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FOOD AND FEEDING IN FOUR SPECIES OF COLLEMBOLA IN N. E. INDIA

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INTRODUCTION

The process of recycling of nutrients and the flow of energy between different tropic levels is greatly influenced by the soil organisms and their biotic relationships. In spite of the importance of such studies, many aspects are still unknown either in relation to structural or functional phenomenon of the trophic relationships of arthropods living in the soil. This is very true especially among those groups of animals which dominate any soil ecosystem like collembola. Most studies exist on the aspects of ecology connected with nutrition biology of collembola in particular to litter decomposition and thereby formation of soil but very little on the feeding behaviour of these groups of animals in nature.

One of the earliest reports in relation to feeding biology of collembola was by Agrell (1941) who showed the occurrence of empty guts related to dry condition in the soil and litter in *Anurophorus laricus*. Hutchinson (1951) showed the effect of physico-chemical instability of the litter and humus microhabitats for the incorporation of fugitive species. The type of vegetation in a region, was reported to be indirectly affected and exerted by the influence of the microfloral composition in the soil (Bellinger, 1954). Periodic non-feeding phases associated with moulting in collembola population was well documented by Poole (1959). Certain microflora are reported to be present as gut symbionts in collembola having an important role in the digestion of plant material (Von Toyne, 1961). The distribution of collembola is directly proportional to the distribution of fungi on which they feed (Knight, 1961) and are greatly influenced by humidity conditions of the habitat (Poole, 1961). Individual preferences of certain plants by collembola species are also known (Dunger, 1962). Such populations when aggregated play at least a peripheral role in soil processes (Macfadyen, 1963), under culture experiments of feeding. It was shown by Sharma and Kevan (1963b : 1963c) that populations of collembola fail to reproduce on a diet lacking in plant

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material and revealed occasional cannibalistic behaviour. However, Christiansen (1964) showed food preferences had a wide range, and that *Bacillus* sp. in the gut of collembola was capable of digesting chitin, thereby, confirming the fact that collembola and micro-or macroflora are directly proportional. In any case the distinction between ingestion and assimilation was shown by Healey (1965), in that certain collembola species utilised only fats and carbohydrates in the fungal hypae without interfering with the reproductive structures of the fungus. Healey (1965) also showed that collembola species can survive upto eighteen months in a state of facultative diapause without feeding.

Knight and Angel (1967) showed that the average collembola spend an inactive or semiactive state for nearly 40-50% of their adult life. Von Torne (1967a ; 1967b) has shown the activity of the collembola gut-enzyme complement along with coprophagy to be responsible for the utilization of common resources. The bacterial contents of the soil and the migration of the collembola to higher densities of the former was shown to be reciprocal by Stebaeva (1967). The lack of breaking down cellulose in collembola was reported by Zinkler (1969) and the diminution of leaves after passing through the gut is the initial step of the decomposition cycle (Tikhomirov, 1969). The action of fungi on such materials could be immediate as they are known to adapt physiologically to a wide range of concentration of nitrogen (Levi and Cowling, 1969), for the growth and regulation of animal populations depended on the food quality (Watson, 1970). This is supported by the fact that the individuals of the same species differing in the gut contents from different habitats, is greater than those in the guts of individuals of different species in the same habitat (Gilmore and Raffensperger, 1970 ; Bodvarsson, 1970).

The nutritional differences between species of fungi with respect to feeding of collembola was shown by Mills and Sinha (1971) which was coupled with the infrequent feeding behaviour of collembola (De With and Joosse, 1971). This was supported by the fact that most collembola species are more or less non-specialized feeders (Petersen, 1971 ; Massoud, 1971 ; Luxton, 1972). Such low degree of specialization was associated with excess of food available (Anderson and Healey, 1972) and that scarcity of food was an important source of stability in reducing the amplitude of population fluctuations (Smith, 1972). Further, Jones (1972) showed the secretion of toxic substances from the root system in control of populations.

The importance of food available under field conditions was shown by Emlen (1973), as an adaptation to varied diet would only seem a selective advantage under laboratory conditions. A direct relationship between fauna and flora in agricultural tilled soil was shown by Kines and Sinha (1973). Moreover, at any one time the greater part of a population does not take part in the utilization of food resources (McMillan, 1975).

Work on Indian collembola and their feeding behaviour is very meagre (Singh, 1969). The aim of the present work was to take up some dominant species of collembola present in different abandoned Jhum fallows of N. E. India and to observe their feeding behaviour in the field. The gut contents of four species of collembola was correlated with one major group of microflora namely fungi of the soil. The studies were carried out seasonally for a period of one annual cycle to identify the selectiveness or non-selectiveness of the food (fungi) present in the soil.

