International Journal of
Science Inventions Today
www.ijsit.com
ISSN 2319-5436
Research Article

POPULATION DYNAMICS MICROARTHROPOD IN SOIL AND LITTER OF *JATROPHA* PLANTATION IN TRIPURA, N.E. INDIA.

Dr. Soma Datta

Associate Professor, Department of Zoology, Women's College, Agartala, Tripura.

ABSTRACT

Present investigation was carried out in Tripura for the period of February 2019 to January,2020 to understand the population dynamics OF microarthropods in Jatropha plantation. The population of all the group of soil microarthropods was found to be peak in July to September and density of them was recorded during August and September. In litter, arthropodan population was higher in July and August during investigation period and least was observed during March. Rainfall, relative humidity, temperature was responsible for population fluctuation of acarine fauna and others. A significant influence of combination of all the climatic factors (F=20.99.p<0.001) and (F=9.44, p<0.001) was observed in the soil and litter of Jatropha plantation on microarthropod population, respectively. Climatic factors play important role in population dynamics.

Keywords: *Microarthropod, soil, litter, Jatropha, Tripura*

INTRODUCTION

Soil animals are widely distributed around the world, playing a biological role of great importance both in natural and agricultural ecosystems. In recent years, much attention has been paid to them as they play an important role in several soil processes such as organic matter decomposition, material and energy cycles and soil formation. Oribatids and collembola form the major part of soil microarthropods in terms of number of individuals and species. Population dynamics is the study of marginal and long-term changes in the numbers, individuals, weight and age composition of individuals in one or several populations, biological and environmental processes influencing those changes.

The earliest work on soil fauna was done by Diem [1], Cameron [2] first carried out the survey of soil insects. Later, in 1917 he first pointed out that the environmental condition may cause difference in the faunal make up in two types of Grasslands. The atmospheric climatic condition to a large extent influence the soil environment which influenced their vital activity, reproduction fecundity and mortality rate of some form of soil micro arthropod was occupied in temperature range between 34^{o}C to 40^{o}C. Noti *et al.,* [3] described various soil microarthropod communities in relation to vegetation, identified indicator species, determined how these communities vary with the seasons and the presence of high termitaria and evaluated the impact of deforestation on them. The population dynamics pattern of microarthropoda groups varied throughout the year according to climatic as well as edaphic factors. Vegetation type, land use pattern, food availability and their phenology also effect the microarthropod population. Soil microarthropod which are dominant and most important biotic component of soil ecosystem play a major role in decomposition of the organic matter.Considering the great role played by various groups of microarthropods, many researchers in India had taken up the studies on soil arthropods in different vegetation sites and agricultural fields. Rainfall, relative humidity, temperature, moisture content is responsible for population fluctuation of acarine fauna and others and they regulate the dynamics of total microarthropod.

Climate changes can influence soil microarthropod community, abundance and composition directly by altering soil microclimate and indirectly by altering resource availability and composition of the soil food web [4]. In fact, soils are extremely responsive to changes in moisture, a pattern seen in numerous studies across diverse ecosystems [5]. Unlike soil moisture, warming also has impacts on microarthropod [6, 7]. Sjursen *et al*., [8] suggested that warming may indirectly alter soil microarthropod communities by causing a shift in the abundance and composition of soil organism upon which they prey. In addition, temperature and other climatic factors may indirectly influence soil microarthropod communities through changes in plant physiology or community structure which can alter resource availability and microhabitat conditions [9].

Rainfall affects various soil biological activities because of its influence on soil moisture and temperature. In litter decomposition, the leaching effect of rainfall cause mass loss at the initial stage of the decay process [10].

Some species are tolerant to a wide range of environmental conditions; others are of only on narrow range, but each species usually functions best only over a limited part of the gradient, termed the species optimal range. The most common abiotic factors that limit the distribution of terrestrial organisms are temperature and moisture. Physical environment can change the composition of species that occur in an area (the community).

Interaction among climate change variables may alter soil microarthropod communities in ways that are not predictable from the impact of individual climate change factors [11].

