Research Paper
Impact Factor: 4.164
Refereed Journal

IJMDRR
E- ISSN –2395-1885
ISSN -2395-1877

QUALITATIVE AND QUANTITATIVE TROPIC NICHE DIFFERENTIATIONS OF SOME FUNGIVOROUS SOIL MICROARTHROPODS AND THEIR FEEDING STRATEGIES

Pradip Kumar Bandyopadhyay*   Sudipta Sinha   Buddhadev Mondal***   Niranjan Gupta******
* Head and Associate Professor of Botany, Burdwan Raj College,Burdwan.
** Assistant Professor in Mathematics, Burdwan Raj College,Burdwan.
*** Assistant Professor in Zoology, Burdwan Raj College,Burdwan.
**** Curator & Project Coordinator, Bardhaman Science Centre, National Council of Science Museums
Ministry of Culture, Govt.of India.

Abstract
Ten fungal species were offered as food substrates simultaneously to single species of Acarines and Collembola to study the tropic niche preferences of fungivorous Acarina and Collembola. It has been revealed that feeding of these organisms on the ten offered species differ between the species. Over all, *Alternaria* was the most preferred as indicated by the high number of faecal pellets deposited by both Acarina and Collembola. These fungivorous microarthropods showed significant differences between species as indicated by protected ANOVAs. Feeding preferences were strong in *Oppia yodai, Scheloribates albialatus*, *S. preincisus, Epilomannia pallida indica*, *Galumna sp.* and *Tectocepheus velatus*; low in *Lamellobates palustris, Hypozetes sp.* and not significant in *Tydeus sp.* and *Tyrophagus sp*. Species with strong feeding preferences generally preferred *Alternaria* and *Bipolaris* except in *Scheloribates albialatus* which is preferentially fed on *Cladosporium*. Acarines with low feeding preferences (*Lamellobates palustris* and *Hypozetes sp*.) preferentially fed on *Aspergillus* and *Bipolaris* respectively. AmongCollembolans, feeding preferences were strong in *Onychiurus sp., Folsomia sp., Entomobrya sp., Lepidocyrtus suborientalis* and *L. medius*; low in *Cyphoderus sp* and not significant in *Lobella sp., Cryptopygus thermophilus, Hypogastrura sp.* and *Proisotoma sp*. *Alternaria and Cladosporium* were the most preferred species for most of the Collembolan species. However, most of them except *Cryptopygus thermophilus* preferred *Glomus sp.* Affinity for *Rhizoctonia* and *Fusarium* found intermediate and overall more than *Glomus sp.*

Key Words: Fungivory,Collembola,Acarina,TropicNiche, Faecal pellets, Manova.Protcted Anovas.

Introduction
Soils contain highly diverse communities of microorganisms and invertebrates. The tropic interactions between these species are largely unknown. Tropic niche differentiation may explain the high diversity of soil animal species. However, tropic niches of soil invertebrates are little understood and it appears that different decomposer soil animal species prefer similar food substrates. Food specialization remains a key issue for understanding animal species diversity in soil. Surprisingly, knowledge on feeding biology of many soil invertebrates is poor and the available information in part is contradictory. It is still not clear if soil living animals are specialist or generalist feeders **(Schneider and Maraun, 2005;Bandyopadhyay et al.2009).**One of the main aim of this study was to explore the importance of partitioning of food resources for high diversity of micro-arthropods particularly Collembolans and Acarines in soil. Soil micro arthropods particularly Collembolans and Oribatid mites, preferentially feed on dark pigmented fungi but their feeding preferences among dark pigmented fungal species are little understood. In accordance, fungivory stands up as a key interaction to be study if we aim to understand the dynamics of the decomposition process and its implications to soil fertility. In relation to decomposition other studies have shown that fungivory increased the respiration rate of the micro-biota in decomposing leaf litter **(Hedlund and Oehrn,2000).**Along with decomposition, fungi have several important functions in the ecosystems, such as symbiosis and parasitism. One-fourth of all described fungal species form lichens and almost all plant species are associated with mycorrhizal fungi **(Smith and Read,1997).** Interactions between micro arthropods and fungi are central to many processes in soil. Surprisingly, the possible mechanisms of these interactions, such as grazing, disturbance and dispersal, have been little studied. Grazing of soil animals on fungi may affect the competition between saprophytic and mycorrhizal fungi **(Tiunov and Scheu, 2005)**, the recovery and succession of saprophytic fungi **(Maraun et al.1998 b)** and the dispersal of fungal propagules **(Anderson, 1988, Renker et al.2005).** In the rhizosphere, micro arthropods affects saprophytic and pathogenic fungi, as well as vesicular-arbuscular and ectomycorrhizal fungi via selective grazing and dispersal **(Lussenhop,1992)**. Arbuscular mycorrhizal fungi are ubiquitous in field soils, as are fungivorous animals such as Collembola and Acarines. It has been suggested that these animals reduce the functioning of mycorrhizal fungus and are thus detrimental to plant growth **(Finlay,1985).** However, recent choice experiments suggest that Collembola preferentially feed on non mycorrhizal fungi in the rhizosphere and therefore, might indirectly benefit plants through an enhancement of mycorrhizal functioning**(Gange,2000)**.