MATERIAS AND METHODS

Details of extraction methods, have been given in an earlier paper on life history studies.

Immediately after collection of the species, the guts were teased out from five individuals. These guts were placed in dilution plate for culture and cut open and spread out on the media with the help of a spray of triple distilled water. Five plates were prepared for each species every month. The soil was taken from the two sites where these species occurred and a similar soil dilution plate method was prepared to isolate the fungi. 10 gm of soil from each site and replicate samples of five were placed in 100 ml of triple distilled water in a 250 ml Ehrlenmayer flask and blended for 1 minute for each replicate sample (5) from both the sites and a total of 10 plates were prepared every month. Final dilution of 1 to 10,000 was used for isolation. The media selected was Martin's rose ± Bengal Agar (Martin, 1950).

Such plates both for the gut contents of the collembola species and soil samples amounting to 20 (animals) and 10 soil replicates were incubated every month at 25 ± 1°C for 5 days. After this period the plates were removed, the fungi identified upto species wherever possible, their colonies counted and expressed as percentages. All this was carried out for a period of one year.

RESULTS

The present study was conducted on four of the dominant collembola species found in two abandoned jhum fallows, the youngest and oldest respectively. One common finding in both the sites from the top soil layers in these abandoned fallows, was that a total of 21 species of fungi were recorded, irrespective of the age of the fallow. Of these 21 species, when the total year was taken into consideration, it was seen that *Trichoderma viride*, Pers, ex. Gray was maximum in the soil of the youngest fallow (nearly 16%) followed by *Penicillium chrysogenum*, Thom. (15%), *Aspergillus niger*, Van Tiegham (14%) and *Fusarium* sp. (12%). All the others recorded less than 10% with *Penicillium nigricans*, Bainier, Thom. (9%) and least were *Cladosporium* sp., *Acremonium* sp. and *Verticillium* sp. all recording only 0.8% (Fig. 1).

A similar analysis of the soil in the oldest abandoned fallow revealed that the maximum was that of *Penicillium nigricans* (13%). All the others recorded were below 10% with only *Aspergillus niger* (nearly 10%). The least occurred species in this site were those of *Actinomucor* sp., *Verticillium* sp. and *Scopullariopsis* sp., all recording around 1.5% (Fig. 2)

It was seen that in the gut of *Seira indica*, the maximum occurrence was that of *Trichoderma viride* amounting to nearly 24% followed by *Fusarium* sp. with nearly 23%. Hence, these two species formed nearly 50% of those fungi found in the gut while the ones not recorded at all throughout the year, though present in the soil were *Cladosporium* sp., *Mucor hiemalis*, *Acremonium* sp., *Cunnighamella* sp., *Actinomucor* sp., and *Scopullariopsis* sp. Out of 21 species of fungi found in the soil, only 14 species were recorded in the gut of this species of collembola (Fig. 1).