MATERIALS AND METHODS

Soil samples were collected from site of *Jatropha* plantation during the year of 2019- 2020) by using rectangular soil corer and microarthropod were extracted through Tullgren Funnel. The extraction was continued for 24 hrs. and the microarthropods were collected in the specimen tube containing 72% alcohol. All other groups except acari were sorted upto major taxa by Stereoscopic Binocular Microscope (Olympus Magnus, Model MS 24,10x 40x) and preserved in 72% ethanol separately. For the group of cryptostimatid and mesostigmatid the specimens were transferred to equal mixture of 90% ethyl alcohol and lactic acid in small vials as suggested by Balogh [12].

The encountered soil and litter dwelling microarthropod populations were sorted and counted in three major taxonomic units such as total microarthropods, total acari and total cryptostigmatid population. Cryptostigmatid populations were studied upto species level and also counted by using stereoscopic binocular microscope (Olympus,Magnus 10Xx40X).The densities of soil inhabiting total microarthropods and its different groups were calculated by using following formula [13] .

$$P= 10000X/ 0.785d^2$$

Where, P= Population density, X=Population /sample, d= Diameter of the sampler.

The ANOVA and multiple regressions employed in the present study were calculated using software Minitab Version 11. Drawing and calculation of density was performed by using MS Excel 2003 and 2007.

RESULTS AND DISCUSSION

The air temperature was ranged from 27^oC (January, 2020) to 33.9^oC (March, May, 2019) throughout the investigation period. The relative humidity was recorded highest during the month of March, 2019(92.64%) followed by February, 2019(91.42%) and minimum was observed during January, 2020.The rainfall has a great impact on population. Maximum rainfall was recorded during August, 2019(361.4 mm.) followed by May, 2019(329.9mm).

Seasonality of microarthropods and its groups:

In soil

The population density of total microarthropods showed trend of fluctuation in the soil of *Jatropha* plantations. The range of it was found as 9.98± 0.25 x 100^2no.m^{-2} to 2.29±0.43 x 100^2no.m^{-2} for *Jatropha* plantations. In soil, maximum population of microarthropod was found in the month of July, 2019 (9.98±0.33

x 100^2no.m^{-2}) and density was least during February, 2019(0.19±0.05 x 100^2no.m^{-2}) (Table1and Figure1). Total insecta was recorded as 3.56±0.33 x 100^2no.m^{-2} in July, 2019 and the minimum population was found to be in the month of February,2019(0.03± 0.2 x 100^2no.m^{-2}). (Table 1 and Figure 1).

Total Acari was recorded as 6.42±0.02 x 100^2no.m^{-2} in July, 2019 In *Jatropha* plantation, the least population was recorded in the month of February,2019 (0.16± 0.11x 100^2no.m^{-2}). The maximum population of Total cryptostigmata was 3.5±0.06 x 100^2no.m^{-2} in September, 2019. The least population was noticed in the month of February,2019 (0.02± 0.01x 100^2no.m^{-2}).

MONTH	MA±SE	TI±SE	ACAR±SE	CRYP±SE
Feb,2019	0.19±0.02	0.03±0.11	0.16±0.01	0.02±0.01
Mar	2.3±0.42	1.0±0.21	1.3±0.11	1.0±0.11
Apr	3.03±0.44	0.98±0.25	2.05±0.03	0.88±0.03
May	4.59±0.23	1.79±0.12	2.8±0.47	1.24±0.47
Jun	5.78±0.33	2.4±0.19	3.38±0.08	2.06±0.08
Jul	9.98±0.25	3.56±0.33	6.42±0.02	2.34±0.02
Aug	9.7±0.33	3.8±0.21	5.9±0.06	2.45±0.06
Sept	8.59±0.59	3.89±0.6	4.7±0.06	3.5±0.06
Oct	3.65±0.36	1.15±0.22	2.5±0.09	1.05±0.09
Nov	6.79±0.2	2.29±0.07	4.5±0.08	2.13±0.08
Dec	3.97±0.39	1.47±0.056	2.5±0.05	1.47±0.05
Jan,2020	1.78±0.4	0.78±0.34	1±0.08	0.78±0.08
'F' value	20.99***	12.92***	21.89***	22.20***
' t' value RF	-0.05 P=0.936	-0.52 P=0.634	-0.65 P=0.514	-0.63 P=0.512
' t' value RH	0.70 P=0.478	0.90 P=0.379	0.36 P=0.72	0.35 P=0.72
' t' value AT	3.40 P=0.002	3.49 P=0.002	2.58 P=0.018	2.50 P=0.021

