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INTERACTION BETWEEN COLLEMBOLA AND FUNGI POPULATIONS : A CASE STUDY AT MUNICIPAL GARBAGE DUMPING AREA AT DHAPA, CALCUTTA

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INTRODUCTION

In India and abroad numerous workers like Christiansen (1964), Edward *et. al.* (1973), Choudhuri and Roy (1967, '72), Hazra and Choudhuri (1983) and Mitra *et. al.* (1983) studied on the qualitative and quantitiative ecology of collembolan population. Some authors like Tadros (1983), Mishra (1964), Gujarati (1968) and Behura (1981) have worked on fungi ecology in different cultivated and uncultivated soils. Hazra and Choudhuri (1990) made a preliminary study on the relationship of soil micro and macro fauna in degraded and polluted soil environment. No serious attempt has so far been made in India to study the process of decomposition involving the interaction between the population of Collembola and soil microflora (fungi-actinomycetes) and its correlation with major soil factors (like temperature, moisture, pH, organic carbon and nitrate) in such a field where the dumping of city wastes is being done regularly and where cultivation of different vegetables is practiced regularly in rotations round the year.

MATERIAL AND METHOD

A total of 324 soil samples were drawn, 9 from each of the three plots each measuring 5 sq. meter, at monthly intervals over a period of one year from January to December, 1997. Each plot was sampled at random by using stainless steel samplers, each measuring 8.55 cm^2 in cross sectional area. The soil samples drawn were extracted through the Tullgren apparatus, modified by Macfadyen (1953). The soil texture was analysed by following the standard procedure as outlined by Folk and Ward (1957) and Shephard (1954) and the nomenclature was used as proposed by them. The soil moisture was determined by oven dry method (Dowdeswell, 1959); soil nitrate was evaluated colorimetrically; organic carbon (%) was eastimated by titration method (Walkley and Black, 1934); temperature was recorded by soil thermometer; pH was eastimated by pH-Meter (WTW—pH 320). The fungi population was assesed by the dilution plate method by inoculating the soil solution of 1 : 1000 dilution in Czapek-Dox medium [containing : sucrose-30.0 gm, sodium nitrate-3.0 gm, magnesium sulphate-0.5 gm, potassium chloride-0.5 gm, agar-agar-13.0 gm/L and streptomycin-30 ml/L (added separately to avoid the bacterial contamination) having pH 7.3 at 25°C]. The fungi population was recorded after 72 hrs. of incubation at 30°C.

THE EXPERIMENTAL SITE

The site is located at Dhapa in east Calcutta, where household and other garbage of Calcutta are dumped regularly by Municipal Corporation. Part of the field, where dumping material is in the state of mineralization, is used for cultivation of mixed vegetable like cauliflower, cabbage, lettuce, different chinese salad leaves etc. rotationally; besides, maize is grown during monsoon. The cast leaves and remains of all these crops after cropping are the source of principal organic litter elements at the site. No tree species is present at this site. The soil is blackish brown in colour and silty sand to sandy in texture (Table : 3) and is mainly composed of huge quantities of decomposed and semi-decomposed organic material, generated from the dumping material.

OBSERVATION

Collembolan fauna

3762 exs. extracted from the soil samples, drawn from the site, belong to 10 genera and 12 species. The most dominant of all the species is *Xenylla* (36.62%) followed by *Lepidocyrtus* sp. (a) (34.44%), *Cyphoderus javanus* (11.72%), *Lepidocyrtus* sp. (b) (10.49%), *Cryptopygus* sp. (3.13%) which appeared sporadically. Further sequences of dominancy were as follows : *Friesea* sp. (1.62%), *Lepidocyrtus* sp. (c) (0.98%), *Ballistrura* sp. (0.69%), *Calx* sp. (0.45%), *Proisotoma (Proisotoma)* sp. (0.37%), *Sphaeridia* sp. (0.079%) and *Isotomiella minor* (0.026%) occurred only once or twice during the period of study. Maximum diversity was found in June (9 species) and minimum in July and November (3 species) (Table. 1, Fig. 1).

