall however, the temperature decreases.

Population results: We depict the temporal variations in population of acarina and collembolan as a function of time through graphs. Other parameters such as density and abundance are explained through tables as these parameters require an overall view of soil micro-arthropods.

Variations in population: Figure 5 shows the population of soil micro-arthropods in a vegetative site of tomato. In the month of April the population of collembolan is larger than that of acarina and for other months it is more or less comparable. The same is true for the population of these soil micro-arthropods in a vegetative site of brinjal as shown in Fig. 6.

Figure 7 shows the population of soil micro-arthropods in an agricultural site of maize. We observe that the population of collembolan is larger than that of acarina in the month of April. However, the population of acarina is larger than that of collembolan in May.

Figure 8 shows the population of soil micro-arthropods in for a natural (unarable) site. We observe that the population of acarina is larger than that of collembolan for April and May. However, there are fluctuations in the populations of acarina for different sampling times.

In what follows, we discuss the net effect in the population dynamics of soil micro-arthropods.

Population dynamics: We now wish to discuss the variations in the population dynamics of soil micro-arthropods on aggregate basis. For that we consider average population, fractional population, population density and the abundance of soil micro-arthropods.

Table 1 shows the average population of soil micro-arthropods in different months. We observe that the average population of acarina in case of tomato increases as we move from April to June while the average population of collembola decreases. The last row of Table 1 contains the average population of soil micro-arthropods in all months taken together. We observe that the total average population of acarina is smaller than that of collembola for vegetative sites of tomato and brinjal. However, the total average population of acarina in case of the agricultural site consisting of maize is larger than that of collembola. The same applies to the natural site also.

Table 2 shows the fractional population (in percentage) of soil micro-arthropods in different months. The fractional population of a month is the number of soil micro-arthropods of one type divided by the total number of soil micro-arthropods within that month and it is multiplied by 100 to convert it into percentage. From Table 3, we observe that for tomato the fractional population of both types of soil micro-arthropods i.e.,

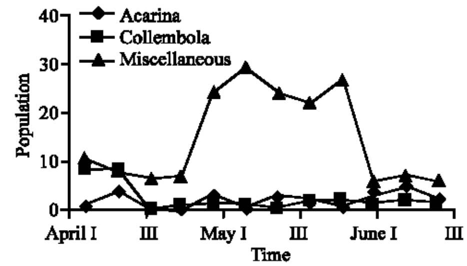

Fig. 5: Population of soil micro-arthropods as a function of time in a vegetative site of tomato

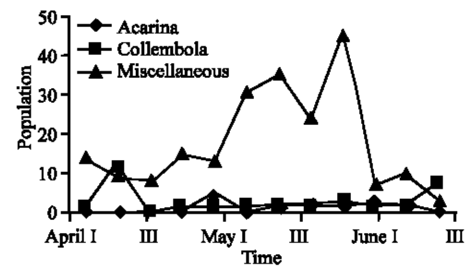

Fig. 6: Population of soil micro-arthropods as a function of time in a vegetative site of brinjal

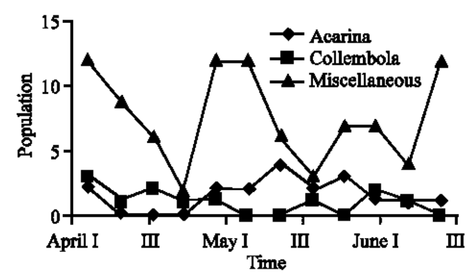

Fig. 7: Population of soil micro-arthropods as a function of time in an agricultural site of maize

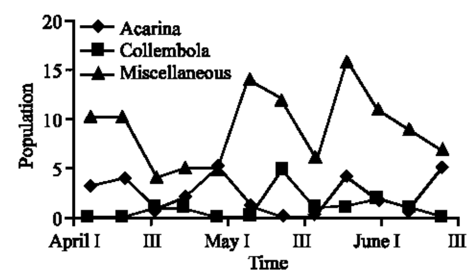

Fig. 8: Population of soil micro-arthropods as a function of time in a natural site

acarina and collembolla in the month of May is less than that of April and June. For brinjal, the fractional population of acarina in May-June is almost same however, it is absent in April; the fractional population of