Table 1: Population dynamics (no./m^2x100^2) of soil microarthropods, total insects, total acari and total cryptostigmatids in *Jatropha* plantation during February, 2011- January,2012

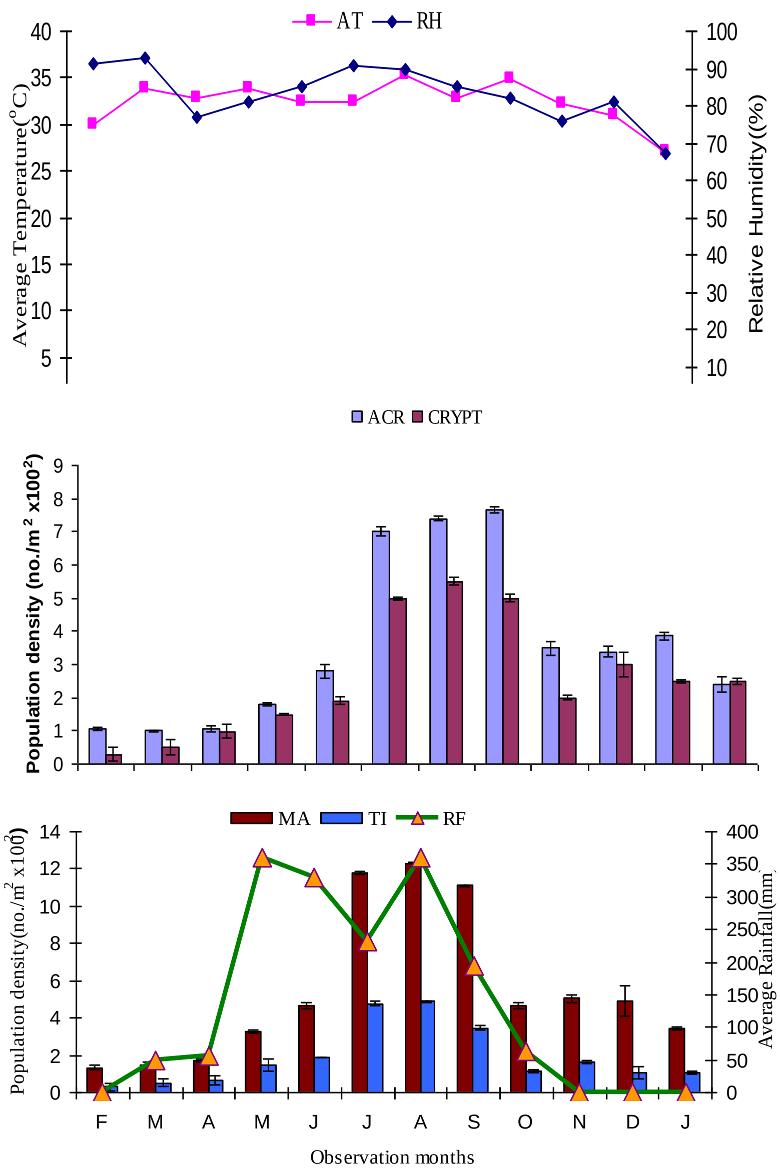

Figure 1: Showing the population dynamics (No. /m² x100²) of total microarthropods, total insecta, total acari and total cryptostigmatids in relation to climatic factors of soil in *Jatropha* plantation (February ,2014 to January 2015).

Note: AT=Average temperature, RF= Total rainfall, RH=Total relative humidity, MA=Total microarthropods, TI=Total insecta, ACR=Total acari, CRYP=Total cryptostigmata.

