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M. G. Sanal Kumar, Akhil Kumar S and S. Nandakumar

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Diversity and Abundance of Soil Microarthropods in Relation to Pedological Characteristics - A Case Study at Aranmula Panchayath, Kerala

M. G. Sanal Kumar*[1], Akhil Kumar S[2] and S. Nandakumar[3]

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A B S T R A C T

The soil is a natural body of mineral and organic constituents differentiated into horizons of variable depth, which differs from the material below in morphology, physical makeup, chemical properties and composition and biological characteristics. In general soil may be considered as the net result of the action of climate and organisms especially vegetation on the parent material of the earth's surface. The texture and porosity of the soil are highly important characteristics and largely determine the availability of nutrients to plants and soil animals. Ecological study was conducted in a field with mixed vegetation and litter. Samples were collected twice in a month, for 12 months from June 2019 to May 2020. Each sample consists of 4 sample units and microarthropods were extracted by Berlese Tullgren funnel. Collected microarthropods were identified and counted with a Stereo Bionocular Microscope. Temperature, pH, Moisture content and Organic carbon of soil samples were also noted. The microarthropod population varies according to season. In pre-monsoon (Februay March, April, & May) the population of microarthropods was observed to be decreased. During the monsoon period (June, to mid. Sept.) the population of microarthropods were observed to be increased. In the post-monsoon period (mid-September to mid-January) a maximum density of population occurred. The population fluctuation in the pre-monsoon, monsoon and post-monsoon months are discussed in association with soil characteristics.

***Key words*:** Microarthropod, Diversity, Mesofauna, Pedological characteristics

Soil arthropods measuring upto 10 mm. in length can be considered as micro-arthropods and considered to be members of mesofauna of the soil. Microarthropod distribution can be influenced by soil moisture percentage, pore space, oxygen saturation deficits, temperature variations, floods, cropping, cultivation, organic matter percentage, litter, nematode populations, man and animal disturbance, soil type and texture, predation and feeding habits among others [1]. Over time, which may involve hundreds or thousands of years, soil structure builds and nutrient availability increases with the addition of metabolic wastes and other byproducts (plant litter, root exudates, feces), and the organisms' remains combined with the weathered mineral elements [2].

Microarthropods disintegrate plant and animal tissues and transform to humic substances. Microarthropods have great ecological significance, in the breakdown and decomposition of litter, nutrient cycling and the role in secondary production and energy flow.

This group consists principally of species of the acarine taxa Oribatida, Prostigmata, and Mesostigmata, and the Collembola. Large numbers of microarthropods are found in most soils [3-4] including those under cultivation [5-6], and these animals may be the dominant arthropods in a variety of environments. the microarthropods comprise the important middle links of soil food webs, serving, in their role as both predator and prey, to channel energy from the soil microflora and microfauna to the macrofauna on higher trophic levels [7]. The present work proposes to shed some light on the influence of soil pH and soil temperature in the population density of microarthropods inhabiting the soils of Kerala.

* **M. G. Sanal Kumar**
✉ akhilkumars998@gmail.com

1 P. G. and Research Department of Zoology, N. S. S. College, Pandalam - 689 501, Kerala, India

2 Department of Animal Science, Manonmaniam Sundaranar University, Abishekapatti - 627 012, Tamil Nadu, India

MATERIALS AND METHODS

The ecological study was conducted in an uncultivated field with an area of about 700 sq. metre on the banks of Pamba river at Aranmula. The site had a mixed

vegetation of trees and shrubs, with some accumulation of litter on the ground. Soil sampling was done monthly from June 2019 twice during the first and fifteenth of each month during morning hours for twelve months. The size of the sample was fixed to be four sample units. Each sample unit had a surface area of 25 cm^2. The sampling was done with a circular steel sampler of 5.6 cms in diameter upto a depth of 15 cms.

Extraction of soil arthropods

The extraction of microarthropods from the soil samples was made using a battery of modified Berlesse Tullgren funnel. The extraction unit consisted of a series of steep sided polythene funnels. Equal number of 40 Watt lamps formed as heat source. The soil cores were transferred to the funnels in an inverted position, on wire gauze with a pore diameter of 1.5 mm. The microarthropods escaping from the heat source migrated down wards, along the moisture gradient passed through the wire gauze and fell into the funnel and were collected in a plastic container with picric acid placed below. The duration of the extraction was varied from 18 to 24 hours. After extraction, the micro arthropods were identified and counted with the help of a stereoscopic Binocular microscope. Temperature of the soil was noted, by introducing thermometer marked in °C, into the hole from where the soil samples were collected.