The aim of the present work was to confirm the tropic niche differentiation of fungivorous Collembola and Acarines in terms of food preferences particularly the soil fungi which provide the principal nutrient for the soil micro arthropods in the soil food web.

Material And Methods

The present study has been carried out by Innovation Hub of Burdwan science Centre,NCSM,Govt.of India,Burdwan and Burdwan Raj College,Burdwan district in West Bengal, India.It is situated at a distance of about 6 km(approx) in the south – west of Barddhaman Railway station. These area falls between 23^{0}23'14"N latitude and 87^{0}86'15"E longitude at an altitude of 30m above sea level.

In the present study soil samples were collected from non-rhizosphere and rhizosphere of most dominant plant species of the study sites at monthly interval over a period of 3 consecutive years (January 2015 to December 2016).In the present investigation **Tullgren funnel** as modified by **Murphy (1962)** was used for extraction of the arthropods. Soil samples for fungi population study were collected separately from the non-rhizosphere and rhizosphere of the dominant species of the study sites. The fungal population was assessed by inoculating the soil solution of 10^{-3} and 10^{-4} dilutions. The conventional dilution plate method was followed, using potato dextrose agar (PDA) media. Feeding preference study was made following the method of **Maraun et al., 2003.** Ten fungal species were offered as food substrates simultaneously to single species of Acarines and Collembola: *Alternaria alternata, Bipolaris spicifera, Cladosporium cladosporioides, Hemicola* sp., *Aspergillus flavus, Rhizoctonia* sp., *Fusarium chlamydosporum*, *Trichoderma viride*, *Mucor hiemalis* and *Glomus fasciculatum*.The fungal species other than *Glomus fasciculatum* were extracted from the soil of study sites. They were stored in the laboratory until beginning of the experiment. Two weeks before the start of the experiment they were freshly inoculated on malt extract agar (2%). Species names of the fungi are subsequently abbreviated as genera names.For *Glomus fasciculatum* pot cultures were maintained in Rhodes grass**.**

The fungi were offered on small agar discs (8mmØ) which were cut out of the growing front of the fungal colonies(for *Glomus fasciculatum* spores and infected root bits of Rhodes grass) and placed in a circle of 5cm in a plastic vessel (7cmØ).The bottom of the vessels consisted of a layer of plaster of Paris. Ten species of each of Acarins and Collembola were placed in the centre of the vessels. After 10 days faecal pellets deposited in close vicinity of the fungal agar discs were counted and taken as measure of the amount of food consumed. There were five replicates per treatment. During the course of the experiment none of the fungal isolates became contaminated with other fungi. For statistical analysis the number of faecal pellets was log-transformed to increase homogenecity of variance. The feeding preferences of all micro arthropods under study were analysed by single factor analysis of variance (ANOVA) with factors 'fungi'(ten fungal species). The food choice (number of faecal pellets) of the respective micro arthropods was analysed by one–way multivariate analysis of variance (MANOVA, Pillai's Trace; **Scheiner and Gurevitch, 2001**) with the factor 'fungi' with 10 levels (the 10 fungal species). Subsequently, protected ANOVAs (**Scheiner and Gurevitch, 2001)** were performed to locate which of the Acarines as well as Collembolan species contributed to significant MANOVA results. The analyses were implemented in SPSS 10.0 for windows.

