The Bioscan 6(2) : 191-194, 2011
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
www.thebioscan.in

EFFECT OF AGRICULTURAL PRACTICES ON THE POPULATION OF COLLEMBOLA

MOHAMMAD ILYAS AND HINA PARWEZ*
Department of Zoology, Aligarh Muslim University, Aligarh - 202 002 (U.P.) INDIA
E-mail: hinap301@gmail.com

KEY WORDS
Agricultural practices
Soil microarthropods
Collembola
Soil temperature
Diplura

Received on :
06.10.2010

Accepted on :
22.02.2011

***Corresponding author**

ABSTRACT
Collembola, an important group of soil microarthropods are usually associated with moist habitats. However, some species show adaptation to ecosystems subject to periodic desiccation. This study examined the effect of agricultural practices on the population of Collembola. The population structure of Collembola communities was studied in native agricultural soil at Aligarh along with concomitant changes in a variety of physico-chemical factors. Soil apterygotes were dominated by collembolans belonging to the families, Isotomidae and Entomobryoidae. The highest density (44.89%) was of Entomobryoidae found during rainy season followed by Isotomidae (36.74%). However the least population (17.24%) was that 0f Japygidae (Diplura) recorded in spring. The present study establishes a direct effect of high atmospheric temperature and low soil moisture on the population density of these microarthropods and this population is also affected by the soil management practices. These soil microarthropods especially Collembola are of great significance for the health of the soil and its fertility

INTRODUCTION

Collembolans play an important role in the formation of microstructure and maintaining the agricultural ecosystem which is enriched by plant litter decomposition. Collembolans are also host of many parasitic Protozoans, Nematodes and pathogenic bacteria. Soil organisms are subjected to a variety of edaphic factors in the soil such as soil moisture, temperature, pH, amount of organic carbon and nitrogen content of the soil which have a direct or indirect effect on the population dynamics of soil microarthropods. The population density of these soil microarthropods may have an effect on our agricultural produce because they are the vital source of maintaining soil health. An agro ecosystem is a regularly disturbed in the context of the above and below ground species population as well as biomass removal, nutrient input and use of pesticides and herbicides (Neher, 1999). Field management practices aim at maximizing the biomass output while minimizing the input cost. Management system implies alterations on abundance of arthropod population and natural enemies present in the crop. The harvested crop removes nutrients from the fields each time. Repeated harvesting of the crop makes the soil even poorer in nutrients and organic matter content. The loss in soil organic matter content adversely affects the soil biodiversity (Adl and Coleman, 2005) in general and Collembola in particular.

The foregoing information clearly establishes that for effective management of soil to optimize its fertility and yield of crop, a comprehensive knowledge of soil microarthropods along with the effects of various edaphic factors governing a particular ecosystem is essential. There is a considerable paucity of this information on soil microarthropods of northern part of India which is essentially a tropical zone. Hence the present study on the population dynamics of soil microarthropods in relation to agricultural practices has been undertaken.

MATERIALS AND METHODS

The area selected for study was agricultural field at Aligarh. Soil samples were collected on monthly basis for one year with the help of a circular corer sampler based on the principle of O'Conor (1957). The extraction of the soil mesofanuna is based on the behavioural response by the animals which display downward movement after being subjected to the appropriate stimulus such as heat, illumination or desiccation. We used the Tullgren funnel for the extraction of insects from the soil samples. A stereoscopic binocular microscope (Olympus Model CX 21) was used for identification of soil microarthropods population. Soil temperature was measured by directly inserting the soil thermometer into the soil upto the required depth, relative humidity of the surface of the soil has been determined with the help of Dial hydrometer, pH by electric pH meter and the absolute water content of the soil was determined by Dowdeswell (1959) method. The details of this methodology have been elaborated in earlier reports (Parwez and Sharma, 2004a).

Statistical analysis

All data was subjected for statistical analysis and Mean, SEM, SD, Correlation (r) and Analysis of variance (ANOVA) were calculated according to the formulae described by Prasad (2003).

RESULTS AND DISCUSSION

The data for seasonal variation in soil edaphic factors is shown in Table 1. Moisture content of the soil ranges between 4.98 - 19.39%, the lowest in May and the highest in September, whereas the soil temperature was recorded as high as 32ºC in the month of May and the lowest (18.5ºC) during December. The total number of soil insects especially apterygote insects collected from the soil samples showed fluctuations corresponding with monsoon peak and a winter low consistently (Table 2). The apterygote insect population was represented by order-Collembola and order-Diplura. Collembolans being the major group of the sub soil community were found in dominant number. They are represented by members of family Poduridae, Isotomidae, Onychiuridae, Nenuridae, and Entomobryoidae. *Entomobrya* sp was highest in number along with other representatives collected in different proportions showed a monsoon peak and a summer minima. Diplurans, the other apterygote insects were also collected but their population was meagre and represented only by *Japyx* sp. (Fig. 2). Similarly, Parwez and Sharma (2004b) observed that the order Diplura represented by *Japyx sp* showed an increase in population during wet months (July-September) coinciding with the peak of abundance of collembolans. The simple correlation coefficient between the apterygote insects mainly Collembola and Diplura with different physico chemical parameters such as temperature and moisture revealed that the variation of the insectan population were significant at $p < 0.05$ level (Table 3).