In litter

Population density of total microarthropods was exhibited a fluctuation of seasonal changes in all the investigation sites. the number of population was observed to be maximum during the month of September, 2019(37.15±0.84 no. /litter bag). Lower population was noticed during February, 2019(2.03±0.16 no. /litter bag) (Table 2 and Figure 2). Total insecta was maximum recorded in September, 2019(13.65±0.09 no./litter bag. The minimum population was noticed during February,2011(0.98±0.02 no./litter bag). Peak population density of Total Acari was observed in September, 2019(23.5±0.5 no. /litter bag) and lesser amount of population was noticed in February, 2011(1.05±0.46 no. /litter bag). Extracted total cryptostigmata showed its peak occurrence in the month of September, 2019(18.5± 0.09 no./litter bag) and September,2020 (12.7±0.04). The minimum population in this site was observed to be least in the month of February, 2019 (1.05±0.02 no./litter bag).

MONTH	MA±SE	TI±SE	ACA±SE	CRY±SE
Feb,2019	2.03±0.16	0.98±0.02	1.05±0.46	1.05±0.02
Mar	4.76±0.12	1.76±0.04	3±0.87	2.5±0.04
Apr	6.35±0.07	2.45±0.04	3.9±0.66	3±0.04
May	4.78±0.16	1.78±0.81	3±0.9	2.5±0.81
Jun	16.1±0.09	6.5±0.2	9.6±0.83	7.5±0.2
Jul	27.59±0.32	9.89±0.38	17.7±0.22	12.5±0.38
Aug	34.35±0.99	12.45±0.13	21.9±0.12	16.790±.13
Sept	37.15±0.84	13.65±0.09	23.5±0.5	18.5±0.09
Oct	31.93±0.08	12.43±0.04	19.5±0.22	16.7±0.04
Nov	18.08±0.07	2.68±0.04	15.4±0.45	4.5±0.04
Dec	10.55±0.47	3.05±0.04	7.5±0.98	4.5±0.04
Jan,2020	7.86±0.16	2.36±0.16	5.5±0.47	3.7±0.16
'F' value	9.44***	8.12***	8.75***	5.75**
' t' value RF	-0.05 P=0.962	-0.65 P=0.96	-0.15 P=0.88	-0.66 P=0.514
' t' value RH	0.72 P=0.488	1.01 P=0.325	1.19 P=0.250	0.36 P=0.723
' t' value AT	3.40 P=0.002	3.23 P=0.004	3.30 P=0.004	2.50 P=0.021

Table 2: Population dynamics of litter (no./litter bags) total microarthropods, total insecta, total acari and total cryptostigmatids in *Jatropha* plantation during February, 2011 January,2012

*** denotes significant at 0.001 level, ** significant at 0.01 level and * significant at 0.05 level. MA=Total microarthropods,TI=Total insecta, ACR=Total acari,CRYPT=Total cryptostigmatid, SEm= Standard Error of Mean

