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A survey of epigeic springtails (Collembola) in organic agro-ecosystems in Brazil

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Abstract

The relative activity of epigeic springtails of two control plots (Pasture and Forest) were compared with that of four experimental plots (Passion fruit, Banana, Cassava and Sugarcane) in Brazil. Various agrochemical inputs (lime and organic fertilizer) were used in the experimental plots. A leguminous cover crop Arachispintoi and crop rotation system were also adopted to increase the soil fertility and soil biodiversity. The relative activities of the epigeic springtails were determined and the taxonomic groups that responded very well to the organic inputs were also identified. The raw data were normalized by log (x+1) transformation and subjected to analysis of variance and Duncan's multiple range test. The results indicate that epigeic springtails responded positively but differently to organic inputs and have the ability to recolonize burnt plots. Four genera of epigeic springtails, Pseudachorutinae,Cryptopgus,Ceratophysellaand Entomobrya benefited more than other generafrom organic fertilization. These genera will be good experimental tools in laboratory studies on the response of epigeic springtails under organic management.

Keywords: *Epigeic springtails; organic inputs; relative activity; agrochemical inputs and leguminous cover crop.*

Resumo

A atividade relativa dos retículos epigeicos de duas parcelas de controle (Pasto e Floresta) foi comparada com a de quatro parcelas experimentais (Maracujá, Banana, Mandioca e Cana de Açúcar) no Brasil. Vários insumos agroquímicos (limão e fertilizante orgânico) foram utilizados nas parcelas experimentais. Uma cultura de cobertura leguminosa Arachis pintoi e sistema de rotação de culturas também foram adotadas para aumentar a fertilidade do solo e a biodiversidade do solo. As atividades relativas dos retículos epigeicos foram determinadas e os grupos taxonômicos que responderam muito bem aos insumos orgânicos também foram identificados. Os dados brutos foram normalizados por transformação log (x + 1) e submetidos à análise de variância e ao teste de múltiplas extensões de Duncan. Os resultados indicam que os springtails epigeicos responderam positivamente, mas diferentemente dos insumos orgânicos e têm a capacidade de recolonizar parcelas queimadas. Quatro gêneros de epigeic springtails, Pseudachorutinae, Cryptopgus, Ceratophysella e Entomobrya beneficiaram mais do que outros gêneros de fertilização orgânica. Esses gêneros serão boas ferramentas experimentais em estudos de laboratório sobre a resposta de springtails epigeic sob gestão orgânica.

Palavras-chave: *Epigeic springtails; Insumos orgânicos; Atividade relativa; Insumos agroquímicos e cobertura de leguminosas.*

Introduction

Collembola are among the most abundant, diverse and functionally important group of soil animals. Collembola inhabit litter and top soil where their food is readily available. Morphological differences that separate high rank taxa of Collembolans have clear functional meaning in relation to life style and habitat requirements. Epigeic springtails are those who dwell in the litter. They are more brightly coloured and pigmented than the endogeic springtails which live in the top 7.5 cm layer of the soil (Afolayan*et al*., 2016). An agro-ecosystem is the basic unit of study inagro-ecology,and is arbitrarily defined as spatially and functionally coherent unit of agricultural activity which includes the living and non living components involved in that unit as well as the interactions between them. Badejo*et al.*, (1995) while studying collembolan abundance, species richness, diversity and evenness found that collembolan populations were more favoured in mulched plots than plots without mulch.Culik*et al.*, (2002) reported a similar trend of greater collembolan populations with mulch in their study of biodiversity of Collembola in tropical agricultural environment. The aim of this study is to investigate the effects of organic fertilizer applications, on the diversity and relative activity of epigeic springtail populations in organic agro-ecosystems in an experimental farm in South-east Brazil.

Materials and methods

Sampling site and Experimental plots.

This study was carried out in plots located within a piece of land of 59 hectares which has been used extensively for farming since 1993 in Seropedica (Latitude 22° 45′ S, Longitude 43° 42′ W and altitude 30-70m) in the state of Rio de Janerio in South East Brazil. The soil in the study site is anUltisol. The area had a bimodal rainfall pattern with an annual average of 1326 mm.Four experimental plots separated by a 2m strip and two control plots (Pasture and Forest) which were 100m and 250m away from the experimental plots respectively were investigated. The experimental plots include Passion fruit, Banana, Cassava/Maize and Sugarcane/Mucuna. The organic fertilizers applied to the experimental plots are composed mainly of cow dung manure in Passion fruit, Banana, Cassava/Maize and chicken manure in Sugarcane/Mucunawith different additives such as ash, thermophosphate, Fritted Trace Element (FTE), lime and gypsum in Passion fruit; lime, gypsum and cocinal (limed algae) in Banana; thermophosphate, rock phosphate and ash in Cassava/Maize; lime, gypsum, thermophosphate, and cocinal (limed algae) in Sugarcane/Mucuna. There was a fire outbreak in the forest plot a few months before sampling began in December 1999. The relative activity (number per trap per day) of the epigeic springtails was determined.

