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Assessing Diversity and Abundance of Soil Microarthropods in Three Discrete Plots of Ramakrishna Mission Vivekananda Ashrama, Narendrapur, South 24 Parganas, West Bengal, India

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ABSTRACT

This paper is a study of diversity and seasonal abundance of soil inhabiting arthropod fauna and their interrelationships with the edaphic factors like temperature, moisture and pH in flower garden, vegetable garden and uncultivated area dominated by weeds in Ramakrishna Mission Ashrama Campus, Narendrapur, South - 24 Parganas, West Bengal. The soil arthropods were collected with the help of Berlese-Tullgren funnels. Altogether, 591 arthropods belonging to 7 different groups viz., Acarina, Arachnida, Collembola, Coleoptera, Diptera, Hymenoptera and Psocoptera were extracted from each of the three plots every month during the entire survey period (August 2018 – July 2019). Microarthropod abundance was found to be greater in uncultivated areas (266 individuals) as compared to that of the flower and vegetable gardens where different agronomic practices are adopted and traditional means of garden nurturing viz. tilling, raking, weeding, etc. are followed. Of the total population in all three plots, mites were the most dominant group (37.06%), followed by ants (25.21%) & springtail (19.29%) populations. Soil arthropods populations are greater in the monsoon season (227 individuals), followed by premonsoon (188 individuals) & postmonsoon (176 individuals).

***Keywords*:** Biodiversity, Soil Microarthropods, RKM Ashrama Campus, Narendrapur, South 24 Parganas

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1. INTRODUCTION

Soil provides food, shelter, anchorage and concealment to rich and varied live communities (Wallwork, 1970). Microarthropods occur in all types of soil. They are of immense importance in the maintenance of various ecological functions, play a pivotal role in soil formation, and increase the porosity, aeration and promotion of soil fertility by breaking down organic matter through the intricate process of digestion (Breure, 2004; Culliney, 2013). The major contribution of arthropods to soil is through decomposition and humification of all organic matter. In the soil, arthropods function as litter transformers, ecosystem engineers and pulverizers (Bagyaraj *et al*., 2016). Several species have been recognized as useful indicators of biological soil quality (Lakshmi & Joseph, 2016). They do not migrate in soil, so when studied, they strictly represent the soil under observation. Studying individual classes or families of organisms may reveal more about ecology of a soil than does studying standard soil health test parameters. They provide a way to measure the biological response to soil environment changes. The importance of these organisms in soil zoology and agriculture are enough to warrant more extensive studies on their taxonomy and bionomics. On this backdrop, the present study attempts to analyze the diversity of soil microarthropods in three discrete plots of Ramakrishna Mission Ashrama Campus, Narendrapur, South 24 Parganas, West Bengal for proper documentation and understanding of the soil ecosystem.

2. STUDY AREA

This survey was conducted between August 2018 and July 2019 within Ramakrishna Mission Ashrama Campus, Narendrapur, South - 24 Parganas (22.44° N Latitude, 88.4° E Longitude) (Fig. 1).

3. MATERIALS & METHODS

Every week, a total of 3 soil samples were collected at random from three selected plots, viz. 1) Flower garden, 2) Vegetable garden, 3) Uncultivated area dominated by weeds (Fig. 2). The samples were taken by means of shovel from the sub-soil layer approximately 4-6 inches deep into the soil, following Chattopadhyay & Hazra (2000); Sanyal *et al*. (2006). Subsequently, they were placed in polythene bags, loosely tied by rubber bands and brought to the laboratory for extraction of soil inhabiting microarthropods. Three bags of soil each of approx. 750 gm were collected from every site during every collection effort. Microarthropods were extracted from the soil samples by using Berlese-Tullgren funnels (Rohitha, 1992; Lakly & Crossley, 2000) (Fig. 3). The process was run for 3-4 days for each sample set up, depending upon the condition of the soil. Mites and other microarthropods extracted were collected and preserved in lactic acid and 70% alcohol, respectively (Ghosh, 1986; Gupta, 1986; Sanyal, 1986).