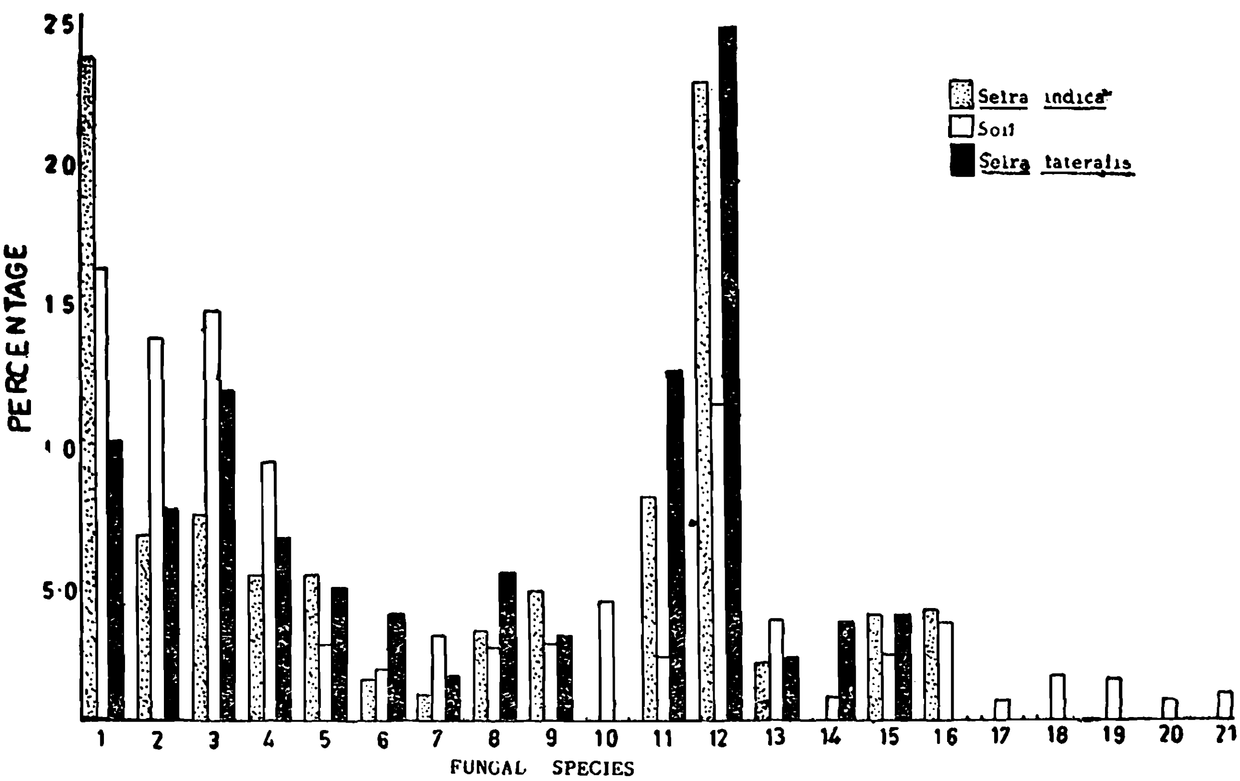

Fig. 1. Percentage occurrence of different species of fungi in the soil and two species of Collembola—for the entire study period.

In *Seira lateralis* it was seen that *Fusarium* sp. formed nearly 25% in the gut followed by *Alternaria alternata* and *Penicillium chrysogenum* with both around 12%. These three groups of fungi occupied nearly 50% of the total fungi in the gut. Again in this species, it was seen that seven fungi were absent viz. *Pythium* sp., *Mucor hiemalis*, *Acremonium* sp. *Cunnighamella* sp., *Actinomucor* sp., *Verticillium* sp. and *Scopullariopsis* sp. It was therefore observed in this species that again only 14 species of fungi were recorded in the gut, out of the 21 species available in soil (Fig. 1).

In the oldest abandoned fallow when a similar observation was made for the two dominant species of Collembola, it was seen that *Salina yosii*, recorded *Alternaria* *alternata* as maximum in the gut (18%) followed by *Fusarium* sp. (14%). All the others recorded were less than 10% with only *Trichoderma viride* recording nearly 10%. Some fungal species were totally absent in the gut. They were *Mucor hiemalis*, *Acremonium* sp., *Cunnighamella* sp., *Actinomucor* sp., *Verticillium* sp. *Scopullariopsis* sp. Out of 21 species of fungi present in the soil only 15 were available in the gut of *Salina yosii* (Fig. 2).