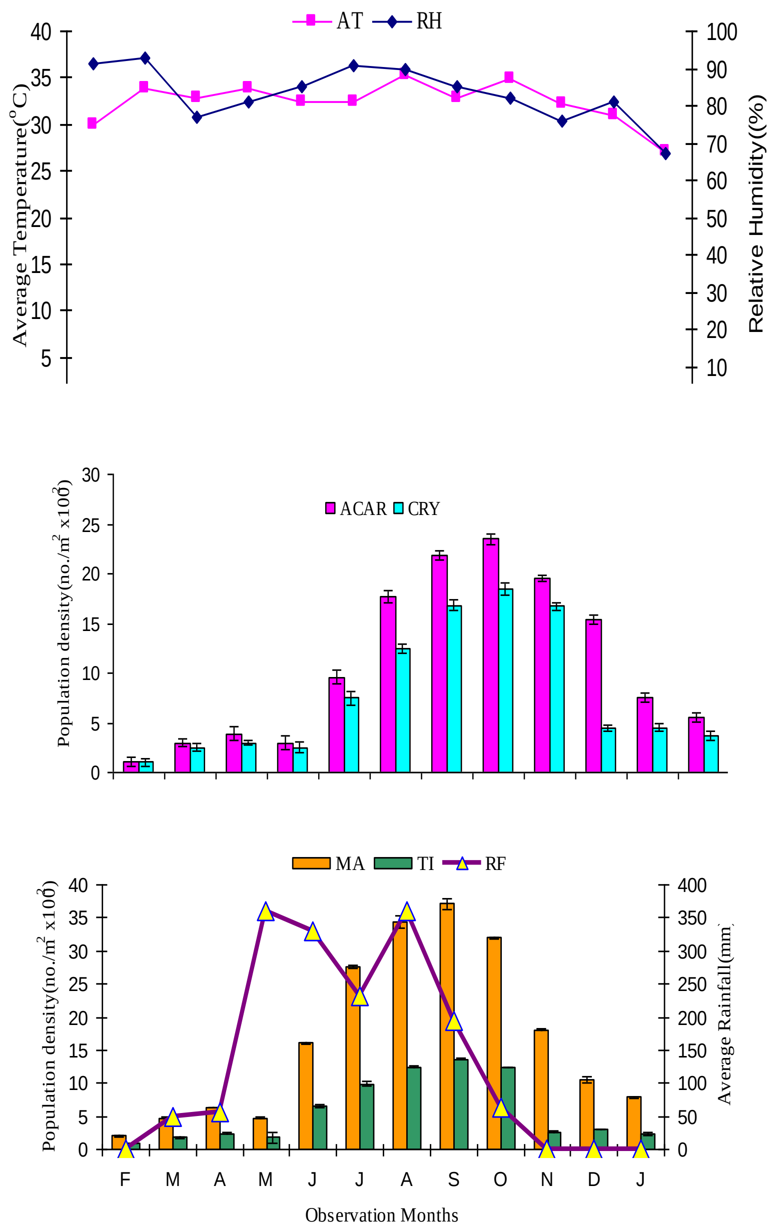

Figure 2: Showing the population dynamics (No. / litter bags) of total microarthropods, total insecta, total acari and total cryptostigmatids in litter in relation to climatic factors on *Jatropha* plantation (February ,2014 to January 2015).

Note: AT=Average temperature, RF= Total rainfall, RH=Total relative humidity, MA=Total microarthropods, TI=Total insecta, ACR=Total acari, CRYP=Total cryptostigmata.

Influence of climatic factors on:

Soil population

In this case, all the combination of climatic factors ($F=20.99.p<0.001$) had positive and significant influence on microarthropod population. In partial correlation, except rainfall ($t=-0.05$ and $p=0.936$), relative humidity (t= 0.70 and p=0.478) and air temperature (t=3.40 and p=0.002) found to be significant and positive influence on population. The climatic factors had large influence on total insecta also which has established for the multiple regression analysis (F-=12.92, p<0.001) but partial correlation showed insignificant relation between population and rainfall (t=-0.52,p=0.634). Relative humidity (t=0.90, p=0.379) and air temperature (t=3.49, p=0.002) were found to be greatly influenced on total insecta population. Total acari population was highly influenced by the combination of all the climatic factors (F=21.89, p<0.001), but here also rainfall (t=-0.65, p=0.514) had no effect on acari population. Relative humidity (t= 0.36, p=0.72) and air temperature (t=2.58, p=0.018) had great influence on population. Cryptostigmatid population was influenced by all the factors (F=22.20, p<0.01) and it revealed that apart from rainfall (t=-0.63, p=0.512), relative humidity (t=0.35, p=0.72) and air temperature (t=2.52,p=0.021) influenced on the population dynamics.

Litter dwelling population:

In litter, all the combination of climatic factors (F=9.44, p<0.001) had positive and significant influence on microarthropod population. In partial correlation, apart from rainfall (t= -0.05 and p=0.962) relative humidity (t= 0.72 and p=0.488) and air temperature (t=3.40 and p=0.002) found to be significant and positively influenced on population. The climatic factors had large influence on total insects also which has established for the multiple regression analysis (F-=8.12, p<0.001) but partial correlation showed insignificant relation between population and rainfall (t=-0.65, p=0.96). Relative humidity (t=1.01, p=0.325) and air temperature (t=3.23,p=0.004)were found to be with great impact on total insecta population. Total acari population was highly influenced by the combination of all the climatic factors (F=8.75,p<0.001), but here also rainfall(t=-0.15,p=0.88) had no effect on acari population. Relative humidity (t= 1.19, p=0.250) and air temperature (t=3.30, p=0.004) had shown influence on population. The population of cryptostigmatid was influenced by all the factors (F=5.75, p<0.01) and it revealed that except rainfall (t=-0.66, p=0.514), relative humidity (t=0.36, p=0.723) and air temperature (t=2.50, p=0.021) influenced population greatly.