Extracts were transferred part by part in a petri-dish and microarthropods were sorted from the extract using needle and fine camel hair brush while under Stereo Zoom Binocular Microscope (model Olympus SZX-16) view. The separated microarthropods were kept in eppendorf tubes containing 70% alcohol. Soil temperature, moisture and pH were measured by

4-in-1 Soil Survey Instrument (Model : AMT - 300) (Fig. 2; Table 1), while soil physico-chemical parameters were assessed following Tewari *et al.* (2016).

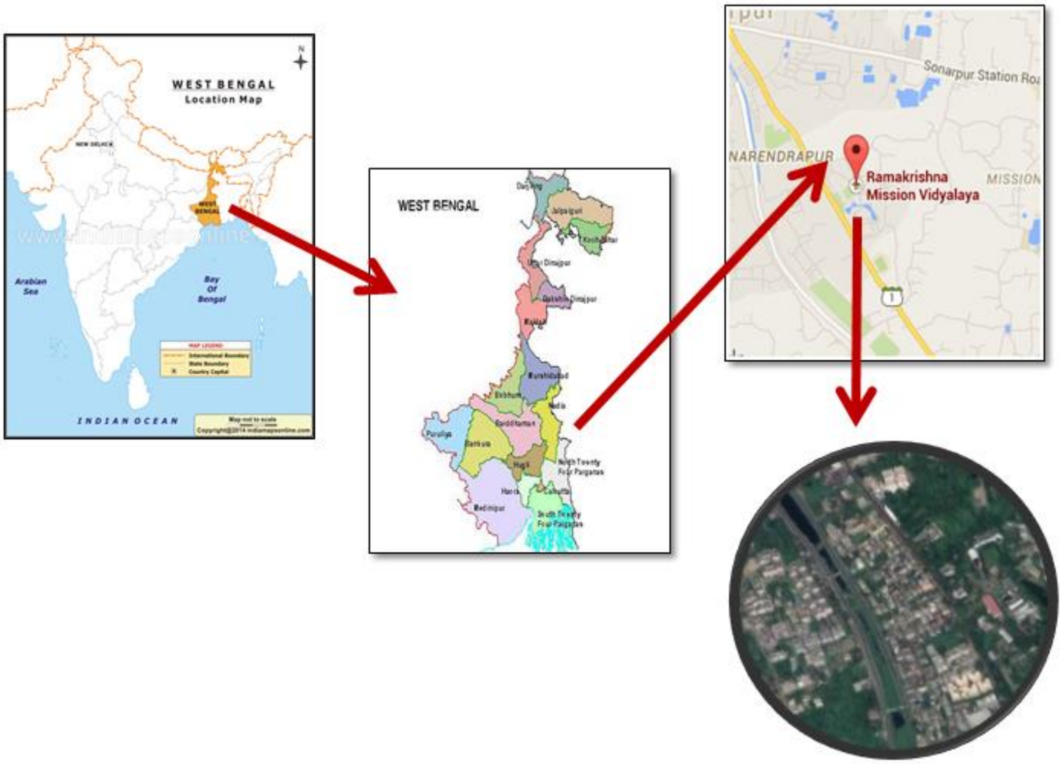

Fig. 1. Study Area.

Fig. 2. Field work.

Fig. 3. Berlese-Tullgren funnels.

4. RESULTS & DISCUSSION

Altogether 591 arthropods belonging to 7 different groups viz., Acarina, Arachnida, Collembola, Coleoptera, Diptera, Hymenoptera and Psocoptera were collected during the entire survey period (Table 1; Figs. 4 & 5). A comparison between arthropods of the uncultivated weed filled plot and the flower garden and vegetable garden plots show that the uncultivated area is rich in faunal groups in comparison to the other two garden plots (Table 1). Microarthropod abundance is more in uncultivated soil (266 individuals) as compared to that of the flower and vegetable gardens where different agronomic practices are adopted and traditional means of garden nurturing viz. tilling, raking, weeding, etc. are followed.