Table 1 : Monthly abundance of collembolan species (in percentage)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Lepidocyrtus sp. (a)	0.026	0.69	31.84	1.14	—	—	—	—	—	—	—	0.026	34.44
Lepidocyrtus sp. (b)	—	—	9.70	0.47	0.23	0.053	—	0.026	—	—	—	—	10.49
Lepidocyrtus sp. (c)	—	—	0.58	—	—	0.10	—	—	0.053	0.026	—	0.026	0.98
Calx sp.	—	—	—	—	—	0.45	—	—	—	—	—	—	0.45
Cyphoderus javanus	0.053	2.41	0.079	0.34	0.026	—	—	0.053	1.08	1.96	3.64	2.04	11.72
Isotomiella minor	—	—	—	—	—	0.026	—	—	—	—	—	—	0.026
Cryptopygus sp.	0.053	1.59.	—	—	0.026	0.15	0.053	0.079	0.61	0.55	—	—	3.13
Proisotoma (Proisotoma) sp.	—	—	—	—	—	—	—	—	—	—	0.37	—	0.37
Ballistrura sp.	—	—	—	—	—	0.50	0.18	—	—	—	—	—	0.69
Xenylla sp.	1.22	17.35	3.69	3.21	0.18	2.23	0.47	1.72	2.28	2.47	1.64	0.34	36.62
Friesea sp.	—	—	0.47	0.15	—	0.55	—	—	0.26	—	—	0.15	1.62
Sphaeridia sp.	0.053	—	—	—	—	0.026	—	—	—	—	—	—	0.079
TOTAL	1.40	22.06	46.38	5.34	0.47	4.12	0.71	1.88	4.30	5.02	5.66	2.60	

