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POPULATION FLUCTUATION OF SOIL ARTHROPODS IN RELATION TO EDAPHIC FACTORS IN CULTIVATED AND NON-CULTIVATED PLOTS AT KHARDAH, NORTH 24-PARGANAS, WEST BENGAL - A PRELIMINARY STUDY

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INTRODUCTION

Soil is a decomposition product, the solid phase of which has two main constituents, one is the mineral material and the other is the organic material. The vegetation growing in the soil provides the organic material that remains closely associated with the mineral part of the soil. The soil microarthropods which are dominant and most important biotic component of soil ecosystem, play a major role in decomposition of the organic matter (Wallwork, 1970). Considering the great role played by various groups of arthropods, many researchers in India had taken up the studies on soil arthropods in different vegetation sites and agricultural fields. A good number of workers also conducted studies to understand the relationship between soil microarthropods and different edaphic factors.

The earliest work on soil fauna was done by Diem (1903). Cameron (1913) first carried out the survey of soil insects. Later in 1917 he first pointed out the environmental condition may cause differences in the faunal make-up in two types of grasslands. Buckle (1921) said that growth of vegetation affects the growth of fauna. Thomson (1924) while working on a piece of grassland observed that collembola and acarina were the dominant groups among other soil fauna with maximum population in winter months. Frenzell (1936) found that the soil moisture had a direct role on the fluctuation of the faunal population. He recorded maximum population of soil organisms in early winter and early spring while the minimum in mid winter and mid summer.

Hammer (1944, 1953) observed soil faunal population was negatively correlated with the soil moisture. Macfadyen (1952) found the population to be maximum in winter and that too in the upper layer of the soil. Davis and Murphy (1961) observed that soil factors like pH, organic carbon and moisture could exert a triggering effect on soil animals. Edwards and Lofty (1969) observed that more drastic population fluctuation of soil microarthropods could be expected from effects of cultivation and addition of organic manure. Edwards and Lofty (1974) while studying the impact of organic manure and the other factors on the invertebrate fauna of grassland, observed that the total collembolan population was little affected by the level of nitrogen. In their opinion Collembola as a whole was influenced by soil pH than mites.

Notable researches have been done by several workers in West Bengal. Choudhuri and Banerjee (1975, 1977) reported a strong positive correlation between the collembolan population and moisture content of soil. According to Singh and Pillai (1975) the Oribatid mites were predominant in the soil with a higher content of organic matter while Prostigmatid mites were dominant in the soil deficient in organic matter. The study of soil mesofauna in a grassland ecosystem by Pillai and Singh (1977) revealed the occurrence of two population peaks of mesofauna, one in the rainy season and the other in the winter season. According to them the contents of moisture and organic matter in the soil played significant role on the population fluctuation of microarthropods. Bhattacharya and Joy (1978), Bhattacharya and Roychowdhury (1979), Bhattacharya *et al.* (1980), Ghatak and Roy (1981), Sanyal (1981, 1982, 1994), Hazra and Sanyal (1989), Sengupta and Sanyal (1991), Sanyal and Sarkar (1993), Sanyal *et al.* (1999), Roy *et al.* (2004) reported their observations on soil arthropod population in uncultivated and cultivated lands in West Bengal.

In the present study an attempt has been made to investigate soil microarthropod population and seasonal fluctuations and their relationship with soil moisture, temperature and pH in two sites, one uncultivated and another cultivated having different crops in different seasons.

SITE DESCRIPTION

Two sites, one cultivated and the other non-cultivated were selected in this study. Both the sites were located at Khardah, North 24-Parganas, West Bengal (Map – 1). The Barrackpore Trunk road runs about ¼ km away from the site on eastern side and the river Ganges runs very near on the western side. Soils of both the sites were gangetic alluvial in nature, blackish grey in colour and clay-loam in texture.

I. *Non-cultivated site (P1)*

The sampling site was non-cultivated and undisturbed. A dumping ground of household wastes was present a little away from the site. It included two sampling plots each 10 meters square in size.

The site was covered with grasses such as *Cynodon dactylon* and *Brachiaria* sp. Some seasonal herbs like *Lantana* sp., *Urinea* sp., *Clerodendron* sp., *Amaranthas* sp., *Solanum* sp., *Ipomoea* sp. and *Croton* sp. were also found at this site. The plot also contained fallen leaves and twigs of trees. Soil was rich in humus content. Shade was found to prevail there in some parts of the day (Fig. 1 & 2).

II. *Cultivated site (P2)*

The site situated near the first one was separated by a brick wall. During the study, the site contained cultivated plants like coriander, mustard (*Brassica* sp.), potato, tomato, etc. Besides these vegetations some garden flower plants like ganda, dhalia, astar, cosmos, etc. were also present in the field. The site was manured by cow-dung only. Insecticides were not used on the vegetation. Plots were watered frequently particularly in winter and summer months. The site was covered with grasses and some wild plants; cut grasses and bamboo logs were also found dumped here and there in the site. The site was divided into two sampling plots each 10 meters square in size (Fig. 3).

MATERIALS AND METHODS

A. *Collection of Soil sample :*

A total number of 120 soil samples were drawn from 4 plots in 2 sampling sites at monthly interval over a period of six months that is from November 2007 to April 2007 @ 5 samples/month/plot. The undisturbed soil samples were drawn at random using stainless steel cores with an internal diameter of 5cm. Each soil core was 25 square cm in surface area and 10 cm in depth.

B. *Extraction of soil arthropods :*

The extraction of soil samples was done by Tullgren funnel apparatus as modified by Macfadyen (1953). The soil samples were kept under extraction for 72 hours. The extracted soil arthropods were then sorted out into different groups under stereoscopic binocular microscope and counted. The adult and comparatively large sized arthropods were collected by hand picking method. All the collected specimens were preserved in separate glass vials containing 70% alcohol for further study.

C. *Recording and analysis of soil factors :*

Soil thermometer was used to record the temperature of the soil. pH of the soil was determined by the electronic pH meter. Moisture of the soil sample was measured by the "Oven dry method" (Dowdeswell, 1959) and expressed in percentage of weight difference before and after the soil samples were dried for 4 hours at 105° C.

RESULTS

I. *Analysis of Edaphic factors : a) pH*

Site P1 (Non-cultivated site)

Soil pH (Table-1) ranged from 5.3 to 6.9. It was maximum in the month of January (6.9) and gradually reduced in the months of March (5.5) and April (5.3).

Site P2 (Cultivated site)

Soil pH (Table-2) ranged from 5.2 to 6.2. There were records of 6.1 to 6.2 in the months of January and February but decreased to 5.7 and 5.2 in March and April respectively.

The pH was observed slightly low in the cultivated site.

b) *Moisture*

Site P1 (Non-cultivated site)

Soil moisture content (Table-1) ranged from 29.70% to 21.50%. The value was maximum in February 29.70%, nearly 26.70% to 27.80% in the months of January and November. The value gradually reduced in the months of March (23.40%) and April (21.50%).