Pitfall Trapping

Pitfall traps were used to collect epigeic Collembola from the experimental and control plots. Sampling was done on three occasions within a period of 20 months. The first sampling was done in April, 1998, while the second and third rounds of sampling took place in December, 1998 and December, 1999 respectively. On each sampling occasion, sixpitfall traps were set randomly in each plot at the exact spots where soil cores were taken by sinking plastic dishes of mouth diameter 9cm and depth 11cm in such a way that their rims were at the same level with the soil surface. Each trap was filled to a depth of 3cm with 4% Formaldehyde and left in place for seven days so as to monitor the activities of springtails at the soil surface. Identification was done using a combination of standard keys as well as illustrations of already identified specimens in the Laboratory for Systematics and Ecology of Soil Micro arthropods in the Department of Zoology, Obafemi Awolowo University, Ile-Ife. The following precautions were taken during the setting of pitfall traps: During the period of seven days, care was taken to prevent overflowing of the trap contents by replacing traps that were filled with rainwater and run-off to a level of 10cm and the 4% Formaldehyde was added to each trap to kill the arthropods. During sorting, the camel hair brush was placed under the field of view each time it was used to introduce a specimen into the preservative (alcohol) so that they are not returned into the petri-dish. The intensity and angle of inclination of reflected light was adjusted to see epigeic springtails of different shades of pigmentation and the different taxonomic group or genera were properly identified and recorded in a data book using the tally system of counting.

Data analysis
All data were subjected to log (x+1) transformation, One-way Analysis of Variance using Duncan's Multiple Range Test (DMR-test) to determine significant difference in the relative activity of epigeic collembolan fauna in each experimental plot at 5% probability level.

Results

Two superfamiliesPoduromorpha and Entomobryomorpha were identified (Table 1, 2 and 3). Under the Superfamily Poduromorpha, the two genera identified were *Ceratophysella*and*Pseudachorutinae.* The third genus could not be identified. Juveniles were also recorded under the superfamily Poduromorpha. In the superfamily Entomobryomorpha, the following nine genera were identified: *Cryptopygus, Isotomurus, Proisotoma, Seira, Paronella, Entomobrya, Lepidocryrtus, Campylothorax and Orchesellinae.* An unknown genus andjuveniles were also recorded. Table 1 reveals that *Cryptopygus*has the highest relative activity of 123.5 per trap per day in the Banana plot in April 1998. In December 1998, *Cryptopygus* was completely absent from all experimental plots and the activities of all available genera were extremely low except *Ceratophysella* whose relative activity was 11.04 per trap per day under Passion fruit and *Lepidocrytus* whose relative activity was 11.9 in the maize plot (Table 2). Table 3 reveals that in December 1999, *Pseudachorutinae* had the highest relative activity of 352 per trap per day in the Cassava plot, *Ceratophysella* ranked second with a relative activity of 93.4 per trap per day while *Entomobrya* ranked third with a relative activity of 81 per trap per day in the Cassava plot.Despite the fact that there was a fire outbreak in the forest plot a few months before sampling began in December 1999, collembolan populationsof seven genera were recorded in the forest plot in December 1999though low in activity. The genera and their respective relative activity include: *Ceratophysella*(4.2), *Entomobrya*(2.8), *Paronella*(1.6), *Cryptopygus*(1.2), *Isotomurus*(0.5), *Orchesellinae*(0.3) and *Campylothorax*(0.04). Fig 1 reveals that the highest relative activity of epigeic springtails was recorded in the Banana plot in April 1998 and in December 1998 and 1999, the highest relative activity was recorded in the Cassava/Maize plot.