Study of soil profile

The pH of the soil was measured with a pH indicator paper. The soil sample was dried in air and mixed with distilled water in 5:1 ratio. The mixture was shaken well and allowed to settle for 1 hour and the supernatant was filtered into a beaker. Indicator paper was dipped in the beaker and matched the colour with the pH indicator and noted the pH value. The soil profile was studied by digging a large pit - about 65 cm. depth, the horizons were measured. Organic carbon content and moisture content of the soil was measured using the procedures of Jackson [8].

RESULTS AND DISCUSSION

Physico- chemical parameters

The physico-chemical characteristics of the soil in the field were observed following the seasonal changes in the atmospheric conditions. The mean temperature in the pre monsoon season was found to be 27.07°C in pre monsoon, 25.3 in monsoon and 24.57 in post monsoon respectively. Chi square analysis revealed that there is no much difference in the temperature of different sampling during pre-monsoon period, monsoon season and post monsoon (Chi square-0.999, 1.00 and 0.999 respectively).

The mean pH in the pre monsoon season was found to be 6.7 in pre monsoon, 6.9 in monsoon and 6.8 in post monsoon respectively. Chi square analysis revealed that there is no much difference in the temperature of different sampling during pre-monsoon period, monsoon season and post monsoon (Chi square-1.00, 0.999, and 0.999 respectively). The mean Organic Carbon in the pre monsoon season was found to be 2.5 in pre monsoon, 2.7 in monsoon and 2.8 in post monsoon respectively. Chi square analysis revealed that there is no much difference in the temperature of different sampling during pre-monsoon period, monsoon season and post monsoon (Chi square-1.00, 0.999, and 0.999 respectively).

Table 1 The physico-chemical characteristics of the soil at pre-monsoon – from 15th Jan. 2019 to 15th May 2019 (Mean ± SD)

Months	15th Jan. 2019	1st Feb. 2019	15th Feb. 2019	1st Mar. 2019	15th Mar. 2019	1st Apr. 2019	15th Apr. 2019	1st May 2019	15th May 2019	Seasonal average	χ^2	χ^2 Critical
Temp (°C)	25±1.12	26.2±1.31	26.3±1.26	27.0±1.17	27.2±1.36	28.0±1.26	28.1±1.23	28.0±1.17	28.0±1.18	27.07	0.9999	15.51
pH	6.7±0.06	6.7±0.05	6.7±0.12	6.8±0.02	6.8±0.05	6.7±0.08	6.7±0.07	6.7±0.07	6.7±0.06	6.72	1.0000	15.51
OC%	2.8±0.03	2.9±0.02	2.4±0.01	2.8±0.03	2.3±0.04	2.4±0.08	2.5±0.09	2.4±0.03	2.4±0.03	2.4	1.0000	15.51
Moisture %	76±0.07	75±0.03	76±0.03	76±0.03	76±0.03	76±0.09	77±0.03	77±0.03	78±0.03	78	0.9999	15.51

Table 2 The physico-chemical characteristics of the soil at Monsoon – from 1st June 2019 to 1stSept. 2019 (Mean±SD)

Months	1st June 2019	15th June 2019	1stJuly 2019	15th July 2019	1stAug. 2019	15thAug. 2019	1stSept 2019	Seasonal average	χ^2	χ^2 Critical
Temp (°C)	25.5±1.13	25.5±1.41	25.4±1.36	25.3±1.27	25.4±1.25	25.3±1.24	25.3±1.27	25.3	1.00	14.07
pH	7±0.04	7±0.04	7±0.03	7±0.04	7±0.02	6.9±0.08	6.7±0.07	6.9	0.99	14.07
OC%	2.8±0.01	2.8±0.03	2.7±0.03	2.7±0.03	2.7±0.08	2.7±0.03	2.7±0.02	2.7	0.99	14.07
Moisture %	82±0.31	83±0.32	83±0.31	82±0.20	82±0.92	82±0.39	82±0.93	82	0.99	14.07

The mean Moisture content in the pre monsoon season was found to be 76.3 in pre monsoon, 82.5 in monsoon and 79 in post monsoon respectively. Chi square analysis revealed that there is no much difference in the temperature of different sampling during pre-monsoon period, monsoon season and post monsoon (Chi square-0.999, 1.00 and 0.999 respectively).