Site P2 (Cultivated site)

Soil moisture content (Table-2) ranged from 29.40% to 24.4%. Maximum amount of moisture content was recorded in the month of February and almost similar concentrations were recorded in November (27.70%),

Table-1 : Showing mean no. of individuals group of arthropod/month and their percentage/month at sampling site P1 (undisturbed and non-cultivated plots) from November 2007-April 2008

Sl. No.	Arthropods and soil factors	November	December	January	February	March	April
		Arthropod/ month Mean no. (%)	Arthropod/ month Mean no. (%)	Arthropod/ month Mean no. (%)	Arthropod/ month Mean no. (%)	Arthropod/ month Mean no. (%)	Arthropod/ month Mean no. (%)
1.	Acarina	34 (12.27)	42 (15.16)	66 (23.82)	72 (25.99)	35 (12.63)	28 (10.10)
2.	Collembola	57 (11.72)	101 (20.78)	112 (23.04)	121 (24.89)	53 (10.90)	42 (8.64)
3.	Hymenoptera	12 (9.67)	15 (12.09)	26 (20.96)	30 (24.79)	21 (16.93)	20 (16.12)
4.	Coleoptera	15 (12.93)	16 (13.79)	22 (18.96)	31 (26.72)	18 (16.51)	14 (12.06)
5.	Diptera	2 (2.2)	3 (3.3)	4 (4.4)	22 (24.44)	27 (30)	32 (35.55)
6.	Insect larvae	20 (13.42)	26 (17.44)	37 (24.83)	42 (28.18)	11 (7.38)	13 (8.72)
7.	Others	7 (3.19)	11 (26.82)	9 (21.95)	7 (17.07)	5 (12.19)	2 (4.87)
8.	pH	6.3	6.2	6.9	6.8	5.5	5.3
9.	Moisture (%)	27.80	24.30	26.70	29.70	23.50	21.50
10.	Temperature (°C)	28.00	22.30	21.50	24.60	33.50	34.00

January (27.20%) and March (27.30%) with minimum in the month of April i.e. 25.00 %.

The percentage of soil moisture content was recorded as slightly high in cultivated site (P2).

c) *Temperature*

Site P1 (Non-cultivated site)

Soil temperature (Table-1) ranged from 21.5°C to 34.0°C. Mximum temperature was recorded in the months of March and April and minimum in January (21.5°C).

Site P2 (Cultivated site)

Soil temperature (Table-2) ranged from 22°C (January) to 33.7°C. The months of March (32.5°C) and April (33.0°C) showed nearly same temperature.

The result indicated more or less similar range of temperature in the two sites.

II. *Faunal make-up :*

A total number of 1283 arthropods belonging to 9 different groups namely Acarina, Collembola, Hymenoptera, Coleoptera, Diptera, Psocoptera, Hemiptera, Diplura and Isoptera were collected. As the number of specimen of Psocoptera, Hemiptera, Diplura and Isoptera was low, these 4 groups were jointly considered here as 'others' The quantitative difference in arthropod population showed that site P1 was rich (1283) in fauna than P2 (796) (Tables 1, 2). Collembola was recorded as most dominant group (P1= 486 and P2 = 374) in both the sites. They contained 37.87 % and 46.98 % of the total arthropod population recorded from sites P1 and P2 respectively. The other faunal groups like Acarina (21.59 %), Hymenoptera (9.66 %), Coleoptera (9.04 %) and Diptera (7.01 %) were found to occupy second, third, fourth and fifth position repetitively in P1 site. In P2 site Hymenoptera (26.13 %), Acarina (12.06 %), Coleoptera (5.65 %) and Diptera (2.51 %) were found to occupy second, third, fourth and fifth position repetitively. The ants were the main components of Hymenopteran insects recovered intheP1 and P2 sites. Different insect larvae collected in P1 and P2 sites were 11.61 % and 3.76 % respectively.

Table-2 : Showing mean no. of individuals group of arthropod/month and their percentage/month at sampling site P2 (disturbed and cultivated plots) from November 2007-April 2008

Sl. No.	Arthropods and soil factors	November	December	January	February	March	April
		Arthropod/ month Mean no. (%)	Arthropod/ month Mean no. (%)	Arthropod/ month Mean no. (%)	Arthropod/ month Mean no. (%)	Arthropod/ month Mean no. (%)	Arthropod/ month Mean no. (%)
1.	Acarina	19 (19.79)	16 (16.66)	27 (28.12)	22 (22.9)	9 (9.3)	3 (3.12)
2.	Collembola	55 (14.70)	67 (17.91)	92 (24.59)	96 (25.66)	33 (8.82)	31 (8.28)
3.	Hymenoptera	21 (10.09)	26 (12.50)	37 (17.78)	49 (23.55)	33 (15.86)	42 (20.14)
4.	Coleoptera	5 (11.11)	4 (8.88)	11 (24.44)	12 (26.66)	7 (15.55)	6 (13.33)
5.	Diptera	4 (20)	2 (10)	1 (5)	3 (15)	4 (20)	6 (30)
6.	Insect larvae	5 (16.66)	4 (13.33)	9 (30)	5 (16.66)	3 (10)	4 (13.33)
7.	Others	2 (8.69)	4 (17.39)	6 (26.08)	6 (26.08)	2 (8.69)	3 (13.04)
8.	pH	6.1	5.9	6.1	6.2	5.7	5.2
9.	Moisture (%)	27.7	24.4	27.2	29.4	27.3	25
10.	Temperature (°C)	27.50	24	22	24.20	32.50	33.70

Table 3 : Showing individuals group of arthropods and their monthly population (%) at sampling site P1 (non-cultivated and undisturbed) and P2 (disturbed and cultivated) at Khardah from November 2007-April 2008

	Group of Arthropods													
	Acarina		Collembola		Hymenoptera		Coleoptera		Diptera		Insect larvae		Others	
Months	P1	P2	P1	P2	P1	P2	P1	P2	P1	P2	P1	P2	P1	P2
November	23.12	17.11	38.77	49.54	8.16	18.91	10.20	4.50	1.36	3.60	13.60	4.50	4.76	1.80
December	19.62	13	47.19	54.47	7	21.13	7.47	3.25	1.40	1.62	12.14	3.25	5.14	3.25
January	23.91	14.75	40.57	50.27	9.42	20.21	7.97	6.01	1.44	0.54	13.40	4.91	3.26	3.27
February	22.15	11.39	37.23	49.74	9.23	25.38	9.58	6.21	6.76	1.55	12.92	2.59	2.15	3.10
March	20.58	9.80	31.17	36.26	12.35	36.26	10.58	7.69	15.88	4.39	6.47	3.29	2.94	2.19
April	18.54	3.15	27.81	32.63	13.24	44.24	9.27	6.31	21.19	6.31	8.60	4.21	4.32	3.15

III. *Population fluctuation :*

In comparing the faunal composition in two sites, it was found that percentage (46.98 %) of collembolan population in P2 site was higher compared to (37.87 %) P1 site. Similarly Hymenopteran population was more in percentage in P2 site (26.13 %) than P1 site (9.66 %). In all other groups like Acarina, Diptera, Coleoptera and Insect larvae the percentage of population

Figs. 1. Non Cultivated Site.

Figs. 2. Non Cultivated Site.

Fig. 3. Cultivated Site.