Table 1: Average population of soil micro-arthropods in different months

	Tomato			Brinjal			Maize			Natural		
Months	A	C	M	A	C	M	A	C	M	A	C	M
April	1.25	4.25	8.00	0.00	3.50	11.50	0.50	1.75	7.25	2.50	0.50	7.25
May	2.00	1.00	25.25	1.75	1.50	26.00	2.50	0.50	8.25	1.50	1.50	9.25
June	2.75	1.50	11.50	1.25	3.25	16.50	1.50	0.75	7.50	3.00	1.00	10.75
Total	1.66	2.25	14.91	1.00	2.75	18.00	1.50	1.00	7.66	2.33	1.00	9.08

Table 2: The fractional population (%) of soil micro-arthropods in different months

	Tomato			Brinjal			Maize			Natural		
Months	A	C	M	A	C	M	A	C	M	A	C	M
April	9.25	31.48	59.25	0.00	23.33	76.67	5.26	18.42	76.32	24.39	4.88	70.73
May	7.08	3.54	89.38	5.98	5.13	88.89	22.22	4.45	73.33	12.24	12.24	75.52
June	17.46	9.52	73.02	5.95	15.48	78.57	15.38	7.69	76.92	20.34	6.78	72.88
Total	11.26	14.84	73.88	3.98	14.65	81.37	14.29	10.19	75.52	18.99	7.97	73.04

Table 3: The total population, population density and abundance of soil micro-arthropods

	Tomato			Brinjal			Maize			Natural		
Parameters	A	C	M	A	C	M	A	C	M	A	C	M
Population	14	27	179	12	33	216	18	12	92	28	12	109
Density	1.17	2.25	14.92	1.00	2.75	18.00	1.50	1.00	7.67	2.33	1.00	9.08
Abundance	1.56	2.70	14.92	2.00	3.00	18.00	2.00	1.50	7.67	2.80	1.71	9.08

collembola in April is the largest, while in the month of May, it is the smallest. In case of the agricultural site that consists of maize, the fractional population of acarina in May is the largest and that in April is the smallest. In case of the natural site, the fractional population of acarina in general is greater than that of collembola. Further, the fractional population of acarina in the month of April is the largest while that in May is the least. The fractional population of collembola in May is the largest, while that in April is the least.

In totality, for vegetative sites the fractional population of acarina is smaller than that of collembola. Specifically, the total population of acarina in case of tomato is 11.26%, while that of collembola is 14.84%. We find that the total population of acarina in case of tomato is 3.58% less than that of collembola. Similarly, the total population of acarina in case of brinjal is 3.98% and that of collembola is 14.65%. In other words, the total population of acarina in case of brinjal is 10.67% smaller than that of collembola. In case of agricultural site consisting of maize and that in natural site, the total fractional population of acarina is larger than that of collembola. Specifically, the total population of acarina in case maize is 14.29% and that of collembola is 10.19%. We find that the total population of acarina in maize is 4.10% larger than that of collembola. Similarly, the total population of acarina in case of a natural site is 18.99% and that of collembola is 7.97%. In other words, the total population of acarina in case of the natural site is 11.02% larger than that of collembola.

Table 3 shows the total population, population density and abundance of soil micro-arthropods for each of these sites. We observe that the total population of acarina in vegetative sites of tomato and brinjal is less than that of collembola. The total population of acarina in the agricultural site that consists of maize is greater than that of collembola. The population density of acarina in case of tomato and brinjal is less than that of collembola while the population density of acarina in case of maize is greater than that of collembola. Specifically, the population density of acarina in case of tomato is 1.17 and that of collembola is 2.25. The population density of acarina in case of brinjal is 1.00 and that of collembola is 2.75. In case of the agricultural site that consists of maize the population density of acarina is 1.50 and that of collembola is 1.00. Similarly, the population density of acarina in case of natural site is 2.33 and that of collembola is 1.00.

A similar trend is observed for the abundance also. Specifically, the abundance of acarina in case of tomato is 1.56 and that of collembola is 2.70. In case of brinjal, the abundance of acarina is 2.00 and that of collembola is 3.00. In case of maize, the abundance of acarina is 2.00 and that of collembola is 1.50. In case of the natural site, the abundance of acarina is 2.80 and that of collembola is 1.71.