Population fluctuation

The population density of Microarthropods attained highest peak immediately after the monsoon periods in September and October. The maximum number of Collembola was observed to be 38 in the beginning of post-monsoon in September and to be 35 during October. The population density of Collembola was decreased in pre-monsoon period. Population density of Collembola in Monsoon period June-August, was about 20 to 22.

In the present study, population density of mites was maximum of 30 in the beginning of post-monsoon in September and 28 in October. The population density of Mites was decreased to a minimum of 14 in pre-monsoon period January and six during May. The population of Mites in Monsoon period June to August was about 16-20.

Accordingly, the population density of Protura was a maximum of 10 in the beginning of post-monsoon in September and October. The population density of Protura

was decreased to minimum of 3 in pre-monsoon period January and obtained only one during May. There was a gradual increase in the population density during Monsoon period - June to August for about 2-4.

The population density of Diplura was maximum in the beginning of post-monsoon, 12 in September and October. Population density of Diplura was decreased in pre-monsoon period, 4 in January and Nil in May. There was a gradual increase in the population density of about 3-4 in Monsoon periods June to August.

Likewise, the population density of Pseudoscorpions was a maximum of 9 in the beginning of post-monsoon in September and 8 during October. The population density was decreased in pre-monsoon period-January was a minimum of 4 and none in May. There was a gradual increase in the population density of about 2-3 in the Monsoon period June to August.

Similarly, the population density of Symphyla was a maximum of 7 in ginning of post-monsoon September and October. The on density was decreased in pre-monsoon period - January fid none in May. There was a gradual increase in the on density of about 2-3'mMonsoon period - June to August. Two-way ANOVA conducted revealed that there is significant difference in the population density of different soil animal groups between different months and between different orders in all seasons ($P<0.05$).

Table 3 The physico-chemical characteristics of the soil at post-monsoon from 15th Sept. 2019 to 1st Jan.2020. (Mean±SD)

Months	15th Sept 2019	1stOct. 2019	15th Oct. 2019	1stNov. 2019	15thNov. 2019	1stDec. 2019	15th Dec. 2019	1st Jan. 2019	Seasonal average	χ^2	χ^2 Critical
Temp (°C)	25.2±1.12	25.1±1.26	25.3±1.32	25.0±1.24	25.0±1.43	24.0±1.25	23.0±1.16	24.0±1.65	24.57	0.99	14.07
pH	6.9±0.04	6.9±0.05	6.9±0.04	6.9±0.03	6.7±0.02	6.8±0.03	6.7±0.05	6.7±0.03	6.81	0.99	14.07
OC%	2.4±0.01	2.8±0.03	2.98±0.02	2.98±0.02	2.98±0.03	2.98±0.05	2.98±0.03	2.8±0.04	2.81	0.99	14.07
Moisture %	79±0.03	79±0.03	78±0.02	80±0.04	80±0.03	79±0.02	78±0.03	79±0.04	79	1.00	14.07

Table 4 Population density of Microarthopods during pre-monsoon from 15th Jan. 2019 to 15th May 2019 (Mean±SD)

Months	15th Jan. 2020	1stFeb. 2020	15th Feb. 2020	1stMar. 2020	15thMar 2020	1stApr. 2020	15thApr 2020	1stMay. 2020	15thMay 2020	Seasonal average
Collembola	18±1.12	17±1.15	17±1.14	16±1.13	14±1.21	13±1.12	12±1.16	10±1.13	8±1.14	13.8±1.12
Mites	14±1.01	14±1.13	12±1.13	10±1.12	11±1.15	12±1.13	9±1.12	7±1.13	6±1.13	10.5±1.15
Protura	3±0.03	3±0.02	2±0.02	2±0.04	0±0	2±0.02	2±0.03	1±0.02	1±0.01	1.7±0.03
Diplura	4±0.04	4±0.03	3±0.04	3±0.02	4±0.03	2±0.04	2±0.04	1±0.02	0±0	2.6±0.02
Pseudo-scorpion	4±0.02	3±0.02	3±0.04	2±0.01	2±0.02	2±0.04	1±0.05	1±0.01	0±0	2±0.04
Symphyla	3±0.04	3±0.03	2±0.02	2±0.05	1±0.02	1±0.03	0±0	0±0	0±0	1.3±0.01