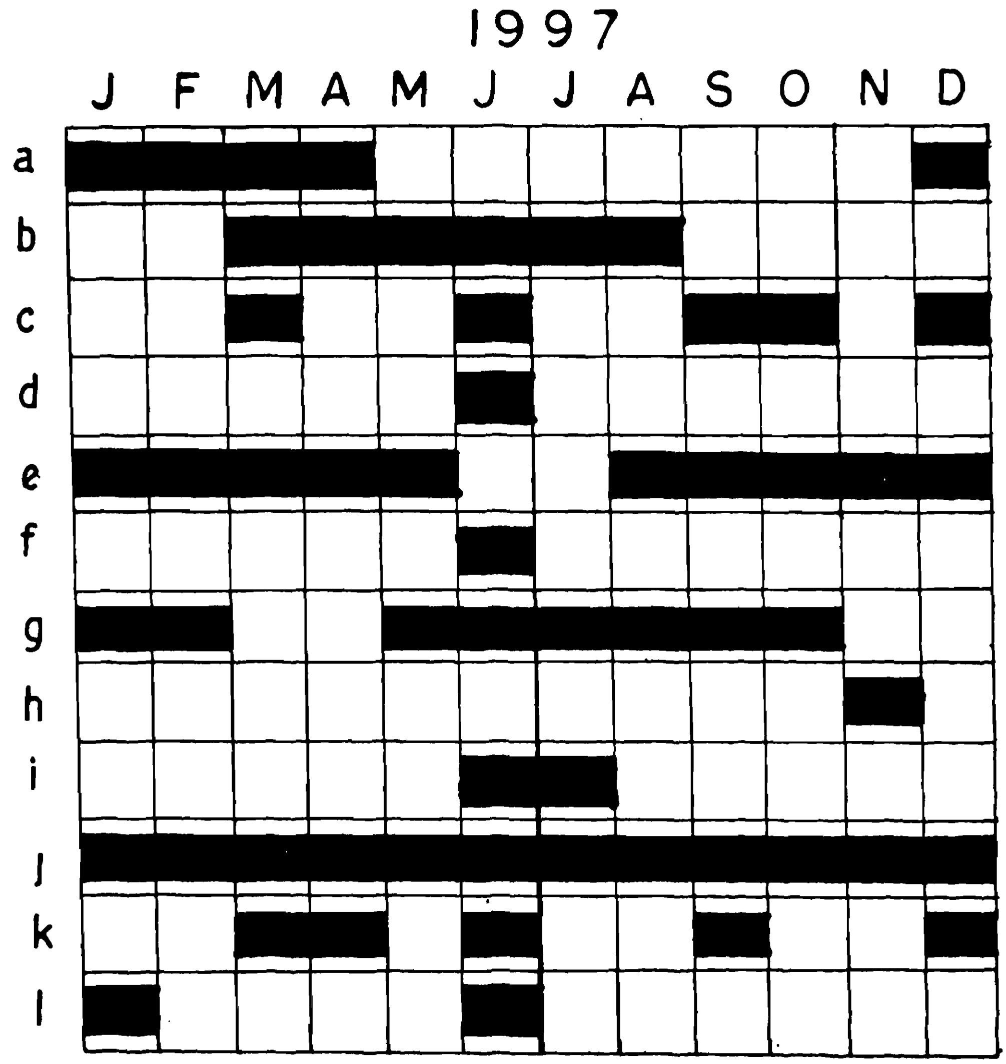

Fig. 1. : Monthly occurrence of different species of Collembola.

Explanations : a. *Lepidocyrtus* sp. (a), b. *Lepidocyrtus* sp. (b), c. *Lepidocyrtus* sp. (c), d. *Calx* sp., e. *Cyphoderus javanus*, f. *Isotomiella minor*, g. *Cryptopygus* sp., h. *Proisotoma (Proisotoma)* sp., i. *Ballistrura* sp., j. *Xenylla* sp. k. *Friesea* sp., l. *Sphaeridia* sp.

Fungi-Actinomycetes population

Fungi population isolated from the soil samples (770 × 10^3 /gm. of soil) belong to 7 genera. Also actinomycetes was isolated from the same dilution plates. The bulk of fungi was represented by Penicillium (55.32%) followed by *Fusarium* (15.84%), *Aspergillus* (7.40%), *Cephalosporium* (3.89%), *Mucor* (1.16%), *Trichoderma* (3.59%), *Sclerotium* (2.59%). Actinomycetes (10.12%) appeared in the culture.

Maximum diversity was observed during April and May when actinomycetes and 5 fungi genera appeared in the culture. It was minimum in September being represented by actinomycetes and 2 fungi genera; however, during June-August, no actinomycetes appeared in the culture (Table 2, Fig. 2).

Table 2 : Monthly abundance of fungi-actinomycetes (in percentage)

	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Penicillium	6.10	0.64	18.44	2.85	3.24	3.76	4.28	3.76	2.33	1.81	6.49	1.55	55.32
Trichoderma	1.03	1.16	1.03	—	—	—	—	—	—	—	0.25	0.12	3.59
Aspergillus	0.12	0.25	1.68	0.12	0.51	0.51	0.64	0.38	0.51	0.64	1.29	0.64	7.40
Mucor	—	—	—	0.25	0.12	0.38	0.25	0.12	—	—	—	—	1.16
Fusarium	—	14.28	—	—	0.38	1.03	—	—	—	0.12	—	—	15.84
Sclerotium	—	—	—	1.42	0.77	—	—	—	—	—	—	0.38	2.59
Cephalosporium	—	—	1.18	2.07	—	—	—	—	—	—	—	—	3.89
Actinomycetes	1.81	1.55	2.72	0.77	0.38	—	—	—	1.03	0.12	0.51	1.16	10.12
TOTAL	9.09	17.92	25.71	7.53	5.45	5.71	5.19	4.28	3.89	2.72	8.57	3.89	