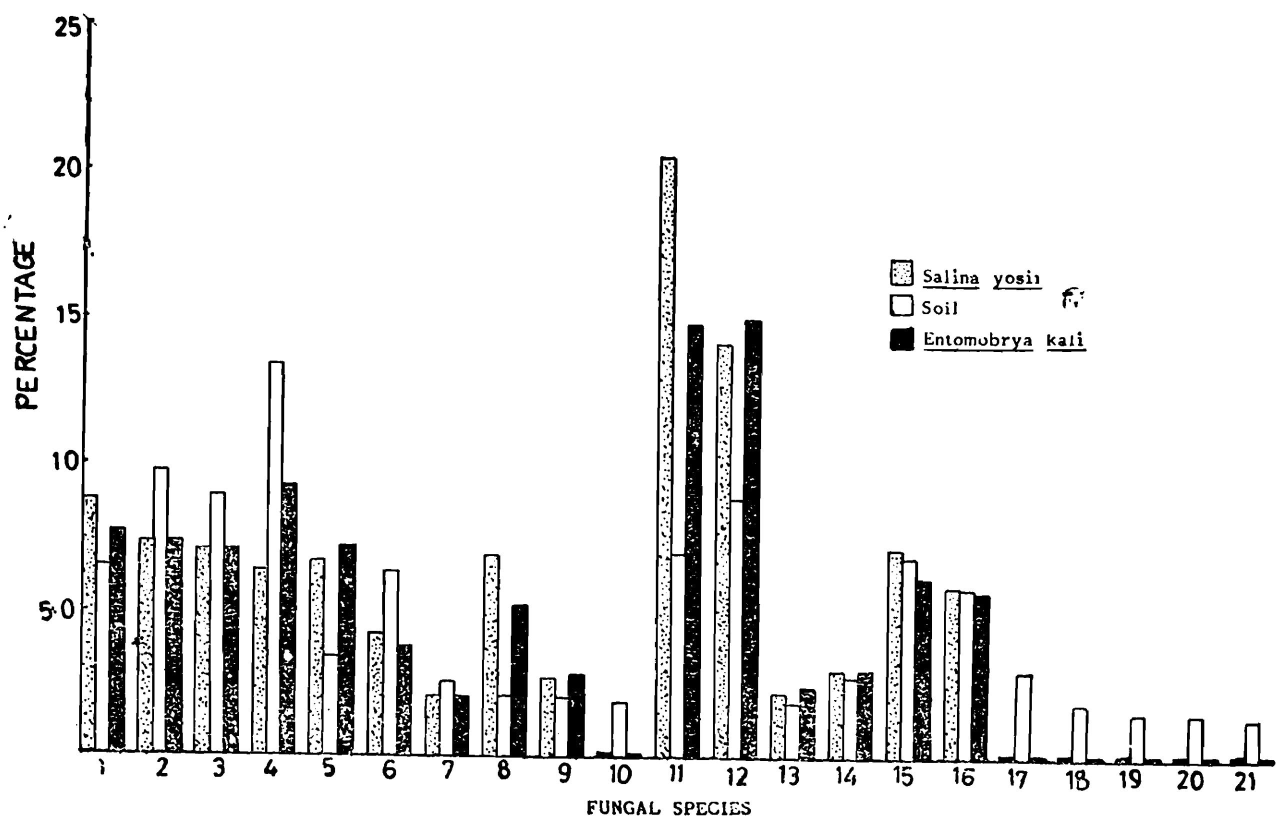

Fig. 2. Percentage occurrence of different species of fungi in the soil and two species of Collembola—for the entire service period.

In the fourth species *Entomobrya kali*, it was seen that *Alternaria alternata* and *Fusarium* sp. occupied nearly 15% each as maximum among the groups of fungi present in the gut. All the others were below 10% with only *Penicillium nigricans* showing 9.3%, being third in order of dominance. Like *Salina yosii* from the same site the same six groups of fungi were totally absent in the gut of three species also (Fig. 2).

In the youngest abandoned fallow the fungi isolated from the surface layers revealed that the dominant species of fungi had peaks in early spring which continued through summer and declined, once the monsoons set in (Table 1).

In the oldest fallow, the seasonal trend revealed that the two dominant fungal species, *Penicillium nigricans* and *Aspergillus niger* recorded peaks of abundance in August and July respectively, while the minimum was observed to be in the month of

TABLE 1. Monthly percentage occurrence of fungal species in the soils of the youngest and oldest abandoned jhum fallows.

Youngest abandoned jhum fallow.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
J	16.6	—	20.6	6.0	4.0	—	—	10.0	10.3	8.3	—	1.6	4.0	—	0.6	5.0	—	—	—	—	—
F	20.0	10.0	10.0	15.0	5.0	—	5.0	—	5.0	—	5.0	—	5.0	1.0	7.0	7.0	—	—	—	—	5.0
M	25.0	17.9	10.0	1.8	—	—	—	—	—	7.0	—	17.9	—	—	9.6	9.0	—	—	—	1.8	—
A	—	7.0	5.2	5.0	—	7.0	—	—	—	16.3	—	15.9	9.3	—	5.0	2.3	—	2.3	—	—	—
M	45.5	17.3	10.0	10.0	9.1	—	—	—	—	—	—	9.1	—	—	—	—	5.2	—	5.0	—	—
J	10.5	25.0	25.0	25.0	—	—	—	—	—	3.8	3.9	19.6	—	—	—	3.8	—	—	—	—	—
J	13.3	31.0	20.0	—	2.0	—	—	—	—	4.1	—	14.3	—	—	—	8.2	—	—	—	6.1	4.1
A	14.5	29.1	20.0	3.6	—	—	5.5	3.6	—	5.5	1.8	14.5	—	—	—	—	—	1.8	—	—	—
S	9.7	16.1	6.5	6.5	—	8.1	10.6	10.0	10.0	—	10.0	10.0	—	—	—	—	—	3.2	—	—	—
O	4.2	3.8	15.3	16.0	4.2	5.0	6.0	5.0	5.0	2.0	5.0	16.7	—	—	—	1.0	1.0	3.0	3.0	1.0	3.0
N	6.2	4.3	5.4	5.0	7.0	—	5.0	—	—	2.0	—	17.0	13.5	8.1	3.0	2.0	2.7	2.0	2.7	1.0	3.0
D	15.9	1.8	15.9	15.9	—	1.0	5.0	1.0	3.0	2.3	2.0	10.9	10.4	1.0	3.0	3.0	1.0	—	6.8	—	1.0