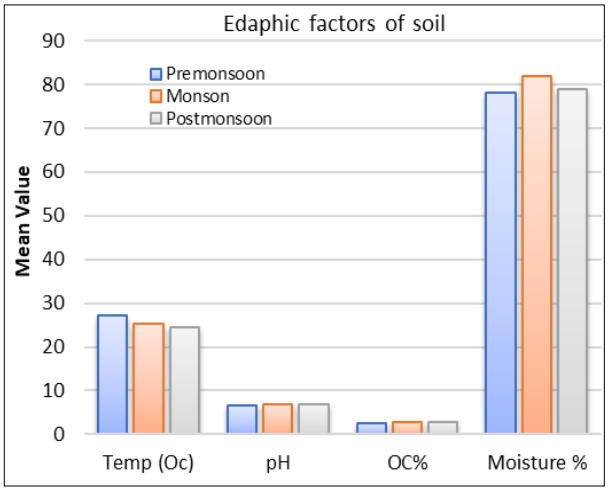

Fig 1 The physico-chemical characteristics of the soil at pre-monsoon, monsoon and post monsoon

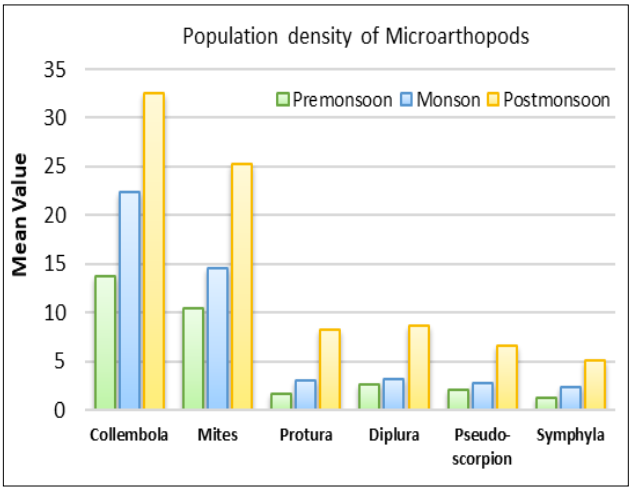

Fig 2 Population density of microarthopods during pre-monsoon, monsoon and post monsoon

Principal component analysis

Principal component analysis revealed that temperature (eigen value 0.3392) and moisture (eigen value 0.3323) are the principal soil edaphic factors controlling the density of acari and isopoda in pre monsoon. Temperature, pH, and organic carbon of soil are influencing the density of collembolan and diplopoda of which pH is the principal factor and organic carbon second. Temperature and pH are controlling the density of protura, isopoda and symphyla as third principal factor during pre-monsoon season.

Temperature, pH and organic carbon content of soil are the principal factors controlling the distribution of isopoda group during monsoon season of which organic content is found to be most influencing (eigen value-0.3729). Proturan, diplopodan, symphylan and isopodan density was controlled by temperature and organic carbon as third principal soil edaphic factors during monsoon season.

Temperature, pH and Moisture content were the principal factors controlling the density of collembolan, acari, protura, diplopoda, isopoda and symphyla during post

monsoon season. Temperature, organic carbon content and moisture content influence the density of collembolan, protura, diplopoda and isopoda as second principal factors. Temperature, pH and organic content are the third principal factors affecting density of acari and protura.

Bellinger [9] stated that the various members of the soil fauna penetrate the soil to different depths, some being confined to the superficial layers, while others may be found as far down as organic matter is present. He also observed some correlation of the population size with rainfall and suggested that the seasonal variations in temperature and soil moisture content probably control the population size and individuals in layers. Similarly, Milne [10] observed a maximum population of Collembola during the winter and early summer. Likewise, Mani [11] reported that at high altitudes the soil moisture is ecologically important only next to soil temperature, and the deep soil has a higher moisture content than the surface soil. Choudhuri and Roy [12] observed that the Collembolan population varied both in quality and quantity in the different habitats and noted that majority of the insects inhabited in the upper or middle sub-sample, than the lower one.