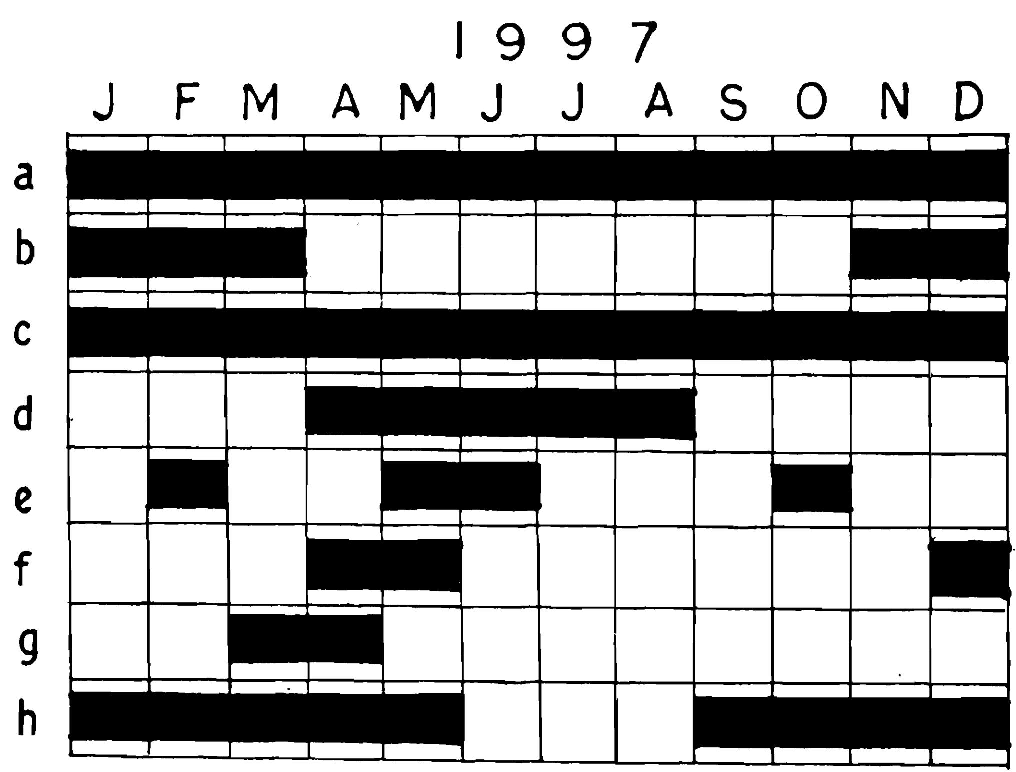

Fig. 2. : Monthly occurrence of actinomycetes and different genera of fungi.

Explanations : a. *Penicillium*, b. *Trichoderma*, c. *Aspergillus*, d. *Mucor*, e. ***Fusarium***, f. *Sclerotium*, g. *Cephalosporium*, h. *Actinomycetes*.

Monthly fluctuation of population of Collembola and fungi-actinomycetes

It is interesting to note that the Collembola exhibited the highest peak of population in the month of March (46.38%) coinciding with the fungi-actinomycetes population (25.71%). During April-May, population of both Collembola and fungi-actinomycetes declined sharply eventually with a moderate peak during June. During July to October, there was a gradual rise in the population of Collembola but fungi-actinomycetes population maintained a constant population. Again the Collembola and fungi-actinomycetes population gave rise a higher peak during November (Fig. 3).