These observations are supported by the earlier works of Sanyal (1991), Sengupta & Sanyal (1991), Sanyal & Sarkar (1993), Cancela da Fonseca & Sarkar (1998), Sarkar *et al.* (2007), Banerjee *et al*, (2009). Of the total population in all the three plots, mites are the most dominant group (37.06%), followed by ants (25.21%) and springtail (19.29%) populations. Soil arthropods are more in the monsoon season (227 individuals) followed by premonsoon (188 individuals) & postmonsoon (176 individuals) (Table 1).

Weather chart and the mean values of selected physicochemical parameters of soil quality during the study period are depicted in the Tables 1 & 2. In the flower garden, correlation coefficient analyses reveal a significant positive relationship of mites and springtails with temperature and soil nitrogen, P_2O_5 and organic carbon, while a negative relationship exists with K_2O.

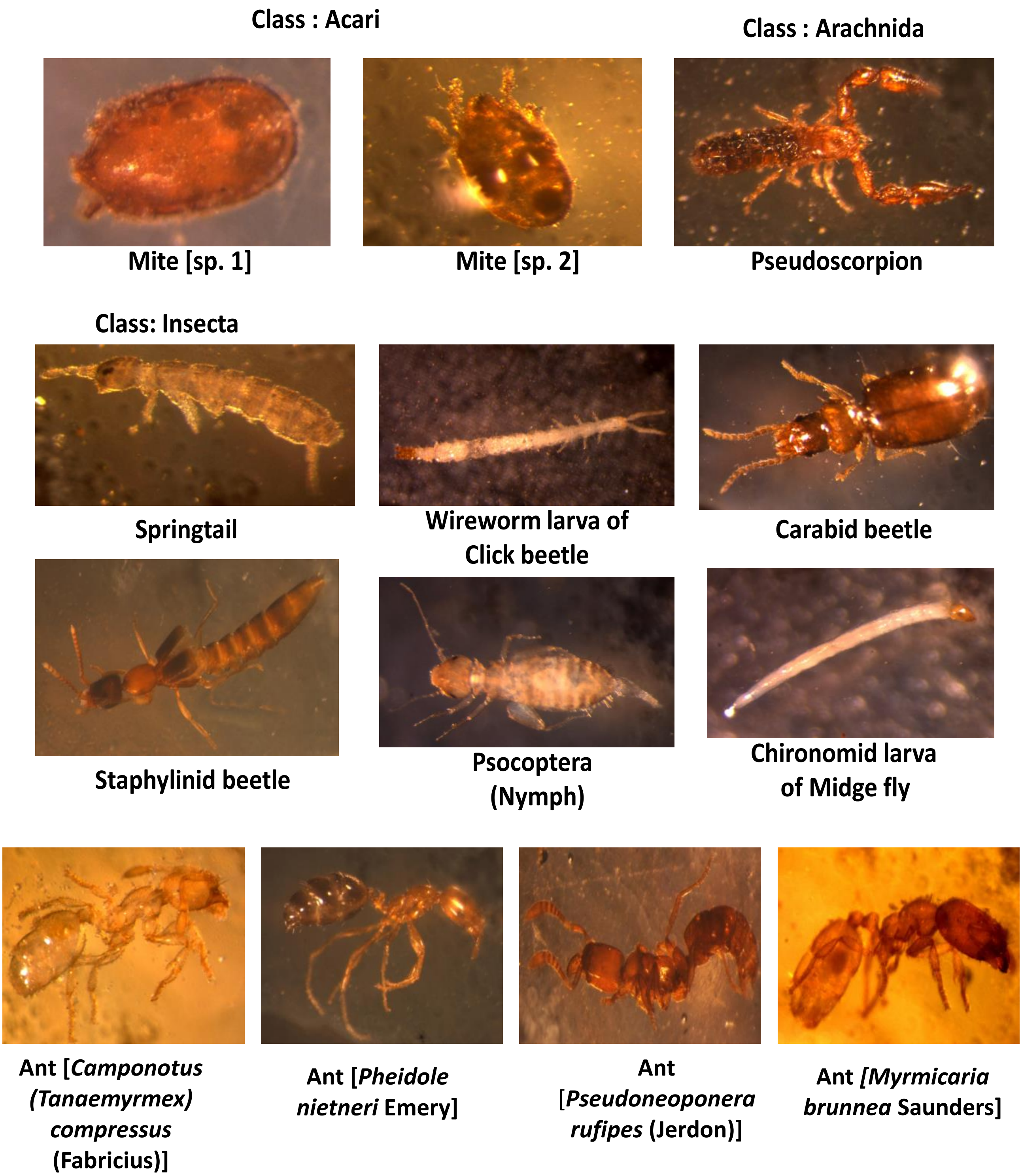

Fig. 4. Microarthropods recorded

In the vegetable garden, an increase in rainfall and soil organic carbon increased the abundance of mite populations. A significant positive impact is also noted for soil organic carbon on the abundance of springtails, whereas, nitrogen, K_2O and organic carbon show positive impact on ant fauna, while P_2O_5 show negative impact. In the uncultivated area, soil nitrogen and organic carbon accelerate the mite numbers, whereas K_2O decelerate. In contrast, P_2O_5 and nitrogen content increases ant numbers, while P_2O_5 and organic carbon show positive impact on springtail populations (Table 3).

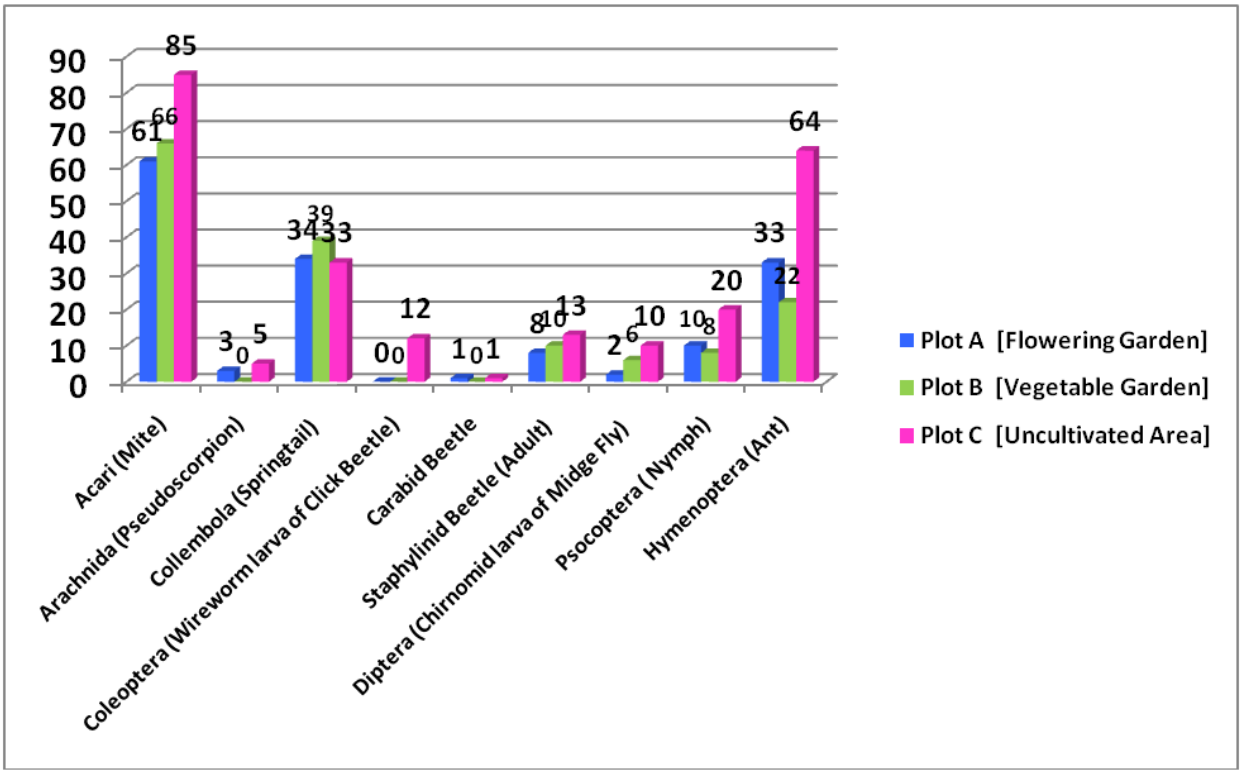

Fig. 5. Total no. of soil arthropod individuals trapped from three different plots.