Table 5 Population density of microarthopods during monsoon from 1st June 2019 to 1st Sept. 2019 (Mean ± SD)

Months	1st June. 2019	15th June 2019	1st July 2019	15th July 2019	1st Aug. 2019	15th Aug. 2019	1st Sept. 2019	Seasonal average
Collembola	20±1.32	22±1.23	23±1.24	22±1.22	22±1.21	23±1.22	25±1.23	22.4±1.12
Mites	16±1.12	18±1.14	18±1.13	19±1.12	20±1.13	19±1.12	21±1.14	14.5±1.12
Protura	2±0.02	2±0.03	3±0.01	3±0.02	3±0.03	4±0.02	4±0.01	3±0.02
Diplura	3±0.02	2±0.03	3±0.02	3±0.03	3±0.02	4±0.02	4±0.03	3.1±0.02
Pseudo-scorpion	3±0.01	3±0.02	3±0.02	2±0.01	3±0.03	3±0.02	3±0.04	2.8±0.02
Symphyla	2±0.02	2±0.01	2±0.03	3±0.03	2±0.02	3±0.03	3±0.02	2.4±0.03

Table 6 Population density of Microarthopods during Post-monsoon from 15th Sept. 2019 to 1st Jan. 2020. (Mean±SD)

Months	15th Sept. 2019	1st Oct. 2019	15th Oct. 2019	1st Nov. 2019	15th Nov. 2019	1st Dec. 2019	15th Jan 2020	1stJan 2020	Seasonal average
Collembola	38±1.13	35±1.12	35±1.13	34±1.13	33±1.14	31±1.15	30±1.14	25±1.14	32.6±1.13
Mites	30±1.12	28±1.12	29±1.14	25±1.15	24±1.14	23±1.13	23±1.12	20±1.15	25.2±1.12
Protura	10±0.03	10±0.03	9±0.02	8±0.04	8±0.02	9±0.04	7±0.02	5±0.01	8.2±0.04
Diplura	12±0.02	12±0.01	10±0.01	9±0.01	9±0.01	7±0.01	6±0.02	5±0.03	8.7±0.02
Pseudo-scorpion	9±0.01	8±0.04	7±0.01	8±0.03	6±0.03	6±0.03	5±0.01	4±0.02	6.6±0.04
Symphyla	7±0.03	7±0.03	6±0.03	5±0.03	5±0.02	4±0.02	4±0.02	3±0.01	5.1±0.03

Table 7 Principal components and eigen values obtained for soil edaphic factors during pre-monsoon, monsoon and post monsoon seasons

Variable	Pre monsoon			Monsoon			Post monsoon		
	PC1	PC2	PC3	PC1	PC2	PC3	PC1	PC2	PC3
Temp (°C)	0.33929	0.09825	0.00673	0.35768	0.28352	0.01485	0.30108	0.04145	0.24607
pH	-0.02924	0.77362	0.30138	0.33342	-0.2132	-0.15099	0.3219	-0.11247	0.33201
OC%	-0.24177	0.10316	-0.86061	0.37291	0.03067	0.06124	-0.19635	0.43217	0.8233
Moisture %	0.33235	-0.174	-0.05074	-0.16366	0.52924	-0.35925	0.07589	0.85574	-0.35748
Collembola	-0.3659	0.05572	0.19776	-0.35498	0.22852	-0.36376	0.35978	0.13351	-0.04657
Mites	-0.36178	-0.0331	-0.09278	-0.33048	-0.01941	-0.35076	0.35607	-0.16168	0.08902
Protura	-0.2522	-0.52092	0.26957	-0.3823	-0.00164	0.15932	0.33508	0.08847	0.07728
Diplura	-0.35247	0.2621	-0.05107	-0.33043	-0.01613	0.64541	0.3649	0.02071	-0.00322
Pseudo-scorpion	-0.36514	-0.06564	0.07118	0.02559	0.61136	0.37952	0.36007	0.10394	-0.08657
Symphyla	-0.35942	-0.04872	0.19451	-0.32223	-0.29924	0.05335	0.3607	-0.05948	-0.00168

The present investigation showed that the soil pH varies from 6.7 to 7.0 and soil pH was somewhat in agreement with that observed by [13]. Soil temperature varied from 23° - 26°C. The soil moisture content was observed to vary in the different soil layers, the maximum percentage in the lower layers [14]. Choudhuri *et al*. [15] observed only a lesser moisture content of about 6.5 to 8.5 while [13] reported an average of 14.2% of soil moisture. [14] observed the organic matter content of the soil varied in different soil layers and in the seasons. The highest

percentage of organic matter was in the upper layer during the monsoon months, about 21.1% and lowest percentage in the lower layers during the summer months about 5.9%.