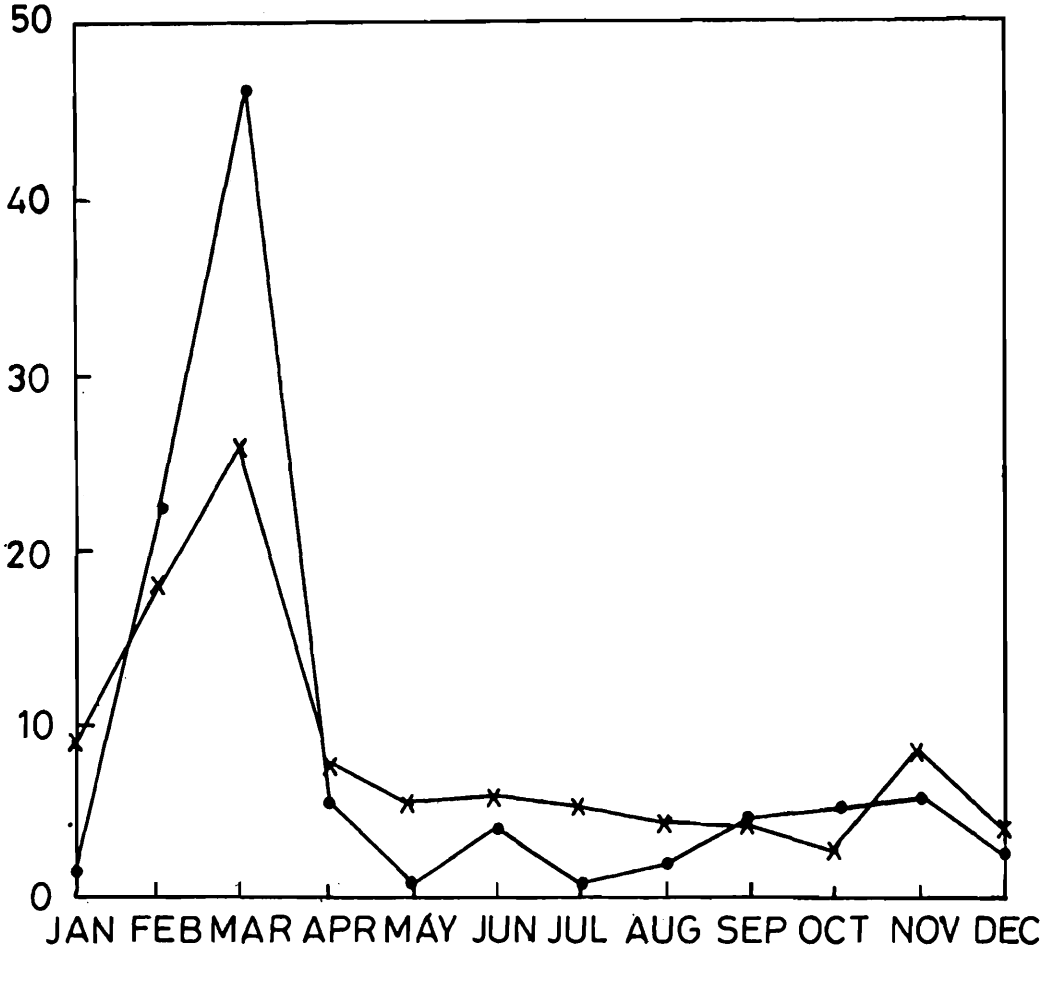

Fig. 3. : Monthly dynamics of Collembola and Fungi-Actinomycetes population.

Soil factors

The soil of the site is silty sand to sandy where the coarse sand was maximum (57.95%). Highest organic carbon was during March (4.11%) and minimum (3.28%) in May. NO_3 content was 23 ppm in August and 806 ppm in March. During July to September there was depletion in NO_3 because of the leaching of soil for monsoon rains. pH of the soil varied between 6.4 to 7.8 during the months under observation. Moisture content varied between 24.06% to 44.56% during this period. Temperature was minimum (21°C) in January and in March it was maximum 39°C (Table. 3, 3A, Fig. 4).