Result and Discussion

From the experiment on feeding preferences of fungivorous Acarina and Collembola it has been revealed that feeding of these organisms on the ten offered species differ between the species($F_{9,490} = 12.19$;$p<0.0001$). Over all, *Alternaria* was most preferred as indicated by the high number of faecal pellets deposited (Fig: 1A and Fig:1B) both in Acarina and Collembola. Among the other taxa *Bipolaris, Cladosporium, Hemicola, Aspergillus* were most preferred by the Acarines (Fig:1A) where as *Cladosporium, Aspergillus, Rhizoctonia, Fusarium* and *Glomus* were preferred by the Collembolans (Fig:1B).*Trichoderma* and *Mucor* being the least preferred by both the Acarines and Collembolan species. Most of the preferred fungi species belongs to the Dematiaceae and the non-dematiacea (*Aspergillus, Rhizoctonia, Fusarium*) ranked among the species of intermediate preference.

Feeding preferences of Acarina significantly differed between species (Table:1A).As indicated by protected ANOVAs feeding preferences were strong in *Oppia yodai*, *Scheloribates albialatus, S. preincisus, Epilomannia pallida indica, Galumna sp.* and *Tectocepheus velatus*;low in *Lamellobates palustris, Hypozetes sp.* and not significant in *Tydeus sp.* and *Tyrophagus sp* .Species with strong feeding preferences generally preferred *Alternaria* and *Bipolaris* except in *Scheloribates albialatus* which is preferentially fed on *Cladosporium* (Fig:2A). Acarines with low feeding preferences (*Lamellobates palustris* and *Hypozetes sp*.) preferentially fed on *Aspergillus* and *Bipolaris* respectively (Fig:2A).

Feeding preferences of Collembolans significantly differed between species (Table:1B). As indicated by protected ANOVAs feeding preferences were different among the species. Feeding preferences were strong in *Onychiurus sp., Folsomia sp., Entomobrya sp., Lepidocyrtus suborientalis* and *L. medius*; low in *Cyphoderus sp* and not significant in *Lobella sp., Cryptopygus thermophilus, Hypogastrura sp*. and *Proisotoma sp. Alternaria* and *Cladosporium* were the most preferred species for most of the Collembolan species. However,most of them except *Cryptopygus thermophilus* preferred *Glomus sp*. Affinity for *Rhizoctonia* and *Fusarium* found intermediate and overall more than *Glomus sp*(Fig:2B).

It is evident from the gut content and experiment on feeding preferences that trophic niche differentiation among the fungivorous micro arthropods (Acarines and Collembola) is very limited but never the less may contribute to the high diversity of these micro arthropods group (**Anderson, 1975a)**.Dark pigmented fungi are generally preferred as diet by these organisms than the hyaline fungi and mycorrhizal fungi. Results of food choice experiment suggest that Acarines particularly oribatid mite and Collembola preferentially feed on fungi with dark melanished hyphae and/or spores over hyaline fungi.

These results also revealed that there is trophic niche differentiation concerning dark pigmented fungi and there are species specific feeding preferences for 'Dematiacea'. Among the dematiacea *Alternaria, Cladosporium and Bipolaris* are most preferred fungi for these micro arthropods which is consistent with the previous findings of **Maraun et al.1998a,b,2003;Schneider et al.2004,Jorgensen et al.2003;Klironomous et al.1999** and several others. But the selectivity and degree of preferences are certainly different at the species level. The preference for these dark pigmented fungi may be due to the melanin itself because genes driving melanin synthesis (pksP) strongly affect the food quality for fungal feeding invertebrates **(Scheu and Simmerling, 2004).**

However, from the present investigation it has been also revealed that most of these fungal feeding micro arthropods feed on a wide spectrum of fungal species suggesting mixed diets increase fitness. Acarines and Collembola fed on *Aspergillus, Rhizoctonia, Fusarium* and vesicular-arbuscular mycorrhizal fungi, *Glomus* considerably but not on *Mucor* and *Trichoderma.* Affinity for mycorrhizal fungi found more in collembola than that of acarines. From published data and from this present experiments it appears that dark pigmented fungi together with plant pathogens like *Rhizoctonia* and *Fusarium* seem to be the most preferred, *Glomus* is also among the more preferred fungi, but ranked below that of *Fusarium, Rhizoctonia* and other saprophytic fungi (especially Dematicea**) (Gange, 2000; Klironomous and Kendrick, 1996).** Saprophytic fungi like Trichoderma and Mucor is often consumed but was not among the more preferred fungi **(Edwards and Fletcher,1998).**