CONCLUSION

In this study, we studied temporal variations in population dynamics of soil micro-arthropods at some selected sites of Aligarh. The contributions of the study are as follows:

- We selected three types of sites: vegetative, agricultural and natural. The vegetative site consists of tomato and brinjal. For all these sites, we studied the population of soil micro-arthropods in terms acarina and collembola

- In the study, we focused on the following parameters: population, population density and abundance of soil micro-arthropods
- We carried out experiments and observed that the total population of acarina in case of tomato is 3.58% smaller than that of collembola and the total population of acarina in case of brinjal is 10.67% smaller than that of collembola
- Further, we found that the total population of acarina in maize is 4.10% larger than that of collembola and the total population of acarina in case of the natural site is 11.02% larger than that of collembola
- The study of different parameters such as the composition of soil and its effect on the population of soil micro-arthropods forms our future research

REFERENCES

Adren, O. and J. Lagerlof, 1983. Soil fauna (microarthropods, enchytreids and nematodes) in Swedish agricultural cropping system. Acta Agric. Scand., 33: 33-52. DOI: 10.1080/00015128309435350.

Bandyopadhyaya, I., D.K. Choudhuri and J.F. Ponge, 2002. Effects of some physical factors and agricultural practices on collembola in a multiple cropping programme in West Bengal (India). Eur. J. Soil Biol., 38: 111-117. DOI: 10.1016/S1164-5563(01) 01114-1.

Behan-Pelletier, V.M., 1999. Oribatid mite biodiversity in agro-ecosystems: Role for bioindication. Agric. Ecosys. Environ., 74: 411-423. DOI: 10.1016/S0167-8809(99)00046-8.

Bedano, J.C., M.P. Cantu and M.E. Doucet, 2005. Abundance of soil mites (arachnida: Acari) in a natural soil of central A r gentina. J. Zool. Stud., 44 (4): 505-512. http://zoolstud.sinica.edu.tw/Journals/44.4/505.pdf.

Butcher, J.W., R. Snider and R.J. Snider, 1971. Bioecology of edaphic collembola and acarina. Ann. Rev. Entomol., 16: 249-88. DOI:10.1146/annurev.en.16.010 171.001341.

Coleman, D.C., D.A. Crossley and P.F. Hendrix, 2004. Fundamentals of Soil Ecology. 2nd Edn. Academic Press, San Diego. ISBN: 0-12-179726-0.

Coleman, D.C., C.P. Reid and C.V. Cole, 1983. Biological strategies of nutrient cycling in soil systems. Adv. Ecol. Res., 13: 1-55. DOI: 10.1016/S0065-2504(08) 60107-5.

Cortet, J., D. Ronce, N. Poinsot-Balaguer, C. Beaufreton, A. Chabert, P. Viaux and J.P.C. Fonseca, 2002. Impacts of different agricultural practices on the biodiversity of microarthropod communities in arable crop systems. Eur. J. Soil Biol., 38: 239-244. DOI: 10. 1016/S1164-5563(02)01152-4.

Fonseca, J.P.C. and S. Sarkar, 1998. Soil microarthropods in two different managed ecological systems (Tripura, India). Appl. Soil Econ., 9: 105-107. DOI: 10. 1016/S0929-1393(98)00062-6.

Natuhara, Y., C. Imai and H. Takeda, 1994. Classification and ordination of communities of soil arthropods in an urban park of Osaka City. Ecol. Res., 9 (2): 131-141. DOI: 10.1007/BF02347488.

Noble, J.C., W.G. Whitford and M. Kaiszweski, 1996. Soil and litter microarthropod populations from two contrasting ecosystems in semi arid eastern Australia. J. Arid Environ., 32 (3): 329-346. DOI: 10. 1006/jare.1996.0027.

O'Connell, T. and T. Bolger, 1997. Stability, ephemerality and dispersal ability: Microarthropod assemblages on fungal sporophores. Biol. J. Linnean Soc., 62 (1): 111-131. DOI: 10.1111/j.1095-8312.1997.tb01617.

Paoletti, M.G., 1999. Using bioindicators based on biodiversity to assess landscape sustainability. Agric. Ecosyst. Environ., 74: 1-18. DOI: 10.1016/ S0167-8809(99)00027-4.

Pokarzhevskii, A.D. and D.A. Krivolutskii, 1997. Problems of estimating and maintaining biodiversity of soil biota in natural and agroecosystems: A case study of chernozem soil. Agric. Ecosyst. Environ., 62: 127-163. DOI: 10.1016/S0167-8809(96)01139-5.

Whitford, W.G., 1989. Abiotic controls of the functional structure of soil food webs. Biol. Fert. Soils, 8 (1): 1-6. DOI: 10.1007/BF00260508.