This work indicates that soil microarthropods appear to be consistent and potentially a good indicator for assessing the impact of land use practices and seasons on soil quality (Tables 2 & 3) (Sharma & Paewez, 2017). Different functional groups of soil microarthropods occupy different trophic levels of food chain & food web within soil (Fig. 6). In soil ecosystems, the status of soil biota at local and regional scales is influenced by different driving forces, such as forestry and agriculture practices, urbanization and seasonal fluctuation. These forces causes changes in land use, soil moisture, temperature, bulk density, SOC and other physio-chemical factors which directly or indirectly affect density and diversity patterns of soil biota.

Seasonal differences in the abundance of soil arthropods have been studied by various workers (Lasebiken, 1974, Usher, 1975, Badejo, 1990 and Badejo & Van-Straalen, 1993). Their findings reported that microarthropods undergo enormous fluctuations in densities due to changes in microenvironment and thus water is a primary abiotic factor influencing population size (Badejo, 1990). Temperature fluctuation during different seasons also commonly induces vertical movement of soil animals in the soil profile (Didden, 1993, Luxton, 1981).

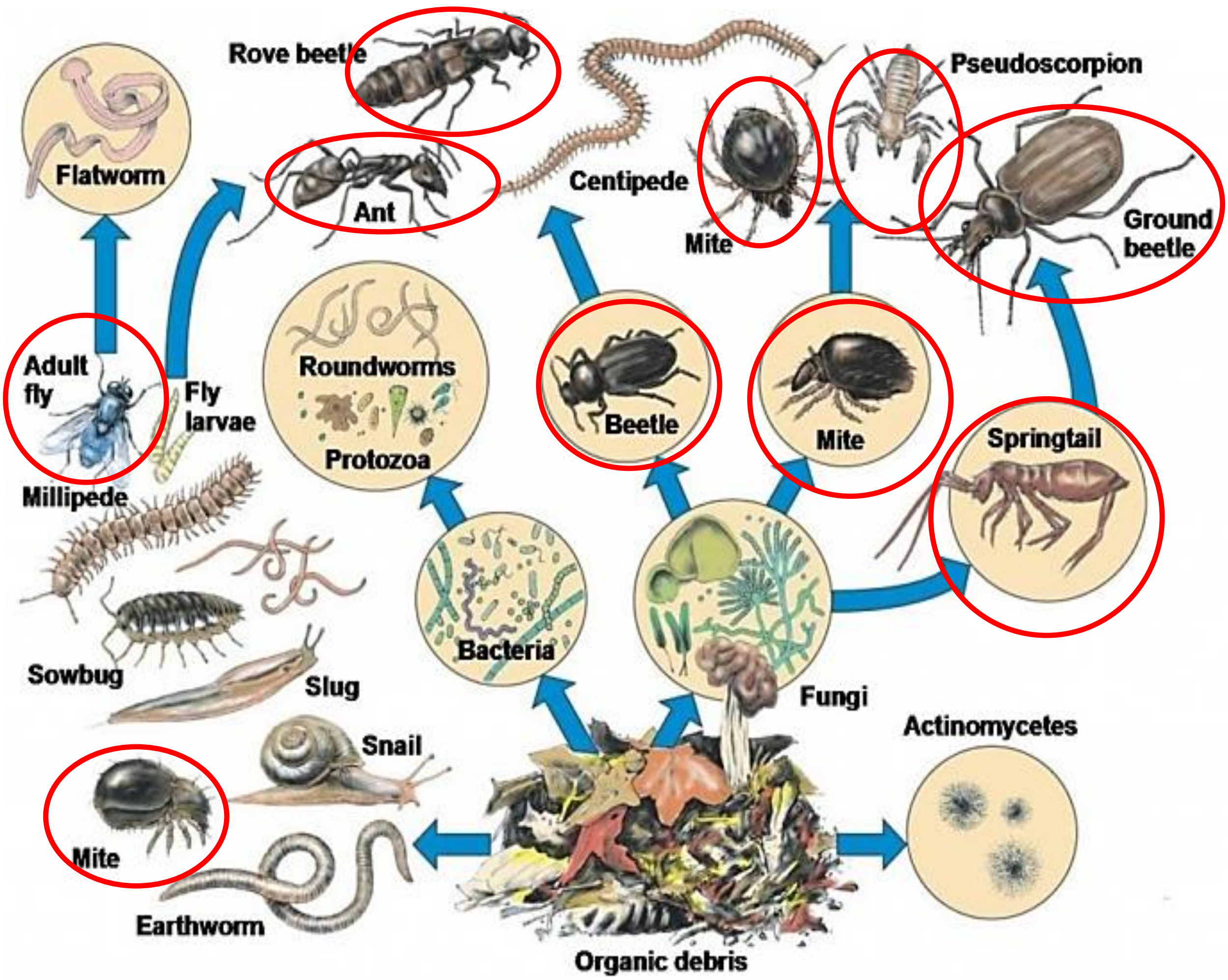

Fig. 6. Relationships of encountered microarthropods in different trophic levels of food chain within soil

Table 1. Seasonwise occurrence of microarthropods in different plots

Arthropods/750 gm & Soil Factors	Flowering Garden				Vegetable Garden				Uncultivated Area			
	PrM	M	PsM	Total	PrM	M	PsM	Total	PrM	M	PsM	Total