Oldest abandoned jhum fallow.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
J	8.4	—	5.0	5.0	—	—	—	—	—	10.0	5.8	5.0	5.0	26.3	10.0	10.0	20.0	3.2	3.3	3.3	3.3
F	9.6	5.0	5.0	7.5	5.0	—	2.0	—	10.0	5.0	10.0	9.6	3.0	7.5	2.0	3.9	2.0	3.0	2.0	3.0	5.0
M	7.0	13.7	13.7	10.0	—	—	—	—	10.0	4.8	3.3	10.0	—	—	7.1	10.0	1.0	2.0	3.0	2.0	2.0
A	—	15.0	10.0	20.0	—	20.0	—	—	—	1.0	—	5.0	—	—	5.0	5.0	1.0	1.0	1.0	1.0	—
M	—	5.8	5.0	8.9	—	10.0	—	—	—	2.7	—	5.1	—	—	20.0	10.0	8.9	10.0	5.4	5.4	2.7
J	9.2	10.0	1.5	10.0	—	2.0	—	6.5	—	—	30.0	30.8	—	—	—	—	—	—	—	—	—
J	5.7	20.0	12.3	30.0	—	8.6	—	—	—	—	12.9	10.0	—	—	—	—	—	—	—	—	—
A	4.1	50.0	15.0	27.6	5.0	6.9	5.0	9.5	—	—	15.0	10.0	2.9	2.0	2.0	2.0	—	—	—	—	—
S	5.1	15.4	10.0	10.0	10.0	10.0	4.0	14.4	—	—	8.6	6.0	5.1	5.4	10.0	5.0	—	—	—	—	—
O	8.2	10.0	7.7	10.0	15.9	2.0	10.9	—	1.4	—	—	8.0	2.3	4.5	16.0	14.0	1.0	1.0	1.0	1.0	1.0
N	11.2	7.6	11.8	10.0	2.0	17.6	5.0	—	1.8	—	—	5.0	2.0	5.0	4.5	6.5	2.5	2.5	1.5	1.5	2.0
D	10.9	10.2	10.0	12.0	5.0	14.8	4.4	—	1.1	—	—	3.4	2.0	5.0	6.5	10.0	1.0	1.0	1.0	1.0	1.0

1. *Trichoderma viridae*, 2. *Aspergillus niger*, 3. *Penicillium chrysogenum*, 4. *Penicillum nigricans*, 5. *Mycogone* sp., 6. *Absidia spinosa*, 7. *Absidia* sp., 8. *Mucor recemosus*, 9. *Mucor circinelloides*, 10. *Mucor hiemalis*, 11. *Alternaria alternata*, 12. *Fusarium* sp. 13. *Cephalosporium* sp., 14. *Cladosporium* sp., 15. *Doratomyces* sp., 16. *Pythium* sp., 17. *Acremonium* sp., 18. *Cunninghamella* sp., 19. *Actinomucor* sp., 20. *Verticillium* sp., 21. *Scopullariopsis* sp.

TABLE 2. Monthly percentage occurrence of fungal species in the guts of *Seira indica* and *Seira lateralis*.