The population density of the microarthropods, observed during the present studies varied according to the seasonal changes, and the influence of environmental conditions. The highest peak in the collembolan density was immediately after the monsoon periods i.e., in the early post-monsoon month of mid. September and noted a second peak of density in monsoon. The present observations on the population density of collembola is in agreement with that observed by [14], that the highest peak in the Collembolan density was immediately after the Monsoon period. Likewise, Roy and Ghatak [16] stated that the total population showed monthly variations with a maximum in November and minimum in February. The population peak was associated with the more concentration of the soil factors, and in at least in some cases, significant, by correlated with the particle size of the soil. Kurup [14], stated that the population peak in October was attributed to the high percentage of moisture content of about 12%. In the present studies, the population peak was maximum in mid. September mainly due to increased moisture content, where the temperature ranged between 25 to 25.2°C and the pH at 6.7. The population density of collembola was a maximum of 38 in mid. September. It decreased to a minimum of 8 during the pre-monsoon month of May at a soil temperature of 28°C. A minor peak of population density was observed in June to August about 20 to 23. From this it was observed that temperature also played a leading role in the abundance of the collembola.

The population density of Mites was a maximum of 30 in the beginning of post-monsoon i.e., in mid-September. It decreased to a minimum number of 6 in pre-monsoon period of May. A minor peak of population density was found, about 21, during monsoon. The population density of Protura was at a maximum of 10 in the beginning of post-monsoon i.e., mid-September. It decreased to a minimum of one in the pre-monsoon period of May. There was a gradual increase in the number of Protura during the month of monsoon.

The population density of Diplura was at a maximum in the beginning of post-monsoon. It decreased in pre-monsoon period and was almost absent in May. There was a gradual increase in the population density of Diplura about 3-4 in the monsoon period. The population density of pseudo-scorpions was at a maximum of 9 in the post-monsoon of September and it decreased in the pre-monsoon period of January to 4. It was found to be absent in May. There was a gradual increase in the population density of Pseudo-scorpions about 2 to 3, during the monsoon period.

The population density of Symphyla was at a maximum of 7 in the post-monsoon period of mid. September. It decreased in the pre-monsoon period of 3 in January and none in May. There was a gradual increase in the population density of about 2-3 in the Monsoon. From these studies, it was found that the number of microarthropods in the soil was also influenced by the soil temperature. The increase in the soil temperature during the pre-monsoon period, due to the absence in the rainfall, resulted in the decrease in the moisture content. This absence in the moisture content was not conducive for the growth of micro arthropods.

Choudhuri *et al.* [15] observed that the population density of collembola varied considerably usually with maximum in July to August (Monsoon months) and minimum in May (summer months) and was found to be depending on the soil factors. Dowdy [17] concluded from these studies that plant communities influenced both the quantitative and qualitative distribution of the Collembolan fauna, the banana area supported the highest population in the former type, while the grassy plots yielded the largest number of species in the latter types. Takeda [18] stated that the seasonal changes in population abundance are determined by the combination of natality and mortality pattern in a population in which migration is not an important factor for the population changes.

Choudhuri *et al.* [15] stated that vertical distribution studies showed larger population in the upper most layer of 0 - 3 cm depth, which was invariably associated with aggregation of juvenile forms. Accordingly, Kurup [14] stated that the distribution of juvenile and adult individuals in the upper, middle and lower layer, in the different seasons, to a certain extent was governed by not only on the soil moisture content, but also by the organic matter content. The soil fauna of a Mull beach forest in comparison to a modern soil was studied by Shaefer and Schauermann [19] and found that the Mull Forest was characterized by larger number of microarthropods.

The present study showed that the microarthropod population varies according to seasons. In pre-monsoon (Feb - March, April and May) the population of microarthropods were observed to be decreased. During the monsoon period (June to mid. September) the population of microarthropods were observed to be increased. A maximum population density of microarthropods were observed in the post-monsoon period (mid. Sept. - December). The Principal Component Analysis results showed the importance of soil edaphic factors to the density of soil microarthropods. In the present study also revealed that temperature, moisture, organic content and pH has great influence on the density and distribution of most of the micro arthropod groups as states by [16].

CONCLUSION

The soil invertebrates move deeper into the soil during the different seasons and found that temperature was the main stimulus behind these movements. Soil edaphic factors like temperature, moisture, organic content and pH revealed the influence on the density and distribution of most of the micro arthropods.

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