Acarina (Mite)	35	21	8	64	21	20	25	66	48	17	24	89
Arachnida (Pseudoscorpion)	-	2	1	3	-	-	-	-	-	-	5	5
Collembola (Springtail)	18	13	6	37	6	9	26	41	12	14	10	36

Coleoptera												
(Wireworm larva of Click Beetle)	-	-	-	-	-	-	-	-	-	12	-	12
Carabid Beetle (Adult)	-	-	1	1	-	-	1	-	-	1	-	1
Staphylinid Beetle (Adult)	-	-	8	8	10	-	-	10	9	4	-	13
Diptera (Chironomid larva of Midge Fly)	-	2	-	2	-	6	-	6	-	10	-	10
Hymenoptera (Ant)	7	14	20	41	3	13	12	28	19	31	30	80
Psocoptera (Nymph)	-	10	-	10	-	8	-	8	-	20	-	20
Total	60	62	44	166	40	56	63	159	88	109	69	266
Temperature (°C)	30.98	29	25.05		30.98	29	25.05		30.98	29	25.05	
Humidity (%)	67	85.5	73.25		67	85.5	73.25		67	85.5	73.25	
Rainfall (mm)	0.5	1.47	0.86		0.5	1.47	0.86		0.5	1.47	0.86	

Table 2. Physico-chemical properties of soil.

Study Area	Flowering Garden			Vegetable Garden			Uncultivated Area		
Seasons / Parameters	PrM	M	PsM	PrM	M	PsM	PrM	M	PsM
pH	7.54 ±0.01	7.40 ±0.03	7.44 ±0.02	7.39 ±0.01	7.62 ±0.01	7.84 ±0.02	7.02 ±0.03	7.26 ±0.02	7.18 ±0.02
EC m.mhos/cm	0.33 ±0.01	0.16 ±0.01	0.11 ±0.01	0.21 ±0.01	0.24 ±0.01	0.30 ±0.01	0.47 ±0.01	0.12 ±0.01	0.09 ±0.01
Organic Carbon (%)	0.66 ±0.01	0.46 ±0.03	0.48 ±0.01	0.64 ±0.02	0.68 ±0.01	0.70 ±0.03	0.68 ±0.02	0.48 ±0.02	0.44 ±0.02
Nitrogen (Kg/ha)	321.06± 0.02	265.8 ±0.03	261.8 ±0.02	301.23 ±0.02	424.4 ±0.01	418.0 ±0.02	351.25 ±0.02	241.6 ±0.02	233.4 ±0.02
P_2O_5 (Kg/ha)	56.93 ±0.02	20.62 ±0.02	18.06 ±0.01	64.62 ±0.02	42.25 ±0.01	38.78 ±0.02	21.79 ±0.01	21.65 ±0.01	22.67 ±0.03
K_2O (Kg/ha)	208.85 ±0.01	324.65 ±0.02	334.65 ±0.01	205.36 ±0.03	286.15 ±0.01	149.18 ±0.02	105.74 ±0.02	278.05 ±0.03	305.08 ±0.02