Seira indica

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
JAN	20.1	—	13.3	6.7	3.3	—	—	—	20.0	—	—	13.3	—	—	13.3
FEB	5.5	5.5	—	11.1	5.5	—	11.1	—	16.6	16.6	—	11.1	—	11.1	5.5
MAR	11.8	11.8	17.6	11.8	—	—	—	—	—	—	17.6	—	—	17.6	11.8
APR	—	10.0	20.0	10.0	—	20.0	—	—	—	—	20.0	—	—	10.0	10.0
MAY	33.3	—	—	—	22.2	—	—	—	—	—	44.4	—	—	—	—
JUN	25.0	—	—	—	—	—	—	—	—	37.5	37.5	—	—	—	—
JUL	50.0	—	—	—	—	—	—	—	—	—	50.0	—	—	—	—
AUG	7.1	14.3	21.4	7.1	—	—	—	21.4	—	28.5	—	—	—	—	—
SEP	33.3	16.7	8.3	8.3	—	—	—	16.0	—	—	16.7	—	—	—	—
OCT	21.4	21.4	7.1	7.1	21.4	—	—	—	—	—	21.4	—	—	—	—
NOV	50.0	—	—	—	—	—	—	—	—	—	50.0	—	—	—	—
DEC	25.0	—	—	—	—	18.8	—	—	18.8	12.5	12.5	—	—	6.3	6.3
			Seira lateralis												
JAN	9.1	—	18.2	9.1	—	—	—	—	—	—	27.3	18.2	—	18.2	—
FEB	9.1	4.5	—	9.1	9.1	—	9.1	—	18.2	13.5	—	9.1	13.6	4.5	—
MAR	15.0	10.0	20.0	10.0	—	—	—	—	—	—	20.0	—	15.0	10.0	—
APR	—	7.1	28.6	7.1	—	28.6	—	—	—	—	14.3	—	7.1	7.1	—
MAY	20.0	—	—	—	30.0	—	—	—	—	—	50.0	—	—	—	—
JUN	—	—	—	—	—	—	—	—	—	57.1	42.9	—	—	—	—
JUL	—	—	—	—	—	—	—	—	—	—	100.0	—	—	—	—
AUG	—	—	—	10.0	—	—	—	40.0	—	50.0	—	—	—	—	—
SEP	15.4	23.1	15.4	—	—	—	3.1	—	—	7.7	—	—	—	—	—
OCT	16.7	16.7	25.0	16.7	16.7	—	—	—	—	—	8.3	—	—	—	—
NOV	28.5	28.5	28.5	—	—	—	—	—	—	—	14.3	—	—	—	—
DEC	4.5	—	4.5	—	—	18.2	9.1	—	18.2	27.2	9.1	—	4.5	4.5	—

1. *Trichoderma viridae*, 2. *Aspergillus niger*, 3. *Penicillium chrysogenum*, 4. *Penicillium nigricans*, 5. *Mycogone* sp., 6. *Absidia spinosa*, 7. *Absidia* sp., 8. *Mucor recemosus*, 9. *Mucor circinelloides*, 10. *Alternaria alternata*, 11. *Fusarium* sp., 12. *Cephalosporium* sp., 13. *Cladosporium* sp., 14. *Doratomyces* sp., 15. *Pythium sp.*

TABLE 3. Monthly percentage occurrence of fungal species in the guts of *Salina yosii* and *Entomobrya kali*.

Salina yosii

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
JAN	11.8	—	17.6	17.6	—	—	—	—	—	5.9	11.8	11.8	5.9	—	17.6
FEB	9.1	6.1	3.0	9.1	9.1	—	6.1	—	15.2	9.1	—	9.1	9.1	9.1	6.1
MAR	19.0	14.3	19.0	4.8	—	—	—	—	—	—	9.5	—	—	19.0	14.3
APR	—	15.4	7.7	17.7	—	23.1	—	—	—	—	7.7	—	—	15.4	23.1
MAY	—	—	—	—	50.0	—	—	—	—	40.0	10.0	—	—	—	—
JUN	—	—	—	—	—	—	—	—	—	84.0	16.0	—	—	—	—
JUL	—	—	—	—	—	—	—	—	—	50.0	50.0	—	—	—	—
AUG	—	—	—	16.7	—	—	—	66.7	—	16.7	—	—	—	—	—
SEP	17.6	17.6	11.8	11.8	11.8	—	—	17.6	—	5.9	5.9	—	—	—	—
OCT	26.7	20.0	20.0	6.7	—	—	—	—	—	—	6.7	—	—	20.0	—
NOV	16.7	12.5	4.2	—	—	16.7	12.5	—	14.7	—	4.2	—	4.2	8.3	4.2
DEC	4.7	2.3	2.3	2.3	9.3	11.6	7.0	—	2.3	—	4.7	11.6	18.6	16.3	7.0
Entomobrya kali															
JAN	2.5	—	16.7	20.8	—	—	—	—	—	8.3	8.3	8.3	8.3	—	16.7
FEB	7.3	7.3	4.9	9.8	9.8	—	4.9	—	14.6	7.3	—	9.8	12.2	4.9	7.3
MAR	14.3	9.5	19.0	9.5	—	—	—	—	—	—	14.3	—	—	19.0	14.3
APR	—	15.0	10.0	10.0	—	20.0	—	—	—	—	10.0	—	—	15.0	20.0
MAY	—	—	—	—	54.5	—	—	—	—	—	45.5	—	—	—	—
JUN	—	—	—	—	—	—	—	—	—	71.4	28.6	—	—	—	—
JUL	—	—	—	—	—	—	—	—	—	60.0	40.0	—	—	—	—
AUG	—	—	—	27.3	—	—	—	45.5	—	27.3	—	—	—	—	—
SEP	16.7	20.8	12.5	12.5	8.3	—	—	16.7	—	4.2	8.3	—	—	—	—
OCT	18.8	12.5	12.5	18.8	—	—	—	—	—	—	12.5	—	—	25.0	—
NOV	16.1	12.9	6.5	—	—	12.9	9.7	—	16.1	—	6.5	—	6.5	6.5	6.5
DEC	6.9	10.3	3.4	3.4	13.8	13.8	0.3	—	3.4	—	6.9	10.3	10.3	3.4	3.4