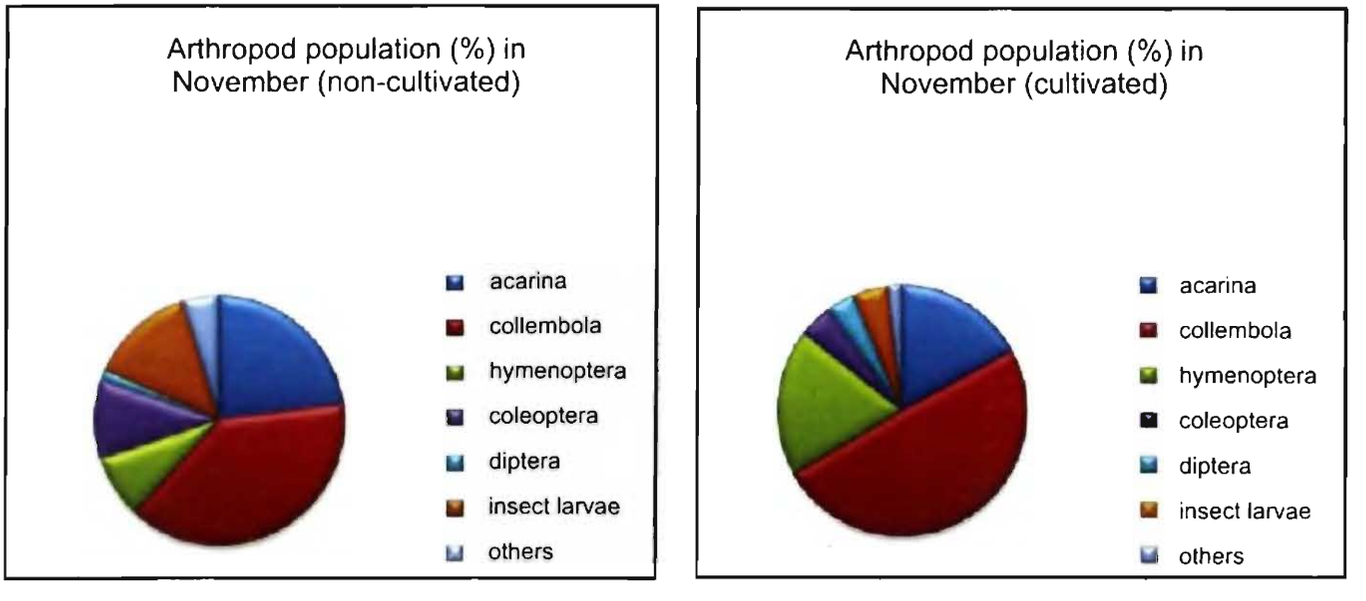


Fig. 4 Pie chart depicting Arthropod population (%) in November in Cultivated and Non-Cultivated plots.

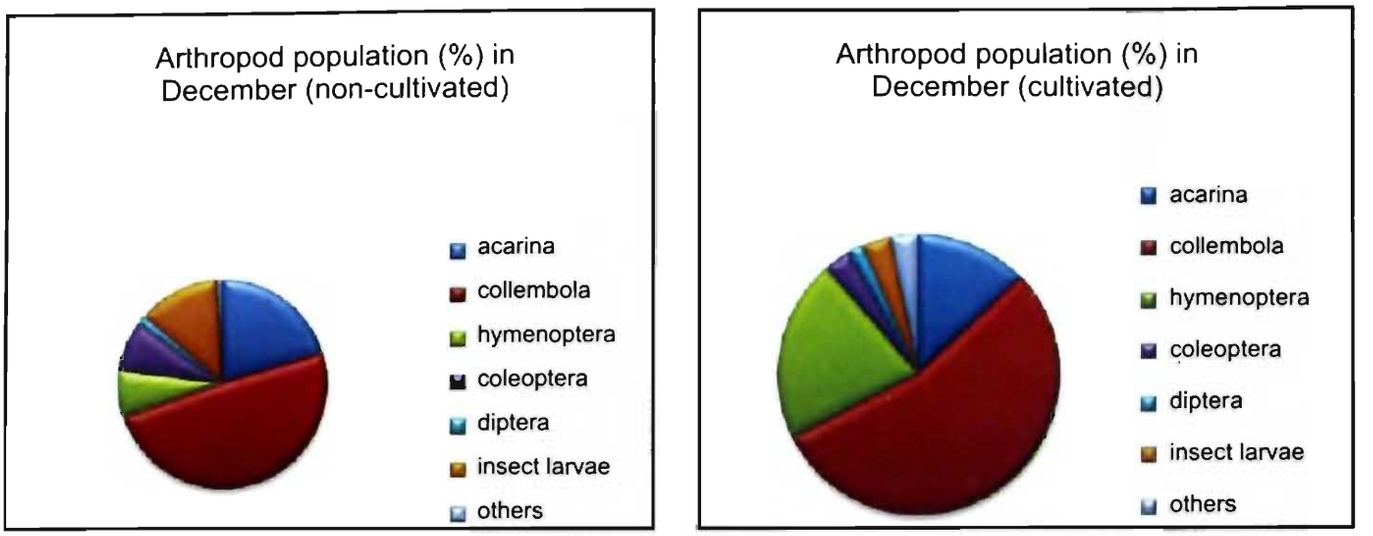


Fig. 5 Pie chart showing Arthropod population (&) in December in Cultivated and Non-Cultivated plots.

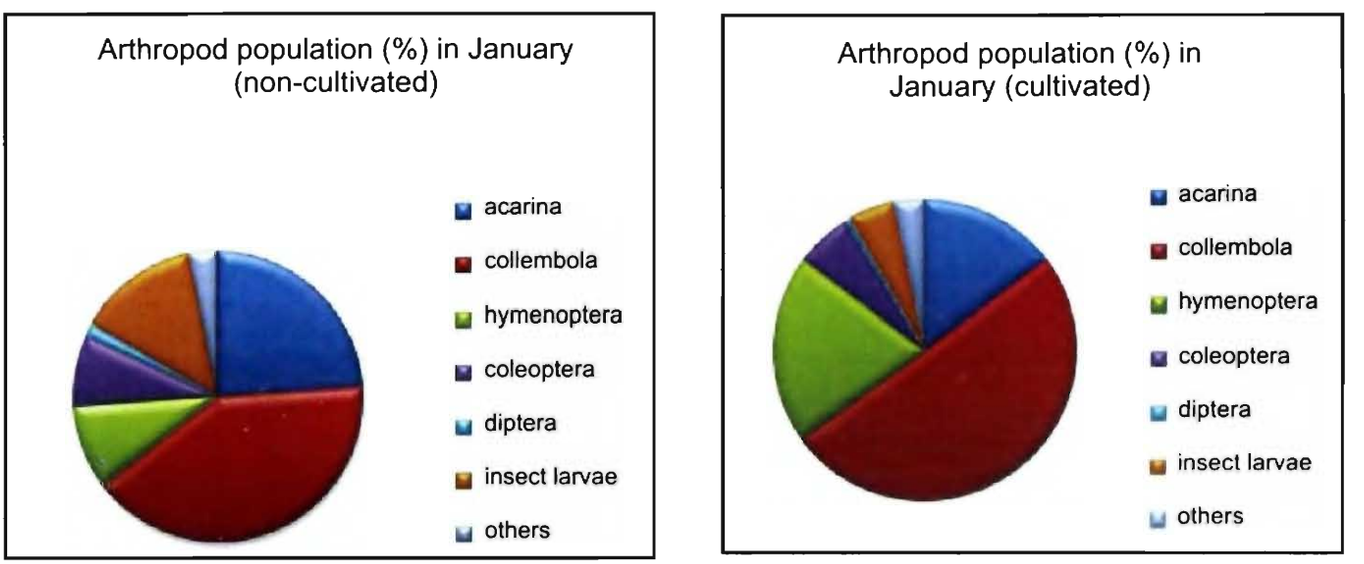


Fig. 6 Pie chart showing Arthropod population (&) in January between Cultivated and Non-Cultivated plots