It has been also predicted from the present study that in presence of several preferred dark pigmented saprophytes and root pathogenic fungi, the affinity of feeding on mycorrhizal fungi by these organisms particularly Collembola definitely reduced and then Collembola might indirectly benefit plants through enhancement of mycorrhizal functioning **(Gange,2000).** It has been reported by **Schneider and Maraun (2005)** that all melanin containing dark pigmented fungi were not preferred by the oribatid mite at the same scale. Thus it is the fungal species diversity in the soil or in leaf litter that control the feeding behaviour of this fungivorous micro arthropods.

Overall, findings of this present study indicate that oribatid mite species and collembola generally feed on a wide spectrum of fungal species. Despite preferences for certain fungal species most oribatid mites are best considered as 'choosy generalists'**(Schneider and Maraun,2005**)because they feed selectively when high quality food is available but in shortage of the preferred food they are also able to feed on other low quality fungi. The Collembola on the other hand may be considered as 'selective' opportunistic feeder and are very sensitive to their feeding behaviour **(Petersen,2002;Zaitsev,2002;Bandyopadhyay et al.2009)**

Table 1A: MANOVA (Pillai trace) of F values on variations in the number of faecal pellets (log transformed data) produced by Acarina feeding on ten different fungal taxa offered as food substrate, and F-values of protected ANOVAs on variations in the number of faecal pellets deposited by each Acarina spp.(log transformed data).

MANOVA	df	F-values
Pillai trace	90.351	2.289***
PROTECTED ANOVA		
Oppia yodai	9,49	10.34***
Scheloribates albialatus	9,49	9.86***
Scheloribates preincisus	9,49	8.75***
Epilomannia pallida indica	9,49	6.30***
Galumna sp.	9,49	4.88***
Tectocepheus sp.	9,49	4.56***
Lamellobates sp.	9,49	2.38*
Hypozetes sp.	9,49	2.33*
Tydeus sp.	9,49	1.49
Tyrophagus sp.	9,49	1.44

***** Significant at 1% * Significant at 5%**

Table1B: MANOVA (Pillai trace) of F values on variations in the number of faecal pellets (log transformed data) produced by Collembola feeding on ten different fungal taxa offered as food substrate, and F-values of protected ANOVAs on variations in the number of faecal pellets deposited by each Collembola spp.(log transformed data

MANOVA	df	F-values
Pillai trace	90.351	3.871***
PROTECTED ANOVA		
Onychirus sp.	9,49	9.87***
Folsomia sp.	9,49	9.11***
Entomobrya sp.	9,49	8.98***
Lepidocyrtus suborientalis	9,49	6.43***
Cyphoderus	9,49	5.14***
Lobella sp.	9,49	2.11*
Cryptopygus sp.	9,49	1.25
Hypogastrura sp.	9,49	1.07
Proisotoma sp.	9,49	0.99