Soil microarthropods, acarina in general and Cryptostigmatid in particular were predominant throughout the investigation period. In February, 2019 to January, 2020, peak population density of total microarthropod including acari and cryptostigmata recorded July, 2019 from *Jatropha* plantation respectively. The total acari population showed peak population during July, 2019 in *Jatropha* plantation. Different Researchers observed different seasonal peaks for microarthropods population in varied climate and ecological zones [14, 15]. The record of higher population in August and June corroborates with the findings of Sanyal and Sarkar [16].*Gope et al*., [17] reported the population density of soil micro arthropods during pre-monsoon (May). Peak population density of micro arthropods was observed during in February in canopy of forest [18] and it was maximum during May in soil. In many temperate regions soil faunal population generally reached their highest level during spring and fall [19] which indicates an optimal combination of temperature and humidity for soil organisms in those period. Dominant arthropod group like acarina, coleoptera, hymenoptera and collembola showed their maximum peak in February [20]. Such observation of spring peak might be due to presence of high humus concentration, high organic matter and their decomposition due to increased soil moisture content and low soil temperature [21]. Higher number of hymenoptera during spring and pre-summer months was presumed to be due to their peak breeding period and their tolerance to high temperature and low moisture content due to evaporation. Summer peak of dipteran may be due to optimum temperature and moisture content for their breeding in humus rich soil. Gradual decrease in population concentration of acarines, collembolans and coleopterans in March-April was due to high rate of evaporation of soil moisture combined with low rainfall which led to a considerable reduction in number possibly through increased mortality of delicate and susceptible live forms [21]. Population maxima were observed during post-monsoon by Moitra [22].

Significant positive correlation of mite population with relative humidity was found in semiarid central India [18]. Gope *et al*., [23] reported the maximum population of microarthropod obtained during dry season may be due to minimum rainfall, humidity, low temperature in subtropical humid climate of NE India. Present investigation stated the minimum population during February which corroborates the findings of Singh *et al*[24].

Higher population was observed in September, 2011 which corroborates the findings of Hoover and Crossley [25]. The population found maximum in rainy season and decreases throughout the year till the completion of one annual cycle. The maximum population occurs when higher amount of litter was available in the bags. Soil biological responses to climatic changes are complex and have seldom been considered in a realistic, multifactor frame work. In the present study, combine effect of climatic factors like rainfall, relative humidity and temperature showed positive and significant relationship on microarthropod groups which supports the findings of Bhattacharya and Roychoudhury (1979), Gope and Ray (2006) and Singh *et al*., (2012)[26,23,24]. Rainfall, relative humidity during wet season lead to increase in soil moisture content, facilitates the growth of vegetation and as result microarthropod population increases. Reddy and Alfred [27] found that temperature shows no relationship with both acarina and collembolan population.Palacios *et al.,* [28] reported that precipitation and temperature significantly correlated with mites and collembolan and also shows significant relationship to abundance of arthropods in litter layer. Kardol et al. [4] demonstrated how simultaneously acting climate change factors can affect the structure of soil microarthropod communities old-field ecosystem, Sweden.

CONCLUSION

Soil is a natural entity with unpredictable spectrum of microhabitats, capable of supporting the replenishment of a dynamic terrestrial community. The microorganisms present in soil forms an intimate part of soil organic matter. The quality and characteristics of organic matter of any soils are heavily dependent on the nature of microorganisms and the biochemical transformations brought about by them. These organisms play an important role in organic matter transformations that no discussion of soil biology or of soil organic matter and its effects on plant growth would be complete without consideration of soil organisms. Soil microarthropods interact with each other's; affect the soil conditions that in turn affect their presence. Soil acarines are very small free living and litter microarthropods known to occupy the topmost position in numerical abundance representing 69-95% of the total arthropod population and most of the species rich components of a terrestrial ecosystem are play a significant role in the decomposition and in maintenance of soil fertility [29]. Soil fauna are considered to be important components of soil ecosystem for maintaining nutrient cycling and biological soil fertility [30, 31, 32, 33]. Climatic factors also play an important role which favours the growth and reproduction of different arthropod groups. It obvious that leaf litter played a vital role in total litter production. The dynamics of litter production and decomposition are processes that replenish the soil nutrient pools, maintain soil life and thus ensure susceptibility to agroforestry systems.