1. *Trichoderma viridae*, 2. *Aspergillus niger*, 3. *Penicillium chrysogenum*, 4. *Penicillium nigricans*, 5. *Mycogone* sp., 6. *Absidia spinosa*, 7. *Absidia* sp., 8. *Mucor recemosus*, 9. *Mucor circinelloides*, 10. *Alternaria alternata*, 11. *Fusarium* sp., 12. *Cephalosporium* sp., 13. *Cladosporium* sp., 14. *Doratomyces* sp., 15. *Pythium* sp.

January for both the species. It was also seen that there were five species which recorded at least 20% or more of the total relative abundance in one or more of the months (Table 1).

As in soil so also in the gut contents of *Seira indica* the two major species were *Trichoderma viride* and *Fusarium* sp. which showed maximum peaks in July (50%) and November (45%) respectively. All others were 20% or slightly more (Table 2).

In *Seira lateralis* it was seen that *Fusarium* sp., recorded 100% in the month of July and nil in the month of February, while *Alternaria alternata* showed a maximum of 57% in the month of June and *Penicillium chrysogenum* showed a maximum of 28.5% in the months of April and November. Again all others were around 20% (Table 2).

In *Salina yosii*, the soil fungi, *Fusarium* sp. and *Alternaria alternata* occurred 50% in the month of July, while *Trichoderma viride* recorded a maximum of nearly 27% in the month of October (Table 3).

In *Entomobrya kali*, the fungus *Alternaria alternata* recorded a peak of nearly 70% in the month of June with a slight drop to 60% in the month of July which reduced to less than half (28%) in the month of August. *Fusarium* sp., was maximum in the month of May (45%) while it dropped to nearly 30% (29.5%) in the month of June and again increased to 40% in July while *Penicillium nigricans* showed two peaks of abundance, one in August (21%) and the other in January (21%) (Table 3).

DISCUSSION

While analysing the gut contents of the four species of Collembola and correlating it with those in the soil from where these species were extracted, it seemed, that, seasonally there was no regularity between the soil fungal flora and the fungal flora in the gut of collembola. Among the dominant species of fungi from the youngest abandoned fallow and the oldest abandoned fallow there were however, significant differences in the seasonal abundance of the various fungal species.

When the gut contents of the collembola species *Seira indica* and *Seira lateralis* from the same site, was compared with the soil, it was seen that among the dominant fungal species, like *Trichoderma viride, Penicillium chrysogenum, Aspergillus niger* and *Fusarium* sp. which recorded peaks of abundance in the soil, they were also abundant in the guts of *Seira indica* and *Seira lateralis* around the same months except for the last which in *Seira lateralis* gut showed a contrasting increase when actually in the soil this was declining. One dominant species of fungus in the soil was *Penicillium nigricans*, which was not recorded in the guts of either of these two collembola species. However, fungal species like *Alternaria alternata, Absidia spinosa* and *Mucor recemosus* which were least recorded in the soil was found to be at least 23% or more in the guts of both species. Moreover *Mucor circinelloides* recorded in *Seira indica* was replaced by *Mycogone* sp. in *Seira lateralis*.