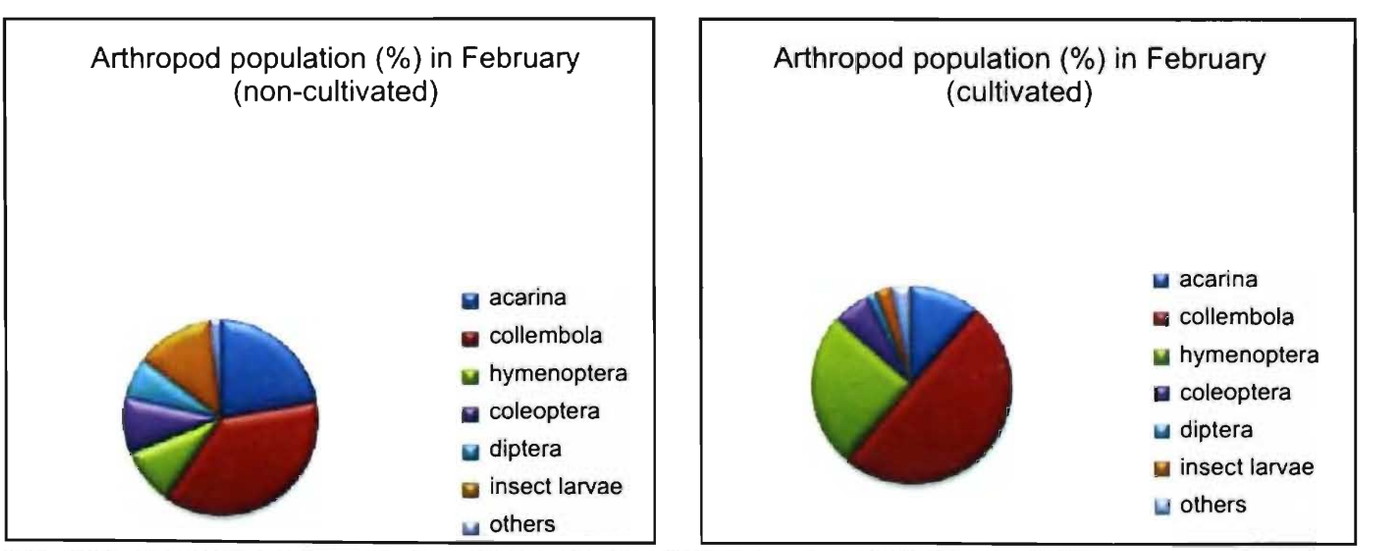


Fig. 7 Pie chart showing Arthropod population (%) in February between Cultivated and Non-Cultivated plots.

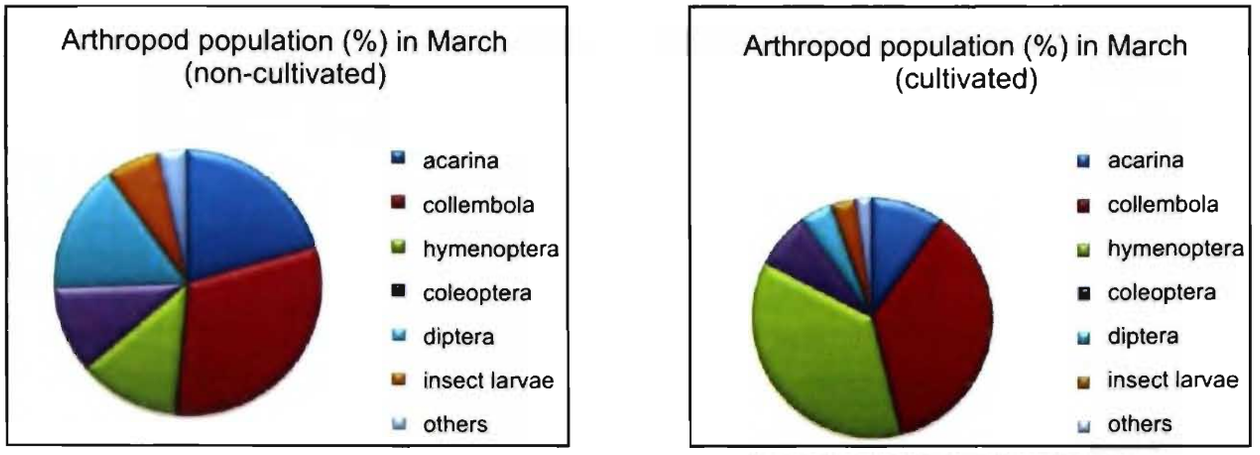


Fig. 8 Pie chart showing Arthropod population (%) in March in Cultivated and Non-Cultivated plots.

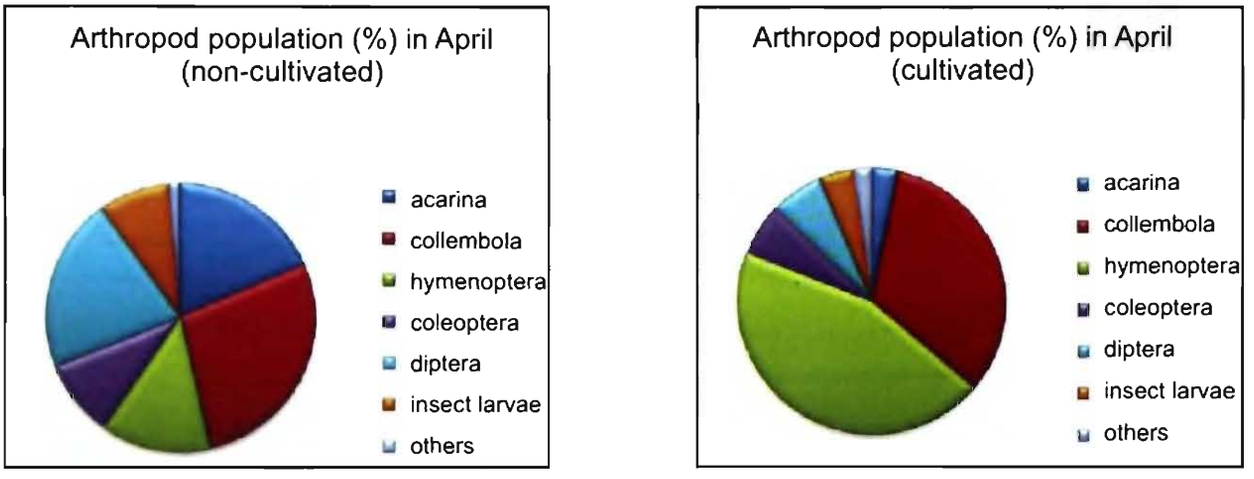


Fig. 9 Pie chart showing Arthropod population (%) in April in Cultivated and Non-Cultivated plots.