Acknowledgement:

Author is grateful to Head, Department of Zoology, Women's College, Agartala, Tripura(west) for providing the proper facilities for smooth running of research work.

REFERENCES

1. Diem, K. Untersuchungen uber die Bodenfauna ibn.den Alpen. Jb. Narurw. *Ges.St. Galen*,1903-02:234-414.
2. Cameron, A.E..General survey of insect fauna of soil within a limited area near Manchester, *Journal of Ecology and Biology*, 1913; 8:159-204.
3. Noti M.I., Andre´ H.M. and Dufrˆene M. Soil oribatid mite communities (Acari: Oribatida) from High Shaba (Za¨ıre) in relation to vegetation. Applied Soil Ecology 5: 81–96 *of Ecology and Environment Protection, Sofia,* Bulgaria, 1996; 93–102
4. Kardol, P.; Reynolds, W.N.; Norby,R.J.andClassen,A.T.Climatic change effects on soil microarthropods abundance and community structure. *Applied soil ecology*, 2011; 47:37-44
5. Moron-Rios, A., Rodriguez, M.A., Perez-Camacho, L. and Rebollo, S., 2010. Effects of seasonal grazing and precipitation regime on the soil macroinvertebrates of a Mediterranean old-field. *Eur. J. Soil Biol*.,46:91–96.
6. Huhta, V. and Hanninen, S.M., 2001. Effects of temperature and moisture fluctuations on an experimental soil microarthropod community. *Pedobiologia.*45:279–286.
7. Hagvar, S. and Klanderud, K. Effect of simulated environmental change on alpine soil arthropods. *Global Change Biol*., 2009;15: 2972–2980.
8. Sjursen, H., Michelsen, A., Jonasson, S., Effects of long-term soil warming and fertilisation on microarthropod abundances in three sub-arctic ecosystems. *Appl. Soil Ecol*, 2005; 30: 148–161.
9. Cotrufo, M.F., Ineson, P., and Roberts, J.D. 1995. Decomposition of birch leaf litters with varying C-to-N ratios. *Soil Biol. Biochem*.,27:1219–1221.
10. Swift, M.J., Heal, O.W., Anderson, J.M., 1979.Decomposition in Terrestrial Ecosystems. Studies in Ecology, Blackwell Scientific Publishers, Oxford, 5:372 pp.
11. Loranger, G.I., Pregitzer, K.S., King, J.S., 2004. Elevated CO2 and O3t concentrations differentially affect selected groups of the fauna in temperate forest soils. *Soil Biol. Biochem.,* 36: 1521–1524.