Table 3 : Analysis of edaphic factors at the studied site (expressed in percentage)

	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Temperature	5.60	8.27	10.41	9.34	9.34	7.47	9.07	7.20	9.71	8.54	7.74	7.20
Moisture	5.38	8.89	10.66	9.97	6.14	8.82	10.81	10.61	8.85	7.58	6.99	6.77
pH	8.94	8.01	7.43	8.82	8.47	8.01	7.78	8.94	8.36	7.54	8.57	9.05
Organic Carbon	8.0	8.98	9.34	8.66	7.46	8.12	7.93	7.93	8.25	8.43	8.57	8.25
Nitrate	6.73	18.24	18.52	9.23	10.94	12.75	1.58	0.52	1.28	7.30	6.57	6.27

Table 3A : Mechanical analysis of soil

Coarse Sand	Medium Sand	Fine Sand	Coarse to Medium Silt	Fine Silt	Clay
57.9562%	3.944%	8.5943%	9.0118%	11.0002%	9.4928

STATISTICAL TREATMENT OF DATA

Data pertaning to the soil factors and population density were subjected to statistical correlation with the number of Collembola (Y) in relation to each of the 6 variables (x = fungi-actinomycetes, organic carbon, nitrate, temperature, moisture, pH) considered in this investigation. Regression analysis was carried out by pulling together data for 12 months. From this analysis, it is found that number of Collembola showed positively significant correlation with fungi-actinomycetes, organic carbon, nitrate and negatively significant correlation with pH. Temperature and moisture, however, showed a positive but no significant correlation with the population density of Collembola (Table. 4).

Table 4 : Regression equation and "r" value between Collembola, Fungi-Actinomycets and edaphic factors

Parameter	Mean	r Value	Regression Equation
y : Collembola Population	8.32		
Fungi-Actinomycetes	8.32	0.94 **	Y = –7.01 + 1.84 x
Organic Carbon	8.34	0.83 **	Y = –171.50 + 21.60 x
Mitrate	7.55	0.73 **	Y = – 5.19 + 1.62 x
Temperature	8.32	0.47	Y = – 30.42 + 4.65 x
Moisture	8.35	0.41	Y = – 15.90 + 2.91 x
pH	8.32	– 0.56 *	Y = 117.18 – 13.07 x

*Significant at 5% level **Significant at 1% level.