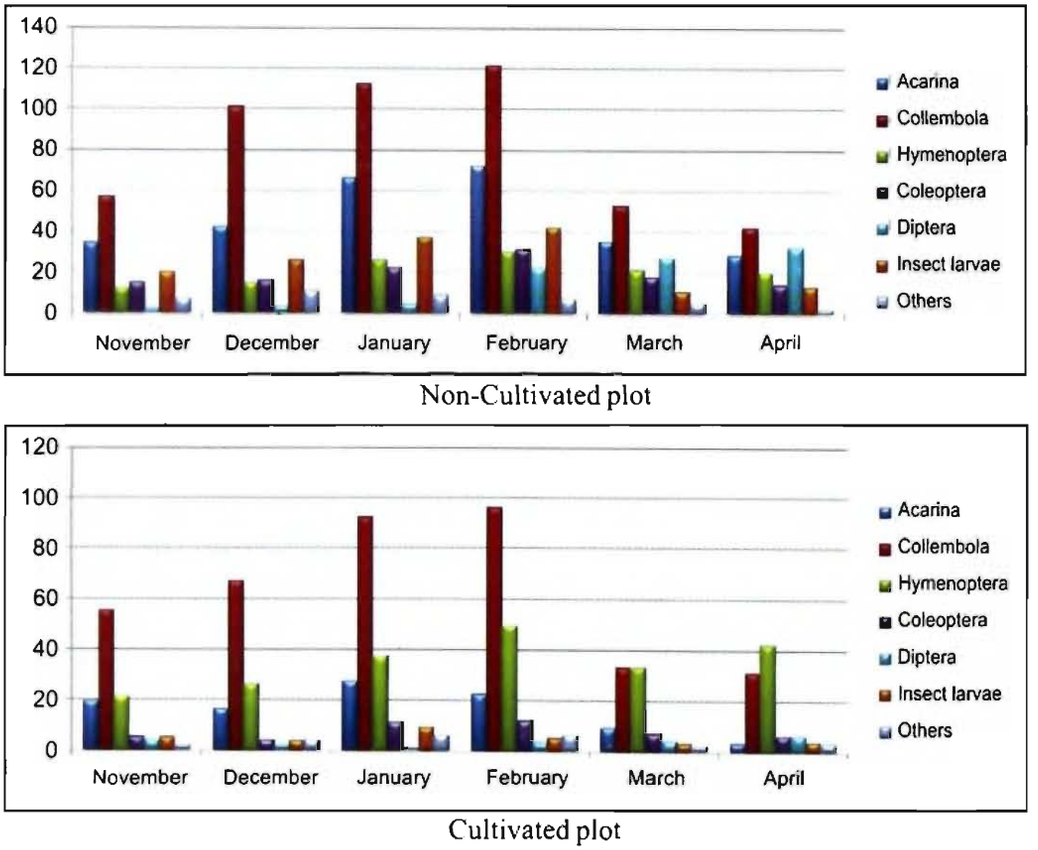
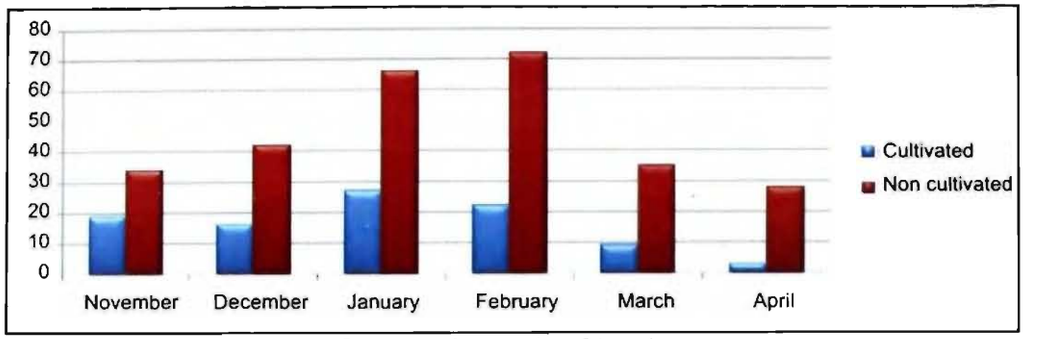
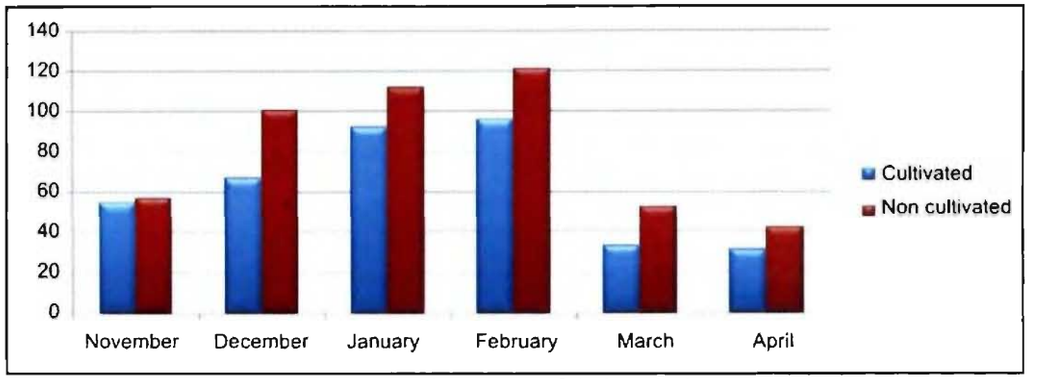


Fig. 10 Comparative study of arthropods in Cultivated (P2) and Non-Cultivated (P1) plots from November to April

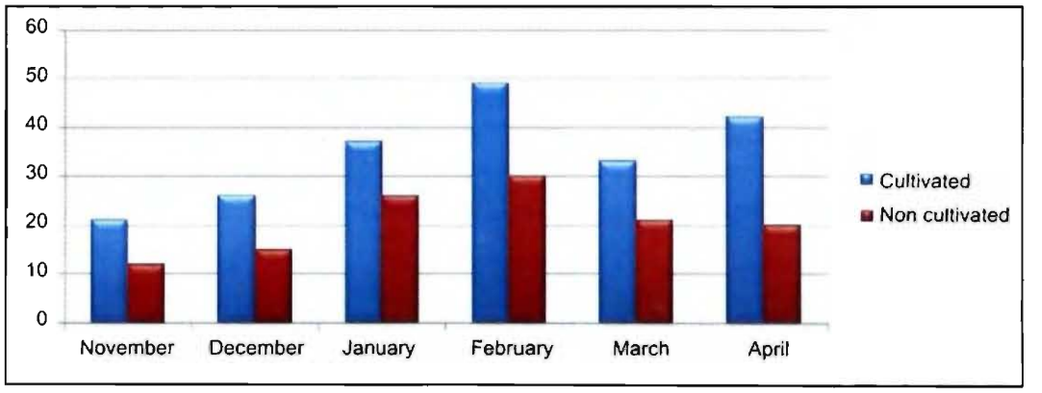


Comparative study of Acarian

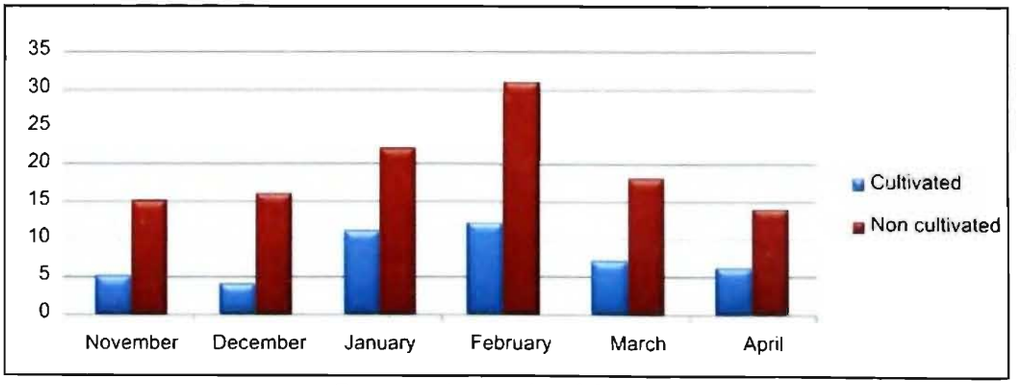


Comparative study of Collembola

Fig. 11 Comparative study of Acarian and Collembola between Cultivated (P2) and Non-Cultivated (P1) plots from November to April