*** Significant at 1% * Significant at 5%

IJMDRR
E- ISSN –2395-1885
ISSN -2395-1877

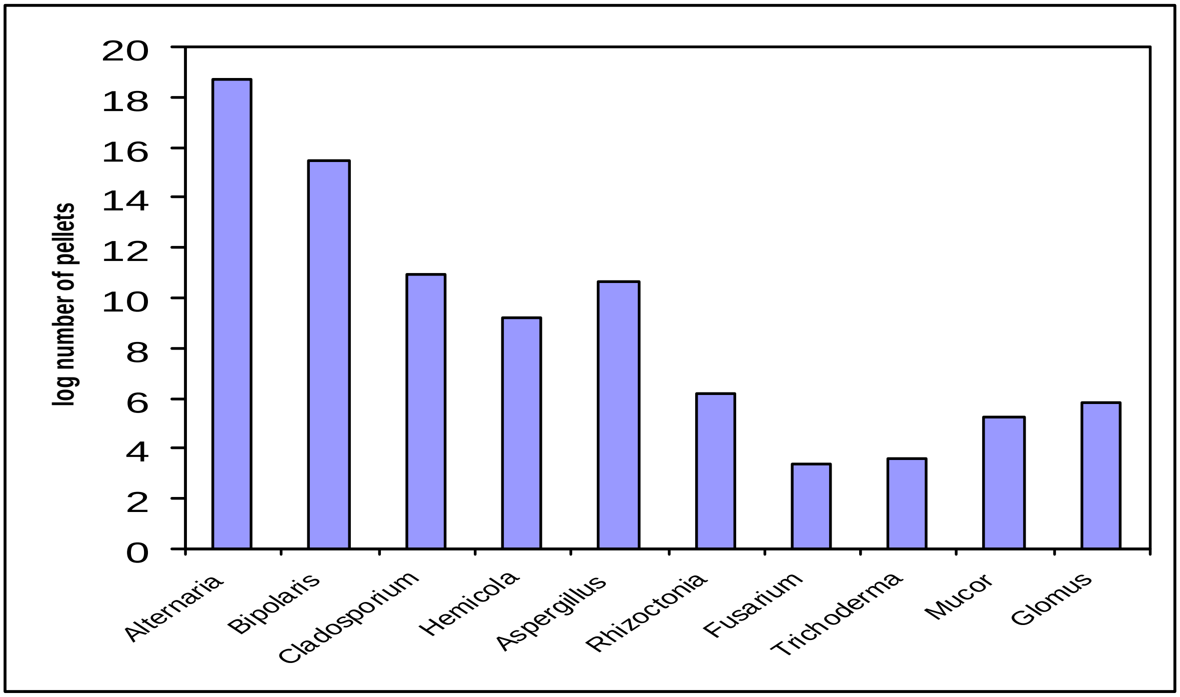

Fig1A: Total number of faecal pellets from all individuals from 10 investigated Acarina spp. deposited close to each investigated fungus.

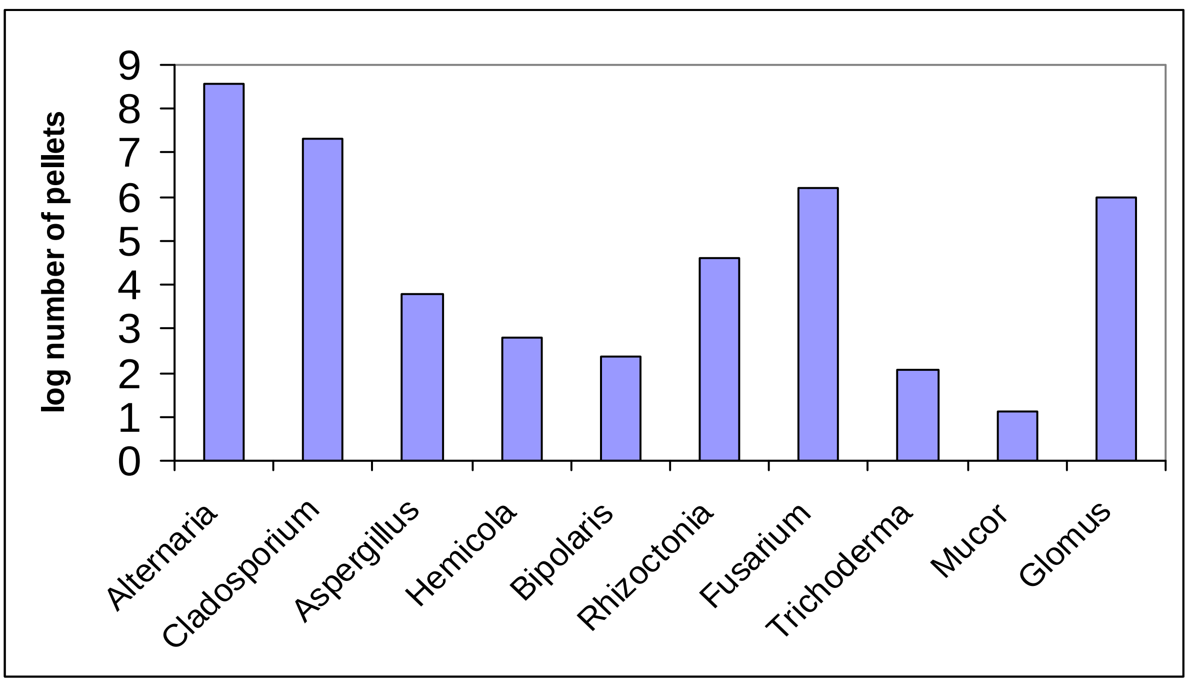

Fig1B: Total number of faecal pellets from all individuals from 10 investigated Collembola spp. deposited close to each investigated fungus.