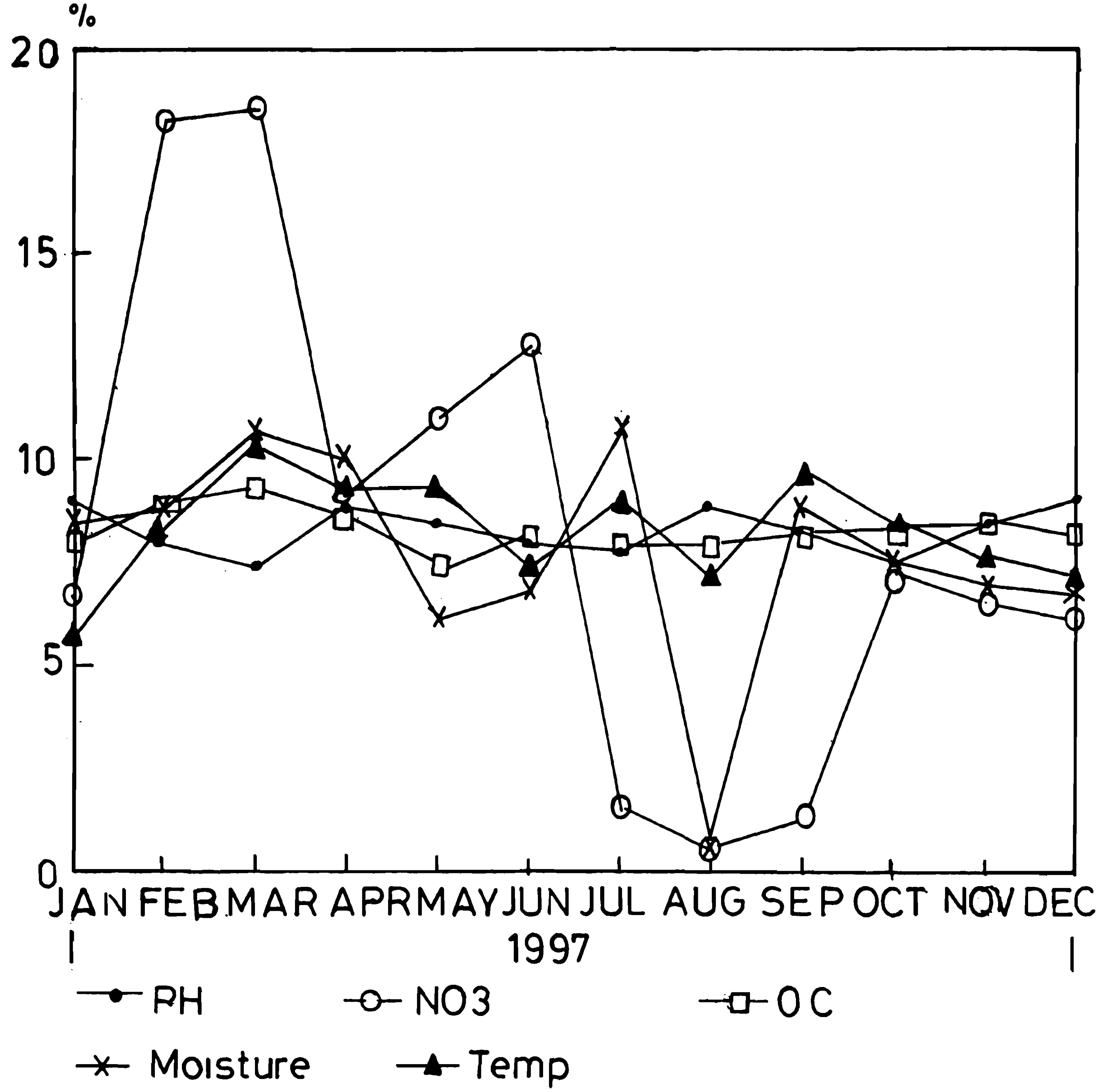

Fig. 4. : Monthly changes of soil factors at the studied site.

DISCUSSION

Population of Collembola consisting of 12 species showed changes with the change of months (Table. 1, Fig. 3) being maximum in March and February and minimum in May. Such was the observation of Sheals (1957), Haarlov (1960), Weisfogh (1948), Macfadyen (1952) in the temperate countries. During the March, refuse of cauliflower, cabbage, letuce etc. remain the main constituent of the dumping material while in other times it is mainly the household wastes from the city. In this study, dominant genera of Collembola *Viz.*, *Xenylla* sp. and *Lepidocyrtus* sp. attained their respective peaks during February and March. *Xenylla* sp. was found consistently throughout the year, but the occurrence of three different *Lepidocyrtus* sp. were always infrequent with low population during the period of observations. Besides, some other species also occurred very inconsistently represented by isolated examples (Table. 1, Fig. 1).

Fungi-actinomycetes exhibited a positive significant correlation with the micro fauna (Table. 4). *Penicillium* found to be predominant and of all the microflora only *Penicillium* and *Aspergillus* were found to be consistent in their occurrence. Other fungi genera were observed inconsistently in the culture maintained. Further, actinomycetes did not appear in the samples during June-August (Table. 2, Fig. 2).

Regarding the soil factors, nitrate and organic carbon content showed a strong positive significant correlation with the collembolan and microbial population. Whereas, temperature and moisture showed a positive but not significant correlation; pH interestingly showed a negative but significant correlation perhaps well within the tolerance range of most of the species. Since most of the Collembola are saprophagous, it may be that the soil pH exerts influence on collembolan population by controlling the growth and activities of microflora.

SUMMARY

The present investigation is based on monthly soil samplings for a period of one year from January 1997 to December '97.

Altogether 3762 examples of Collembola were extracted from 324 soil samples. Culturing of soil samples *in vitro* (Czapek-Dox medium) resulted in the development of fungi and actinomycetes colonies approximately 770 × 10^3/gm. of soil. The contribution incorporates monthly population dynamics of Collembola in relation to fungi serving as major food for edaphic and euedaphic Collembola. The result shows that there is direct correlation between population of Collembola and fungi while the other parameters like moisture, nitrate and organic carbon have indirect bearing.

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