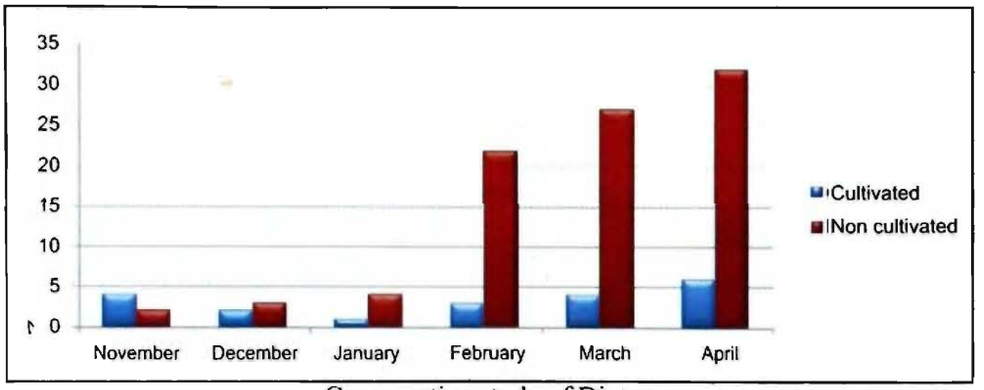


Comparative study of Hymenoptera

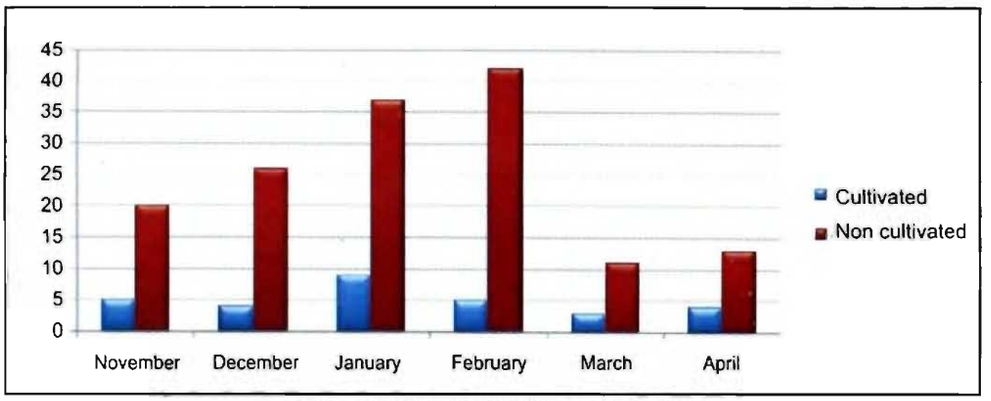


Comparative study of Coleoptera

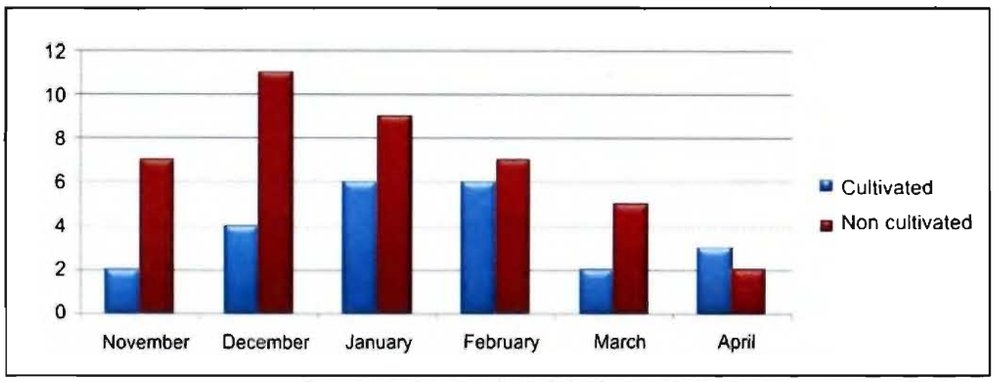
Fig. 12 Comparative study of Hymenoptera and Coleoptera between Cultivated (P2) and Non-Cultivated (P1) plots from November to April



Comparative study of Diptera



Comparative study of Insect Larvae



Comparative study of Anthropods

Fig. 13 Comparative study of Diptera, Insect Larvae and others between Cultivated (P2) and Non-Cultivated (P1) plots from November to April

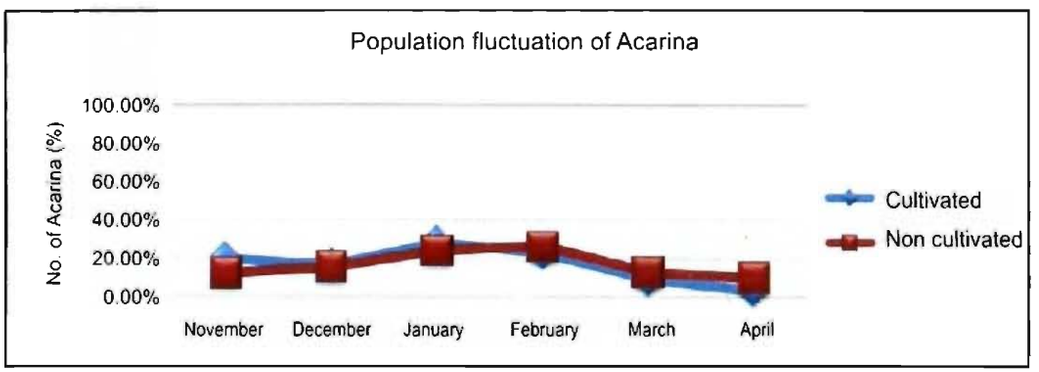


Fig. 14 Population function of Acarina.

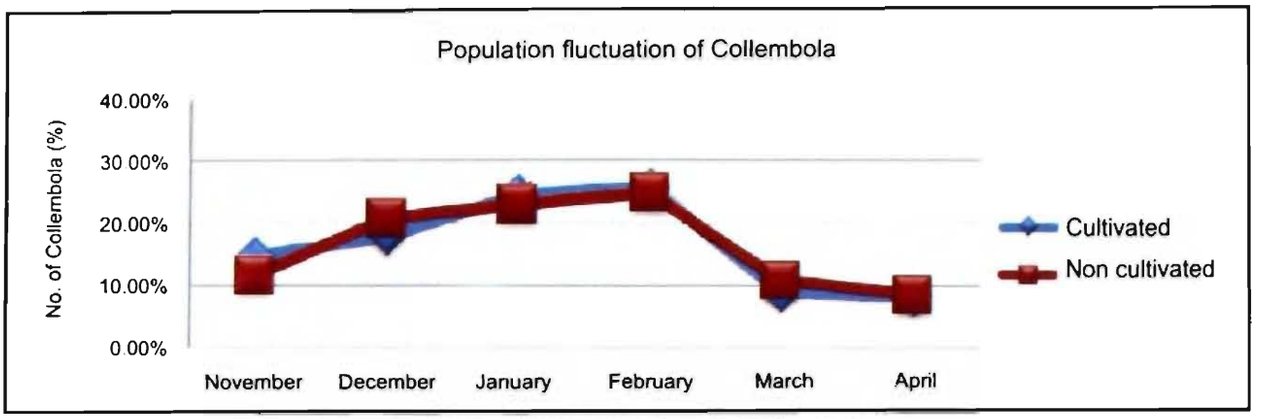


Fig. 15 Population function of Collembola.

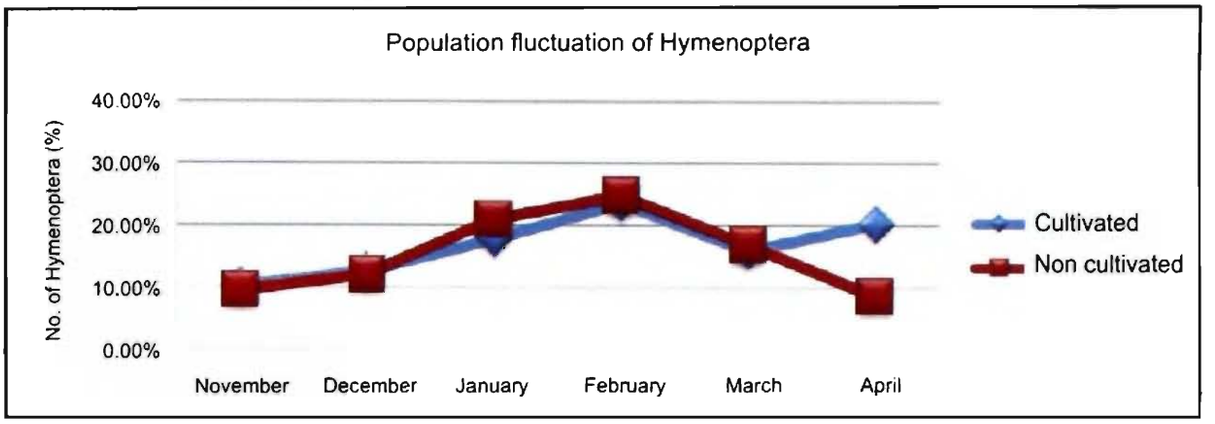


Fig. 16 Population function of Hymenoptera.