The results presented in this study are based on the survey of soil samples collected from an agricultural field which is under frequent tillage. The tillage and manuring of the area would disturb the soil profile. The site under study was utilized throughout the year by different crops. In the month of February sowing of Luffa crop is done which is harvested by the end of August. After this the field is ploughed and Mustard seeds are sown which is harvested at the end of January or February but before March. The agricultural intensification through crop rotation is only to overcome the insufficient food production for the needs of an expanding population. The outcome in terms of food production may be positive but maintenance of decomposer communities is very essential. The farmers have used chemical fertilizer for sustaining and improving the fertility of the soil. The changing land use and agricultural intensification has a profound effect on the structure and diversity of decomposer community (Beare *et al.*, 1997). Further the impact of tillage that is when the field experienced heavy ploughing, has a direct effect on the soil profile as well as on the population of insects. Before sowing and after harvesting, the area is ploughed or tilled which turns the whole soil profile upside down and it was during this period that we observed low population of collembolans and very low of diplurans. This temporary decline in the population during March and April could be explained partly due to the effects of herbicide and insecticide and manual tilling of the soil (Choi *et al.*, 2006). When the fields become lush green with vegetation, the population of microarthropods showed an increasing trend despite the fact that fields are tilled and the

Table 1: Seasonal variations in edaphic factors in an agricultural soil at Aligarh (U.P.), India

Months → Edaphic Factors ↓	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temperature (ºC)	20	21	22	31	32	32	28	31	29	27	23	18.5
Moisture (%)	7.96	6.34	5.17	5.10	4.98	5.02	19.39	14.13	15.04	18.05	10.42	8.10
Relative humidity (%)	55	46	34	42	36	36	95	70	66	45	81	52
pH	7.8	7.5	7.4	7.4	7.5	7.7	7.6	7.6	7.5	7.4	7.7	7.6

Table2: Total population and density of Collembola in an agricultural land at Aligarh

Family↓	Months →	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total Average
Isotomidae	Population	27	35	40	42	46	50	57	70	78	49	36	28	558.00
	Density	6.75	8.75	10.00	10.52	11.50	12.50	14.25	17.50	19.50	12.25	9.00	7.00	11.625
Entomobryoidae	Population	10	12	15	20	47	56	68	72	80	50	40	20	490.00
	Density	2.50	3.00	3.75	5.00	11.75	14.00	17.00	18.00	20.00	12.50	10.00	5.00	10.208
Poduridae	Population	8	30	28	20	15	12	30	40	40	55	30	27	335
	Density	2.00	7.50	7.00	5.00	3.75	3.00	7.50	10.00	10.00	13.75	7.50	6.75	6.979
Onychiuridae	Population	10	15	20	25	28	30	28	20	29	20	22	15	262
	Density	2.50	3.75	5.00	6.25	7.00	7.50	7.00	5.00	7.25	5.00	5.50	3.75	5.458
Nenuridae	Population	25	32	35	30	12	15	60	55	50	30	27	25	398
	Density	6.25	8.00	8.75	7.50	3.00	3.75	15.00	13.75	12.5	7.50	6.75	6.25	8.271
Diplura / Japygidae	Population	2	1	2	3	2	1	3	4	2	3	4	2	29
	Density	0.50	0.25	0.50	0.75	0.50	0.25	0.75	1.00	0.50	0.75	1.00	0.50	0.604

Table 3: Correlation between different apterygote populations with edaphic factors during the year

Order (Family)→ Variables↓	Collembola (Poduridae)	Collembola (Isotomidae)	Collembola (Onychiuridae)	Collembola (Nenuridae)	Collembola (Entomobryoidae)	Diplura (Japygidae)
Soil Temperature	0.90	0.97	0.99	0.90	0.90	0.92
Moisture	0.90	0.92	0.87	0.94	0.92	0.91

All values were significant at $p < 0.05$

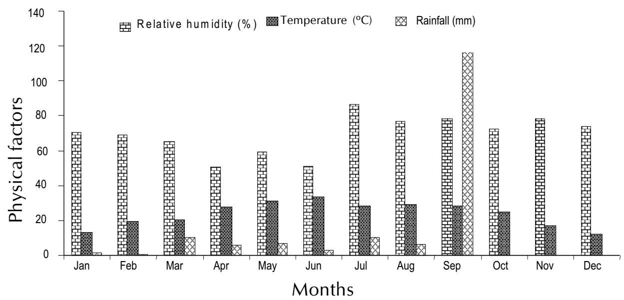

Figure 1: *Climatological data of Aligarh* during the period of present investigation