This opinion confirms our findings, as microarthropods are more in the monsoon season. However, the mechanism of the population dynamics of microarthropods in the soil ecosystem is complex, often without a sole environmental factor that can explain the variation in microarthropod population (Miyazawa *et al*., 2002).

Modern agricultural practices, such as use of heavy machinery for tillage operation, application of chemical fertilizers, and pesticides have led to severe negative impacts on the soil ecosystem. Among these impacts, the reduction in soil biodiversity and degradation of soil quality are often viewed as major threats for the future (Solbrig, 1991). Land use change and agricultural intensification generate severe habitat degradation or destruction for soil biota (Decaens *et al*., 2006). Hence, understanding soil arthropod communities prove useful in developing management plans for both wild and cultivated ecosystems (Bagyaraj *et al*., 2016).

Table 3(A, B, C). Co-efficient of Correlation (r) Values between abundance of dominant species and physico-chemical parameters.

A). Flower Garden

	pH	Temperature	Humidity	Rain fall
Acari (Mite)	-0.0475	+0.7900	+0.4287	-0.0815
Hymenoptera (Ant)	+0.4423	-0.6005	+0.2081	+0.4089
Collembola (Springtail)	+0.0721	+0.7938	+0.2081	-0.0820
	Nitrogen	P_2O_5	K_2O	Organic Carbon
Acarina (Mite)	+0.9509*	+0.9505*	-0.9543*	+0.8934
Hymenoptera (Ant)	-0.4520	-0.4507	+0.4619	-0.3124
Collembola (Springtail)	+0.9630*	+0.9626*	-0.9659*	+0.91130*

B). Vegetable Garden

	pH	Temperature	Humidity	Rain fall
Acari (Mite)	-0.3458	+0.1513	+0.5490	+0.7608
Hymenoptera (Ant)	-0.4035	-0.5046	+0.2610	+0.5705
Collembola (Springtail)	+0.0144	-0.4067	-0.0444	-0.0094

	Nitrogen	P_2O_5	K_2O	Organic Carbon
Acarina (Mite)	+0.2834	-0.4417	+0.3940	+0.8910
Hymenoptera (Ant)	+0.8058	-0.8944	+0.8697	+0.9841*
Collembola (Springtail)	+0.4985	-0.6381	+0.5968	+0.9721*

C). Uncultivated Area

	pH	Temperature	Humidity	Rain fall
Acari (Mite)	-0.3493	+0.6170	+0.1514	-0.1934
Hymenoptera (Ant)	-0.5256	-0.4085	+0.3691	+0.5577
Collembola (Springtail)	-0.3259	+0.3781	+0.4142	+0.1736
	Nitrogen	P_2O_5	K_2O	Organic Carbon
Acarina (Mite)	+0.8977	-0.0842	-0.9057*	+0.8922
Hymenoptera (Ant)	+0.3960	+0.9911*	+0.3788	-0.4072
Collembola (Springtail)	+0.0985	+0.8026	-0.1170	+0.0863

* Correlation is significant at the 0.05 level

5. CONCLUSION

Almost 98% of Earth's diversity is in the terrestrial ecosystem, of which soil is the main component, so conservation of soil and its components like microarthropods is critically important. Microarthropods because of their small size and non-appealing shapes, are generally not considered valuable for conservation. Moreover, the knowledge of these creatures is lacking in the public. Yet, as they are crucial for soil health, the landscapes which soil microarthropods inhabit should be preserved or sustainably used, as they play a major role in the ecosystem.

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