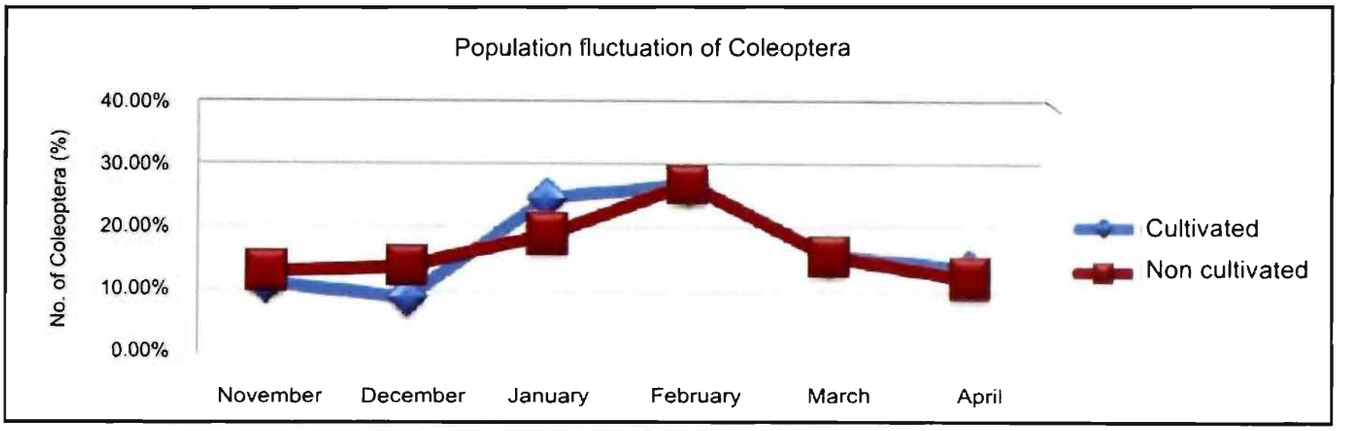


Fig. 17 Population function of Coleoptera.

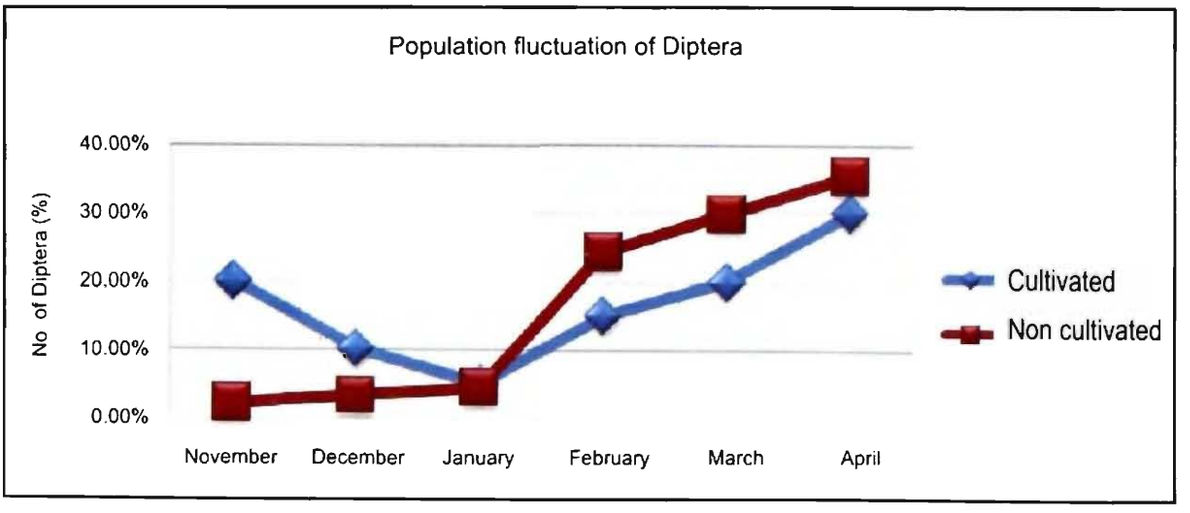


Fig. 18 Population function of Diptera.

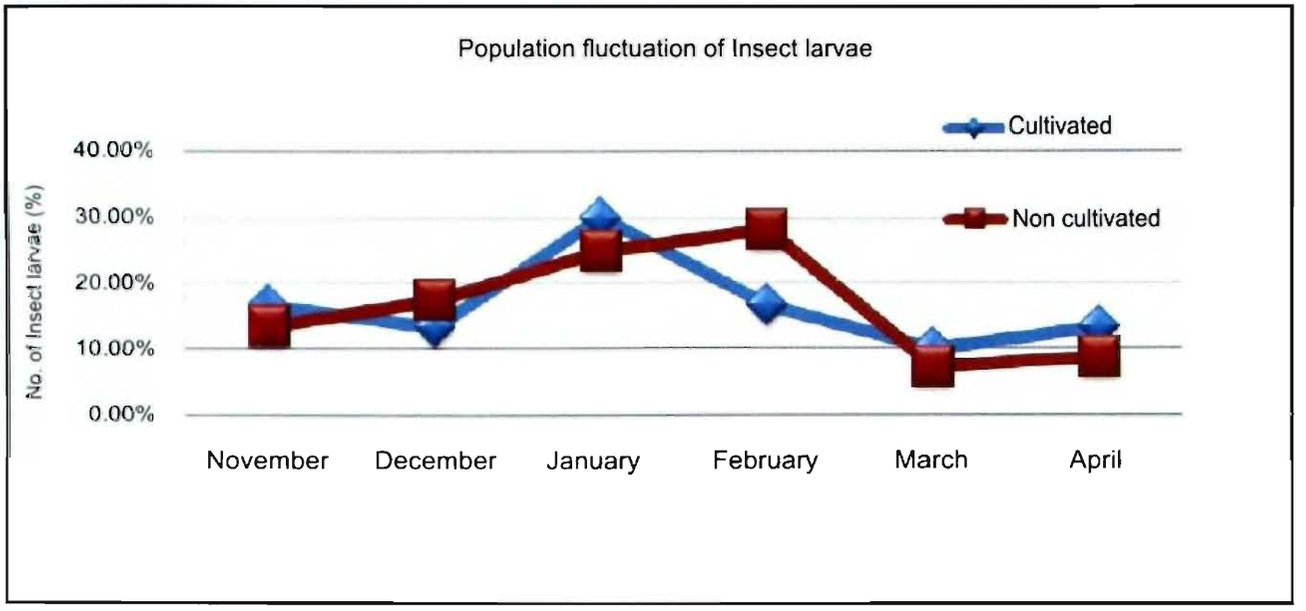


Fig. 19 Population function of Insect Larvae.