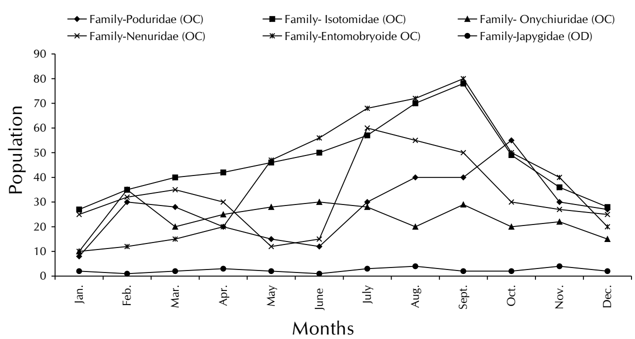

Figure 2: Mean value of insectan population of mineral soil up to a depth of 5 cm; OC = Order-Collembola, OD = Order-Diplura

cash crop is rotated throughout the year.

In the present study we also observed that various groups of collembolans have shown different moisture preferences. Members belonging to family Isotomidae showed highest population profile throughout the year from January to December whereas members of Poduridae family remained lowest all through. The population of members of other groups of collembolans remained confined between these two groups. The reason for such varied population density could be attributed to treatments given to the soil during different cropping and harvesting periods which may directly affect the soil water content, soil temperature and also the diversity of soil microarthropods (Maria *et al.,* 2004). The soil moisture plays a vital role in maintaining the population of microarthropods with an increase in monsoon months. During monsoon months due to heavy rains, we observed low pH (7.4) in the soil and increased atmospheric humidity. The soil pH is an important edaphic factor for the well being of communities of soil organisms. The pH is also affected by the pollutants added up in the soil along with rain water (Jaeger and Eisenbeis, 1984). Soil pH also influences the fecundity and longevity of Collembola (Hutson, 1978). The longevity was highest at pH 4 – 6, egg production maximum at pH 7.2 and optimum fecundity was at pH 5.2. These observations fall in line as when pH was low (7.4) the population density was 35.

During this study, we observed an increase in the population of collembolans during monsoon months and their decline during hot summer and extreme winter months. Heavy rains which increase the moisture content of the soil (Fig. 1) and decrease in the soil temperature, this condition to some extent have a direct effect on the population of soil microarthropods. These observations fall in line with that of Huhta and Hanninen (2001) that varying moisture contents affect the population of collembolans. The densities of collembolan species were higher in wet soil than in dry soil. The effect of soil moisture was also studied as the population of Collembola which was low in pre monsoon months May (4.98%) and high (19.39%) in post monsoon month (July). It was observed that soil moisture is a major limiting factor on vertical distribution of the Collembola.

Temperature plays an important role in seasonal variation of these microarthropods specially collembolans and diplurans which had also been reported earlier by Sinha *et al.,* (1988). We observed a low population of Collembola in winter that corresponded well with consistent decrease in soil and atmospheric temperature (18.5°C and 12°C). The reason for this low population of Collembola at low temperature could be that during low soil temperature, the moisture content of the soil is also very less (20°C, 4.98%) which is unfavourable since soil microarthropods flourish well in moist conditions. In dry and desiccated soil the fungal growth is negligible and fungus being the main food of the collembolans, their population show a declining trend during this period. Yet another reason of low collembolan population at low temperature could be that the arrest in reproduction and higher adult mortality. It has also been observed that many collembolans species undergo hibernation (Joose, 1981). Earlier Christiansen (1964) have reported that temperature regulates the reproduction of springtails but the role of moisture is equally important in regulating and synchronizing the reproductive activity, hatching and mortality. According to Parwez and Sharma (2004c) the temperature and moisture content play a significant role in the regulating of population density of soil mesofauna. This is likely to be linked with the reproductive activities of this group of organisms. Similarly Collembola may be influenced by the occurrence of long dry spell during hot summer months because they are prone to desiccation (Parwez and Sharma, 2004a). Some of the collembolans have become adapted to periodically dry environment. To avoid summer drought, the collembolans have adopted certain strategies such as a primitive tracheal system and a thick integument and also aestivation (Alvarez *et al.,* 1999). Therefore in hot summer months, when the atmospheric temperature was very high and humidity was low and the soil temperature was also very high, the collembolan population was affected. The optimum temperature preference for these collembolans to grow and survive is 30°C (Ashraf, 1971). Parwez and Sharma (2004d) observed that the collembolan populations showed a negative correlation with soil temperature and a positive one with soil moisture which is also supported by our study since there is a decline in population in hot months when atmospheric temperature was more than 45°C. The collembolan population showed a negative correlation with soil temperature (Bandhopadhay *et al.,* 2002). In conclusion, it may be stated that the present study has clearly established that soil management practices such as rotation of crop, tillage, ploughing, application of fertilizers and pesticides have profound effect on the overall population dynamics of collembolans. This important group of soil microarthropods is also affected by variety of edaphic factors namely, atmospheric and soil temperature, humidity, soil moisture content and pH which are independently correlated with collembolan population.