12. Balogh, J. and Mahunka, S. 1968. Some new Oribatids (Acari) from Indonesian soil. *Opusc. Zool.* Budapest. 13: 341–346.
13. Singh,J;Mahajan,S.V. and Singh,R.K.1978.Smpling,extraction and precision regarding some statistcal studies for population ecology of soil mesofauna. Bull.Entomol.,19:130-145.
14. Borah, M. and Kakati, L.N. 2014.Population dynamics of soil acarina in natural and degraded forest ecosystem at Pathalipam, Lakhimpur, Assam. IQSR *Journal of Environmental Science, Toxicology and food technology.* 8(1): 45-50.
15. Abbas, J. M. and Parwez, H. 2012. Impact of edaphic factors on the diversity of soil microarthropod in an agricultural ecosystem at Aligarh. *Indian Journal of Fundamnatal and Applied Life Sciences*. 2(1): 185-191.
16. Sanyal, A.K. and Sarkar, B.S.1983.Qualititative composition and seasonal fluctuation of oribatid mites in saline soil in West Bengal. Indian j. Acar.8:31-39.
17. Gope, R.; Ray, D.C.and Sanyal,A.K. 2007a. Seasonal distribution and diversity of soil oribatid mites (Acari: Cryptostigmata)in homegarden and secondary successional vegetation of Barak Valley,Assam(NE India). *Environment and Ecology*, 255 (3) 498-502.
18. Ray,D.C.; Singh,S.M. and Singh,L.M. 2013. Faunal composition of soil cryptostigmata (Acari: Arthropoda) in different ecosystems of Cachar District, North Eastern India. *Indian Forster,* 130(5):415-419
19. Wallwork, J.A., 1976. The Distribution and Diversity of Soil Fauna. Academic Press, New York, 35 Wallwork, J.A.1959. The distribution and dynamics of some forest soil mites. Ecology, 40:557-5635.
20. Hazra,A. K. and Choudhuri, D.K. 1990. Ecology of subterranean macro and microarthropod fauna in different degraded and polluted soil environment of West Bengal, India. *Rec. zool. Surv. India. Occ.,* 120: 1-295
21. Paul, P.; SAnyal,A.K. and Dey,D.(2011). Population fluctuation of soil arthropods in relation to edaphic factors in cultivated and non-cultivated plots at Kharda, North-24 Parganas, West Bengal-A preliminary study. *Rec. zool. Surv. India*.111 (Part-2):7-21. East India. Acta Botanica Indica.12:180-184.
22. Moitra, M.N.2013. On variation of diversity of soil oribatids (Acari: Oribatida) I n three differently used soil habitats- a waste disposal site, a natural forest and a rea garden in the northern plains of Bengal, India. *International Journal of Scientific and Research publications*. 3(11):1-10.
23. Gope, R and Ray, D.C. 2006a.Ecological studies on soil microarthropods in Banana (Musa *sp*.) Plantation of Cachar district (Assam). *Indian Journal of Environment and Ecoplanning.*12 (1): 105-109.
24. Singh, S.M., Singh.A.M., and Ray.D.C.2012. Seasonal ecology and diversity of soil microarthropod with special reference to Acari and collembolan in forest and Imperata Grassland of Cachar district,Assam.*Journal of Environmental & Ecology*,30:1094-1098.
25. Hoover,C.M. and Crossley, D.A.Jr. 1995. Leaf litter decomposition and microarthropod abundance along an altitudinal gradient. In:Collins, H.P. Robertson, G.P. and Klug, M.J. (eds). The significance and regulation of soil biodiversity. Klwer Acadamic Publishers, Netherlands. 287-292.

26. Bhattacharya,T. and Raychaudhuri, D.N. 1979. Monthly variation in the density of soil microarthropods in relation to some climatic and edaphic factors. *Entomon*. 4(4): 313-318.
27. Reddy,M.V. and Alfred,J.R.B.1992. Consumer and decomposer arthropods in pine plantations of Meghalaya,NE India-a biodiversity and Ecological analysis .Record of the Zoological Survey of India. Occasional Paper No.152.1-129.
28. Palacios-VargaS, J.G.; Castaño-Meneses, G.; Go′mez-Anaya, J.A.; Martinez-Yrizar, A.; Mejia-Recamier,B.E.and Martinez-Sa′nchez,J.2007. Litter and soil arthropods diversity and density in a tropical dry forest ecosystrm in Western Mexico. *Journal of Biodivers Conserv*,16:3703-3717.
29. Seastedt, T.R., 1984. The role of microarthropods in decomposition and mineralization processes. Ann. Rev. Entomol. 29, 25–46.
30. Edwards, C.A. and Lofty, J.R., 1982. Nitrogenous fertilizers and earthworm populations in agricultural soils. *Soil Biology and Biochemistry* .14: 515-521.
31. Hedlund, K., and Öhrn, M.S., 2000. Tritrophic interactions in a soil community enhance decomposition rates. *Oikos* .88:585-591.
32. Wolters, V., Silver, W.L., Bignell, D.E., Coleman, D.C., Lavelle, P., van der Putten, W.H., de Ruiter, P., Wall, D.H., Wardle, D.A., Brussaard, L., Dangerfield, J.M., Brown,V.K., Giller, K.E., Hooper, D.U., Sala, O., Tiedje, J., van Veen, J.A., 2000. Effects of global changes on above- and belowground biodiversity in terrestrial ecosystems: implications for ecosystem functioning. *Bioscience.,* 50:1089–1098.
33. Osler, G.H.R., Sommerkorn, M., 2007. Toward a complete soil C and N cycle: incorporating the soil fauna. *Ecology*. 88, 1611-1621.