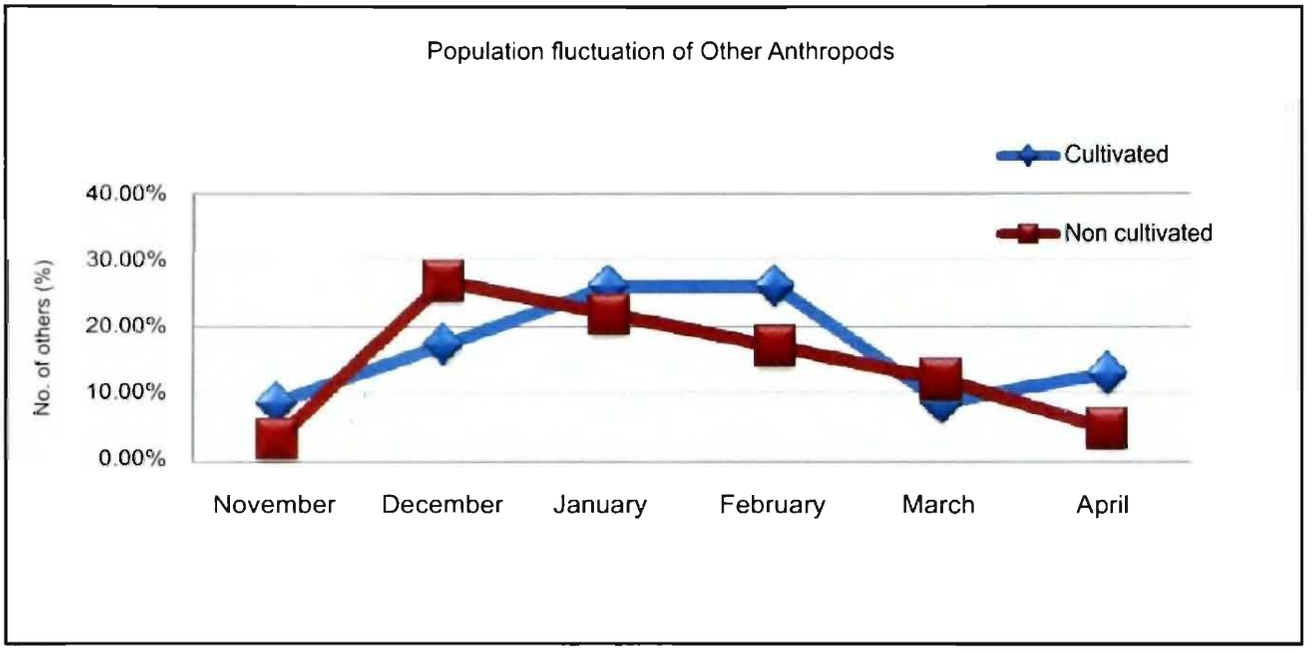


Fig. 20 Population function of Anthropods.

Table 4 : List of Species of different Arthropods collected from soil samples of P1 and P2 plots at Khardah, North 24 Parganas from November 2007 to April 2008

Sl. No.	Name of species	Order	Family
	ACARINA		
1.	1. *Scheloribates albialatus*	Cryptostigmata	Oribatulidae
2.	2. *Oppia yodae*	Cryptostigmata	Oribatulidae
3.	3. *Tectocepheus vitatus*	Cryptostigmata	Oribatulidae
4.	4. *Trichonropoda asaki*	Mesostigmata	Uropodidae
5.	5. *Pachylaelaps dorsalis*	Mesostigmata	Pachylaelapidae
	COLLEMBOLA		
6.	1. *Entomobrya* sp.	Collembola	Entomobryidae
7.	2. *Lepidocyrtus* sp.	Collembola	Entomobryidae
8.	3. *Isotomurus* sp.	Collembola	Isotomidae
9.	4. *Cryptopygus* sp.	Collembola	Isotomidae
	HYMENOPTERA		
10.	1. *Solenopsis geminate*	Hymenoptera	Formicidae
11.	2. *Oligomyrmex* sp.	Hymenoptera	Formicidae
12.	3. *Pheiddogeton* sp.	Hymenoptera	Formicidae
13.	4. *Monomorium* sp.	Hymenoptera	Formicidae
14.	5. *Cerapachys* sp.	Hymenoptera	Formicidae
15.	6. *Pachycondyla* sp.	Hymenoptera	Formicidae
16.	7. Sp. *X1*	Hymenoptera	Eulophidae
17.	8. Sp. *X2*	Hymenoptera	Eulophidae
	COLEOPTERA		
18.	1. *Cryptophilus* sp.	Coleoptera	Langureidae
19.	2. *Silvanoprus scuticollis*	Coleoptera	Silvanidae
20.	3. *Stilicus pygmacus*	Coleoptera	Staphylinidae
21.	4. *Leptocimus gracilis*	Coleoptera	Staphylinidae
22	5. *Lathobuim* sp.	Coleoptera	Staphylinidae
23.	6. *Leptocimus* sp.	Coleoptera	Staphylinidae
24.	7. *Lobochilus fortepunctatus*	Coleoptera	Staphylinidae
25.	8. *Platylomalus oceanitis*	Coleoptera	Histeridae
26.	9. Sp. 1	Coleoptera	Tenebrionidae
27.	10. Sp. 2	Coleoptera	Carabidae
28.	11. Sp. 3	Coleoptera	Dermestidae
	DIPTERA		
29.	1. *Lestremia* sp.	Diptera	Ceidomyidae
30.	2. *Sciara* sp.	Diptera	Sciaridae

decreased in P2 plots compared to P1 plots. In month wise observations on populations of different groups of arthropod, it was found that Acarina, Collembola, Hymenoptera, Coleoptera and Insect larvae were maximum in number in the month of February and slightly less in January and minimum in April (Table-3, Figs. 4-9).

There was a tendency of gradual increase in population of different groups of arthropods from November to February and conversely there was gradual decrease from March to April in P1site. On the contrary, dipteran population in P1 site was maximum in April and minimum in November. There was a tendency of gradual increase in population from November to April (Figs. 10-13).

In P2 plots, monthly observations showed that maximum number of mite specimens and insect larvae were recovered in January where as maximum number

of collembolan, hymenopteran and coleopteran insects were found to occur in February. Dipteran population was more or less constant in November, March and April but decreased in December and January. Maximum number of coleopterans was found in the month of January and February (Figs. 14-20).

DISCUSSION

The similarity in faunal composition in two sites may be attributed to the fact that two sites were located very close to each other and in the same eco-geographical area. The dissimilarity in population fluctuation in two sites may be due to difference in nature of vegetation, agricultural practices like tillage and intermittent organic manuring by cow dung in the cultivated site.

Choudhuri and Roy (1972) and Hazra and Choudhuri (1983) reported an indirect influence of vegetation on collembolan population with the resultant increase in moisture holding capacity of soil. They also recorded high population of Collembola in P1 site in February may be due to rich humus and high moisture content (Edwards and Lofty, 1969, Sanyal, 1993).

The total population of arthropods as obtained from two sampling sites P1 and P2 under the preview of the study when considered together showed numerical variation with change of three seasons like prewinter (November), winter (December and January) and premonsoon (February- April). In the present study the population of Collenbola became maximum in January and February and minimum in April as was observed by Macfadyen (1952), Choudhuri and Roy (1972), Sanyal and Bhaduri (1982). The winter peak of population of Acarina, Coleoptera, Hymenoptera and Collembola might be due to population spurt in winter in non-cultivated (P1) plots. Such peaks were also observed in India by Choudhuri and Roy (1972), Pillai and Singh (1977), Sanyal (1981, 1988, 1991) and Sanyal and Sarkar (1993). The soil arthropod species collected from two sites showed maximum number of species in coleoptera followed by hymenoptera, acarina, collembola and diptera (Table-4).

The pattern of month-wise variation appeared to be different in different orders which perhaps indicated the existence of different breeding periods. In both P1 and P2 sites the dominant microarthropod groups like Acarina, Coleoptera, Hymenoptera and Collembola showed their maximum peak in February (Hazra and Choudhuri, 1990). Such observation of spring peak might be due to presence of high humus concentration in P1 plots and high organic manure like cow dung concentration in P2 plots and their decomposition due to increased soil moisture content and low soil temperature. Furthur, high Hymenopteran concentration in spring (February and March) and presummer month (April) in P2 plots was presumed to be due to their peak breeding period and their tolerance to high temperature (33.7°C) and low moisture content due to evaporation (Ghosh *et al.*, 1999).

Summer peak of dipterans in P1 plots was due to optimum temperature and moisture for their breeding in humus rich soil. Maximum number of maggots was available near the decomposition sites (Hazra and Choudhuri, 1981, Joy and Bhattacharya, 1981, Mitra *et al.*, 1983, Ghatak and Roy, 1991, Sanyal, 1996). Gradual decrease in population concentrations of acarines, collemboles and coleopterans in P1 plots in March and 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. Information regarding population fluctuation and population concentration should always be recorded through over the years. So from the present preliminary study no definite conclusion on population fluctuation of soil microarthropods and their correlation with edaphic factors could be made. A clear picture could only be depicted after the work is completed.

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