IJMDRR
E- ISSN –2395-1885
ISSN -2395-1877

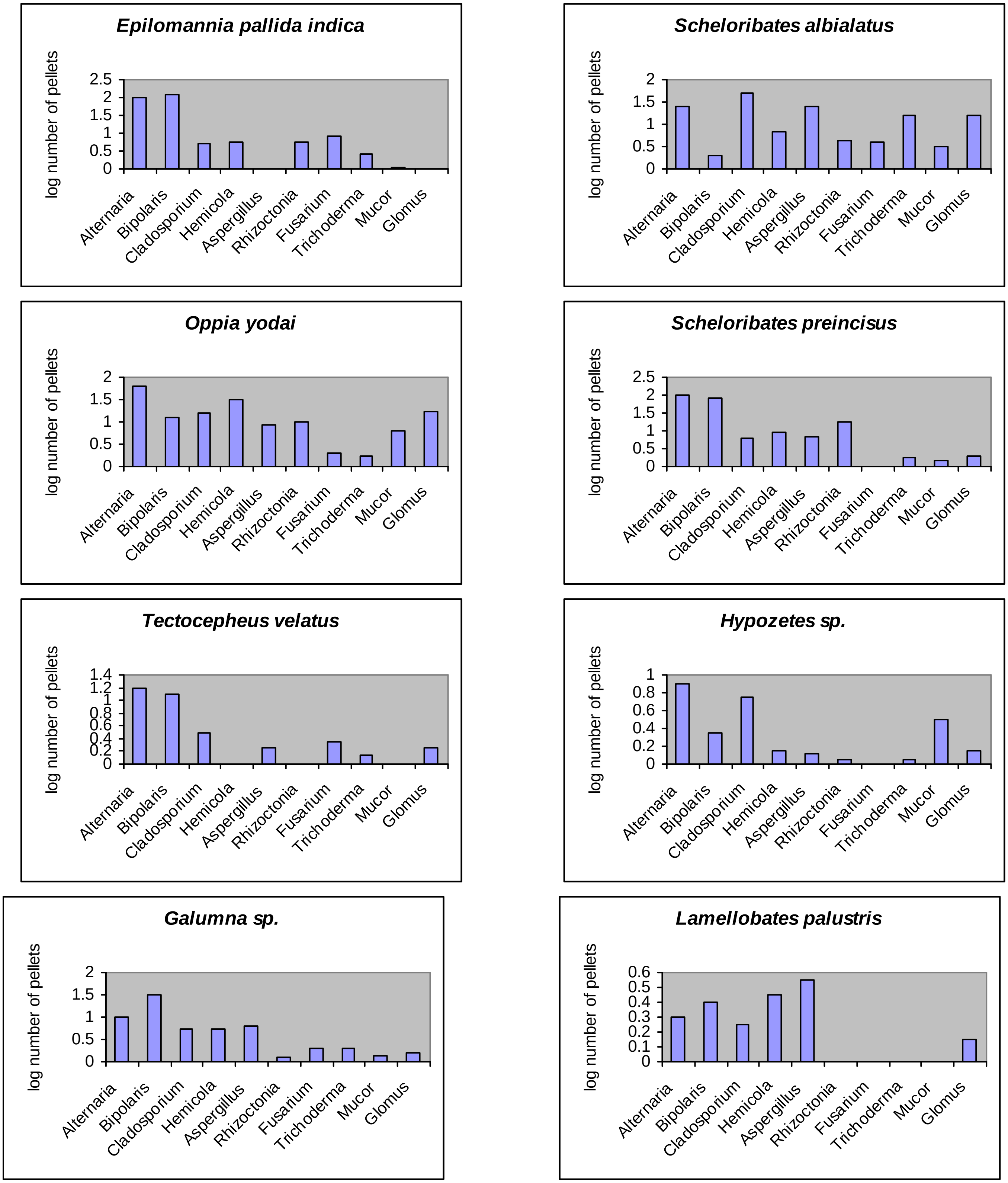

Fig2A: Number of faecal pellets produced by different species of Acarina during 10 days of incubation.