A similar analysis of the soil fungi from the oldest abandoned fallow and the guts of the collembola species, revealed that only *Alternaria alternata* and *Fusarium* sp. when forming a peak in the soil was also maximum in the guts of both the species, while *Penicillium nigricans* and *Absidia* sp. had similar speaks both in soil and in the gut of *E. kali* only. They showed a different pattern in *S. yossi* and in fact the former fungal sp. always recorded below 20%, though revealed a peak similar to soil recording only 16%. *Doratomyces* sp. showed similar peaks of abundance between soil and *Salina yosii* gut contents but totally different for *Entomobrya kali* gut contents. *Aspergillus niger* recorded maximum in mid-monsoon, and had peaks of abundance in the guts of *Salina yosii* and *Entomobrya kali*, only in the autumn months. *Acremonium* sp. which did show more than 10% in the soil was totally absent in the guts of both the species. In addition to these, fungal species like *Trichoderma viride*, *Penicillium chrysogenum*, *Mucor recemosus* and *Pythium* sp., which occurred well below 10% in the soil, were present as peaks of 20% or more in the gut of *S. yosii*. Of these, the last two species were also present in the gut of *Entomobrya kali* while the former two were absent. *Mycogone* sp. similarly occurred in the gut of *E. kali* and not in the gut of *S. yosii*.

As a general occurrence of the various fungal species in the gut of the collembola irrespective of the area from where they were collected, it was seen that *Aspergillus niger*, *Fusarium* sp. *Absidia spinosa*, *Alternaria alternata* and *Mucor recemosus* occurred in the guts of all the four species of Collembola irrespective of whether they formed 10% or more in the soil from the two different sites. *Trichoderma viride* and *Penicillium chrysogenum* were seen to occur only in *S. indica*, *S. lateralis* and *Salina yosii* guts, while *Penicillium nigricans* in the gut of *Entomobrya kali* only. Species like *Doratomyces* sp. and *Pythium* sp. seemed to show a relation to the collembola from different sites in that they failed to occur in the guts of *S. indica* and *S. lateralis*, while present in *Salina yosii* and *E. kali*. Interestingly, enough, *Mycogone* sp. was found only in *S. lateralis* and *E. kali*, the former from the youngest abandoned fallow and the latter from the oldest abandoned fallow. *Mucor circinelloides* was a species which occurred only in the gut of *S. indica* and in no other collembola species.

It is seen that the four species of collembola were more or less non-specialised feeders (Petersen, 1971 ; Mcmillan, 1975). This low degree of specialization is probably attributed to the excess food available to these decomposers (Healey, 1972). In the present study, when particular fungal species becomes rare, there did not seem to be a distinct selective advantage in contrast to Emlen (1973). In all the four species of collembola undertaken there was no incidence at all of empty guts. This was probably because the region under consideration always had high humidity and rainfall above average in comparison to the rest of India. However, it has been seen that there was a high feeding activity immediately after the onset of monsoon (Joosse, 1976). It is seen that there is a great synchronisation of total collembola population to the feeding behaviour, where the amplitude of population fluctuations increase in autumn (Smith, 1972 ; Joosse and Testerink, 1977). This, therefore primarily attributed to soil moisture condition more than anything else (Verhoef, 1977). Of the 10 or 11 species of fungi it was seen that more than 50% are common in the soil as also in the gut contents of two species from the same habitat. This is in concordance with several studies, that the gut contents of collembolan species living under similar conditions, show similarity (Poole, 1959 ; Gilmore and Raffensperger, 1970 ; Bodvarsson, 1970 ; McMillan and Healey, 1971). But this ability of such extensive numbers of detritus species not only co-existing but also utilising identical food resources, conflicts the general theory of ecological concepts, that related species sharing same habitats evolve food differentiation and hence the concept of ecological niche (De-Bach 1966 ; Slobodkin *et al.* 1967 ; Reynoldson and Davies, 1970).

Further, species of collembola are known to vary in their ability to digest particular components and also vary in the activity range of their own enzyme component (Von Torne, 1967a ; 1967b). In the present study, the micro habitat differences between species have been left undetected because of the complexity of the work. It seems that the low degree of food specificity in these species was due to an interaction, reducing competition pressure between the species which superficially utilise the rather uniform resources under moist soil conditions (Anderson and Healey, 1972 and Dowding, 1976).

Despite this fact, fungi among microflora are the most efficient penetrators of plant remains and within a limited period, nutrients get incorporated in microbial tissues, which represents not only production of equal or similar food resources but also a high quality of nutrition.

SUMMARY

Very little is known in India, regarding the structural and functional aspects of the trophic relationships of soil arthropods. The present study was undertaken in four dominant a species of collembola occurring in the soil of abandoned jhum fallows of N. E. India. Their feeding habits in relation to soil fungi was carried out for a period of one year. It was observed that all the collembola species undertaken for the study were not only non-selective feeders, but also did not restrict their feeding to only the dominant fungal species occurring in the soil that they inhabited.

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