ACKNOWLEDGEMENTS

The authors are grateful to Chairman, Department of Zoology, AMU, Aligarh for providing necessary research facilities. This work has been supported by the research grant no. 34-423/2008 (SR) sanctioned by University Grants Commission, New Delhi.

REFERENCES

Adl, M. S. and Coleman, D. C. 2005. Dynamics of soil protozoa using a direct count method. *Biology and Fertility of Soil*. 168-171.

Alvarez, T., **Frampton, G. K. and Goulson, D. 1999.** The effects of drought upon epigeal Collembola from arable soils. *Agricultural and Forest Entomology*. **1:** 243-248.

Ashraf, M. 1971. Influences of environmental factors on Collembola. *Rev. Ecol. Biol. Sol.* **8:** 243-252.

Bandhyopadhyaya, I., Choudhari, D. K. and Ponge, J. F. 2002. Effects of some physical factors and agricultural practices on Collembola in a multiple cropping programme in West Bengal (India). *European J. Soil Biology*. **38:** 111-117.

Beare, M. H., Reddy, M. V. T. and Srivastava, S. C. 1997. Agricultural intensification, Soil Biodiversity and agroecosystem function in the tropics: The role of decomposer biota. *Applied Soil Ecology.* **6(1):** 87-108.

Christiansen, K. **1964**. Bionomic of Collembola. *Ann. Rev. Entomol.* **9:** 147-178.

Choi, W. I., Moorhead, D. L., Neher, D. A. and Ryoo, M. I. 2006. Study of soil temperature and moisture effects on population dynamics of *Paronychiurus kimi* (Collembola: Onychiuridae). *Biology and Fertility of Soil*. **43(1):** 69-75.

Dowdeswell, W. H. 1959. *Practical Animal Ecology***.** Methuen and Co. Ltd., London.

Huhta, V. and Hanninen, S. M. 2001. Effects of temperature and moisture fluctuations on an experimental soil microarthropod community. *Pedobiologia*. **45(3):** 279-286.

Hutson, B. R. 1978. Influence of pH, temperature and salinity on the fecundity and longevity of four species of Collembola. *Pedobiologia*. **18:** 163-179.

Jaeger, G. and Eisenbeis, G. 1984. pH-depended absorption of solution by the ventral tube of *Tomocerus flavescens* (Tullberg, 1871) (Insecta, Collembola). *Rev. Ecol. Sol*. **21:** 519-531.

Joose, E. N. G. 1981. Ecological strategies and population regulation of Collembola in heterogeneous environment. *Pedobiologia*. **21(5):** 345-356.

Maria, A. T., Athanasios, S. K., Eleni, K., George, P. S. and Stefanes, P. S. 2004. Responses of soil microarthropods to experimental short-term manipulations of soil moisture. *Applied Soil Ecology*. **29(1):** 17-26.

Neher, D. A. 1999. Soil community composition and ecosystem processes: comparing agricultural ecosystems with natural ecosystems. *Agrofor. Syst.* **45:** 159 185.

O'Conor, F. B. 1957. An ecological study of the enchytracid worm population in a coniferous forest soil. *Oikos* **8:** 161-199.

Parwez, H. and Sharma, M. K. 2004 a. Seasonal fluctuation in the population density of soil insects under Acacia Plantation. *Annals of Biology*. **20(2):** 115-122.

Parwez, H. and Sharma, M. K. 2004 b. Species diversity and population dynamics in the soil Mesofauna of arable land. *Annals of Biology*. **20(2):** 123-130.

Parwez, H. and Sharma, M. K. 2004c. Circanual variations and interrelationship of abiotic factors with the soil dwelling mesofauna in a fallow land. *Bulletin Pure and Applied Sciences*. **23A(1):** 35-40.

Parwez, H. and Sharma, M. K. 2004d. Dynamics of the collembolan population in two different ecotypes in a tropical reson. *Bio-Science Research Bulletin*. **20(1):** 27-38.

Prasad, S. 2003. Elements of Biostatistics. *Rastogi Publications*.

Sinha, P. B., Sen, N. S. and Jafri, H. A. 1988. On the seasonal population fluctuation of Collembola and Acarina in deciduous forest at Ranchi. *J. Environ. Biol*. **9(1):** 79-83.