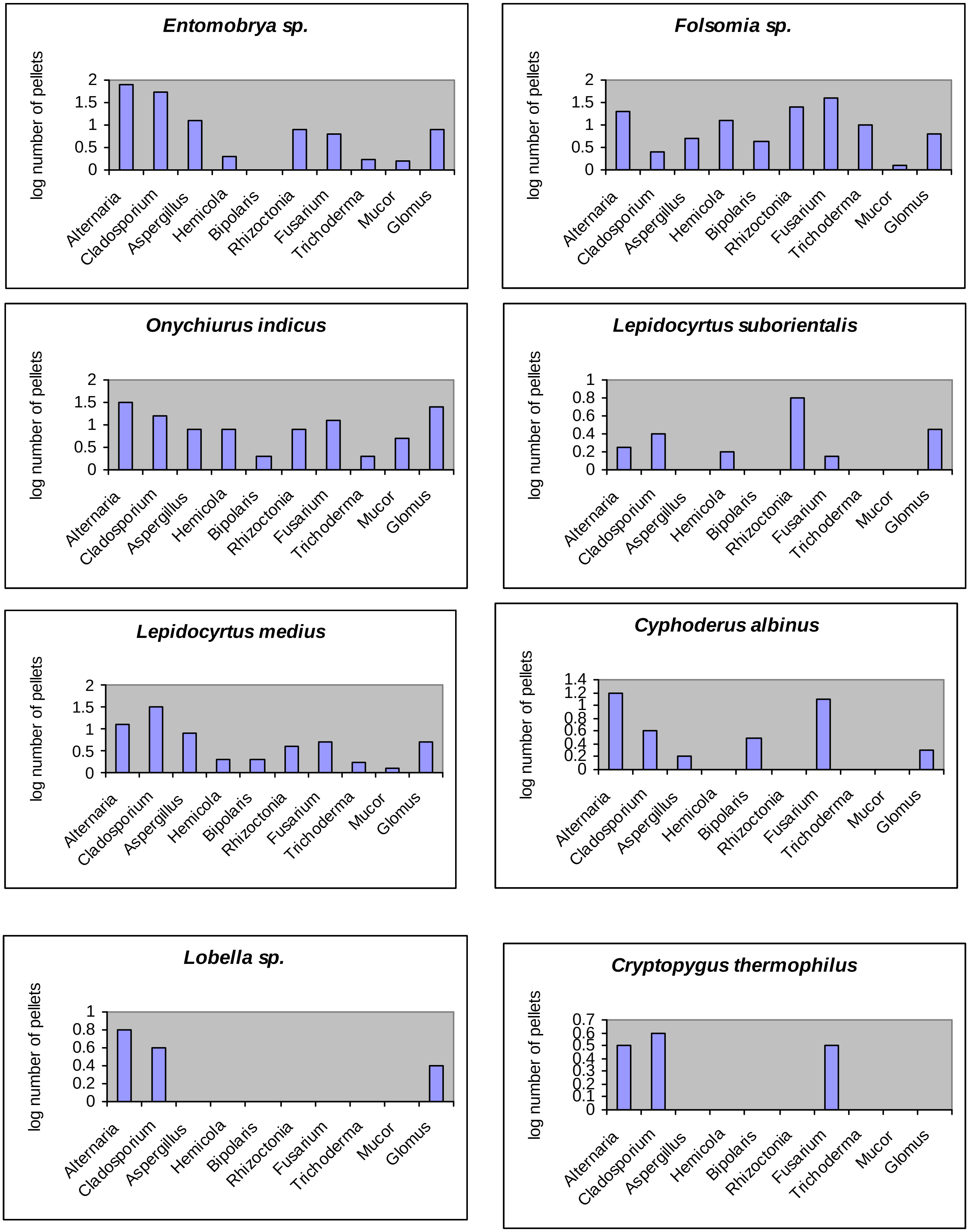

Fig2B: Number of faecal pellets produced by different species of Collembola during 10 days of incubation.

IJMDRR
E- ISSN –2395-1885
ISSN -2395-1877

References

1. Anderson, 1988. The role of soil fauna in agricultural systems. Ir. Wilson J.R(ed) Advantages in nitrogen cycling in agricultural ecosystem CAB, Waling Ford Oxen UK.pp 89-112
2. Bandyopadhyay,P.K; S.Khatun,N.C.Chatterjee 2009.Isolation of Gut Fungi and feeding behaviour of some selected soil microarthropods of Wastelands of Burdwan District.Asian J.Exp.Sci.Vol.23,No.1,253-259
3. Edwards, C.A., Fletcher, K.E. 1998. Interactions between earthworms in a simle food preference study . Soil Biology and Biochemistry 29, 569—575
4. Finlay RD 1985. Interaction between soil mnicro arthropods and endomycorrhizal associations of higher plants In Fitter AH(ed) Ecological interactions in soil. Blackwell, Oxford, pp 319-331
5. Gange A 2000. Arbuscular mycorrhizal fungi, collembola and plant growth. Trend Ecol Evol 15 : 369-372
6. Hedlund, K and M.S.Oehru,2000.Trophic interactions in a soil community enhance decomposition rates Oikos 88: 585-591.
7. Jorgensen , H.B. Elmholt, S.R Peterson, H 2003. Collembolan dirtary specialization on soil grown fungi. Biol. Fertil. Soils 39, 9 – 15.
8. Klironomes JN, Kendrick B 1995. Stimulative efferts of arthropods on endomy corrhizas of suger maple in the presence of deeaying litter. Funel Eclo. 9 :528 – 536.
9. Lussenhop J 1992.Mechanisms of microarthropod microbial interactions in the sail. Adv Ecol Res 23:1—33
10. Maraun M.Visser S,Schens 1998b. Oribatid mites enhance the recovery of microbial community after a strong disturbance.Applied Soil Ecology 9,175-181
11. Maraun M.Martens H,Migge M.Thuens A,Scheu S 2003.Adding to the enigma of soil animal diversity fungal feeders and saprophagus soil invertevrates prefer similar food substrates.Eur J Soil Biol 39:85-95
12. Maraun M.MiggeS,Schaefer M.Scheu S1998a. Selection of microfungal food by six oribatid mite species (Oribatida,Acari)from two different beech forests.Pedobiologia 42,232-240
13. Murphy P.W.1962a. Effict of sample treatment and extraction efficiency with split funnel extractor.Progress in soil Zoology,(Ed.P.N.Murphy)
14. Petersen H.2002. General aspects of collembolan ecology at the turn of the millennium pedobiologia 46:246—260.
15. Schneider K.Maraun M 2005. Feeding preferences among dark pigmented fungi (Demaliacea) indicate trophic niche differentiation of oribatid mites. Pedobiologia 49 :61 – 67.
16. Schener SM, Gurevitch J(eds) 2001. Design and analysis of ecological experiments. Oxford University press, Oxford Scheu S.Selala H (2002) Multitrophic interactions in decomposer foodwebs. In : Tscharntke T.Hawkins BA (eds) Multitrophic level interactions. Combridge University Press, Cambridge , PP 233 – 264
17. Scheu S.and Simmerling F. 2004. Grouth and reproduction of fungal feeding Collembola as affected by fungal species , melanin and mixed diets. Ecophsiology , Oecologia PP 347 – 353.
18. Schneider K, Migge S.Norton RA , Scheu S, Langel R, Reineking A, Maraun M 2004 .Trophic niche differentiation in oribatid mites (Oribatida, Acari) : evidence from stable isotope rations (15N/14N). Soil Biol Biochem 36 : 1769 – 1774.
19. Smith, S.E.and Read, D.J 1997. Mycerrhizal symbiosis , Academic press.
20. Tiunov AV, Scheu S 2005. Arbuscular mycorrhiza and collembola interact in affecting community composition of saprotrophic microfungi. Oecologia 142.636—642.
21. Zaitsev As, Chauvat M, Pflug A, Wolters V.2002. Oribatid mite diversity and community diversity and community dynamics in a spruce chronosequence in Germany. Soil Biol Biochem 34: 1919—1927.