Table 1: The relative activity (numbers/trap/day) of epigeic springtails in the experimental plots sampled in April 1998

Taxonomic group	Passion fruit	Banana	Cassava	Sugar cane	Pasture	Forest
PODUROMORPHA						
Ceratophysella	1.1c	4.2b	0.1d	3.7bc	12.0a	0.2d
Pseudachorutinae	0.2c	18.5a	0	0.2c	1.2b	0
Unknown (x)	0	0	0	0.1	0	0
Juveniles	1.7	0	0	0	0	0
ENTOMOBRYOMORPHA						
Cryptopygus	0.04b	123.5a	0	0	0.1b	0
Isotomurus	0	0	0	0	0	0
Proisotoma	1.0b	10.7a	0	0	0.1c	0.2c
Seira	0	0	0	0	0	0
Paronella	0.1a	0	0	0.4a	0.2a	0.3a
Entomobrya	0.6b	0.4b	1.7a	0.3b	0.6b	0.2b
Lepidocryrtus	0.5a	0.1a	0	0.2a	0	0.3a
Campylothorax	0	0	0.04b	0	0	0.4a
Orchesellinae	0.2a	0	0	0	0	0.8a
Unknown(x)	0	0.04b	0.04b	0	0.3a	0
Juveniles	0	0	0	0.2	0	0
No. of taxonomic units*	8	7	4	6	7	7
No. of codominants (>10)	0	3	0	0	1	0

All values are log (1+ x) transformed. Value (s) in any given row with same letter(s) in common are not significantly different at 5% probability level according to Duncan Multiple range test.

**Excluding juveniles*

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Table 2: The relative activity (numbers/trap/day) of epigeic springtails in the experimental plots sampled in December 1998

Taxonomic group	Passion fruit	Banana	Maize	Sugarcane	Pasture	Forest
PODUROMORPHA						
Ceratophysella	11.0a	2.9b	13.0a	6.7b	0.2c	0
Pseudachorutinae	0	0	0	0	0	0
Unknown (x)	0	0	0	0	0	0
Juveniles	0	0	0	0	0	0
ENTOMOBRYOMORPHA						
Cryptopygus	0	0	0	0	0	0
Isotomurus	0	0	0	0	0	0
Proisotoma	0	0	0	0	0	0
Seira	0	0	6.0a	0.1b	0	0
Paronella	0.8b	0.8b	5.2a	0	0.8b	0.9b
Entomobrya	2.3ab	2.3ab	3.6a	2.1b	0	0.6c
Lepidocryrtus	0.1d	0.6c	11.9a	2.7b	0.4dc	0.1d
Campylothorax	0	0	0	0.1a	0	0.8a
Orchesellinae	0	0.1a	0	0	0.2a	0
Unknown(x)	0	0	0	0	0	0
Juveniles	0.1	0.5	4.9	0	0	0
No. of taxonomic units*	4	5	5	5	4	4
No. of codominants (>10)	1	0	1	0	0	0

All values are log (1+ x) transformed. Value (s) in any given row with same letter(s) in common are not significantly different at 5% probability level according to Duncan Multiple range test
**Excluding juveniles.*

Table 3: The relative activity (numbers/trap/day) of epigeic springtails in the experimental plots sampled in December 1999

Taxonomic group	Passion fruit	Banana	Cassava	Sugar cane	Pasture	Forest
PODUROMORPHA						
Ceratophysella	93.4a	18.1b	0	21.6b	0	4.2c
Pseudachorutinae	0	0	352.0a	0	3.5b	0
Unknown (x)	0	0	0	0	0	0
Juveniles	0	0	0	0	0	0
ENTOMOBRYOMORPHA						
Cryptopygus	0.9c	8.9b	42.0a	15.2b	0.1d	1.2c
Isotomurus	0.2c	0.9ac	1.2a	0.3c	0.04d	0.5c
Proisotoma	0	0	0	0	0	0
Seira	0	0	0	0	0	0
Paronella	0.3c	0.2c	0.8b	0	6.0a	1.6b
Entomobrya	7.2b	5.5bc	81.0a	6.5b	2.8c	2.8c
Lepidocryrtus	0	0.6b	0.5b	1.1a	0.1b	0
Campylothorax	0.8a	0.04b	0.3a	0.1a	0	0.04b
Orchesellinae	0.4a	0	0	0.04b	0	0.3a
Unknown (x)	0	0.04a	0	0	0	0
Juveniles	0	0	0	0	0	0
No. of taxonomic units*	7	8	7	7	6	7
No. of codominants (>10)	1	1	3	2	0	0

All values are log (1+ x) transformed. Value (s) in any given row with same letter(s) in common are not significantly different at 5% probability level according to Duncan Multiple range test.

**Excluding juveniles.*

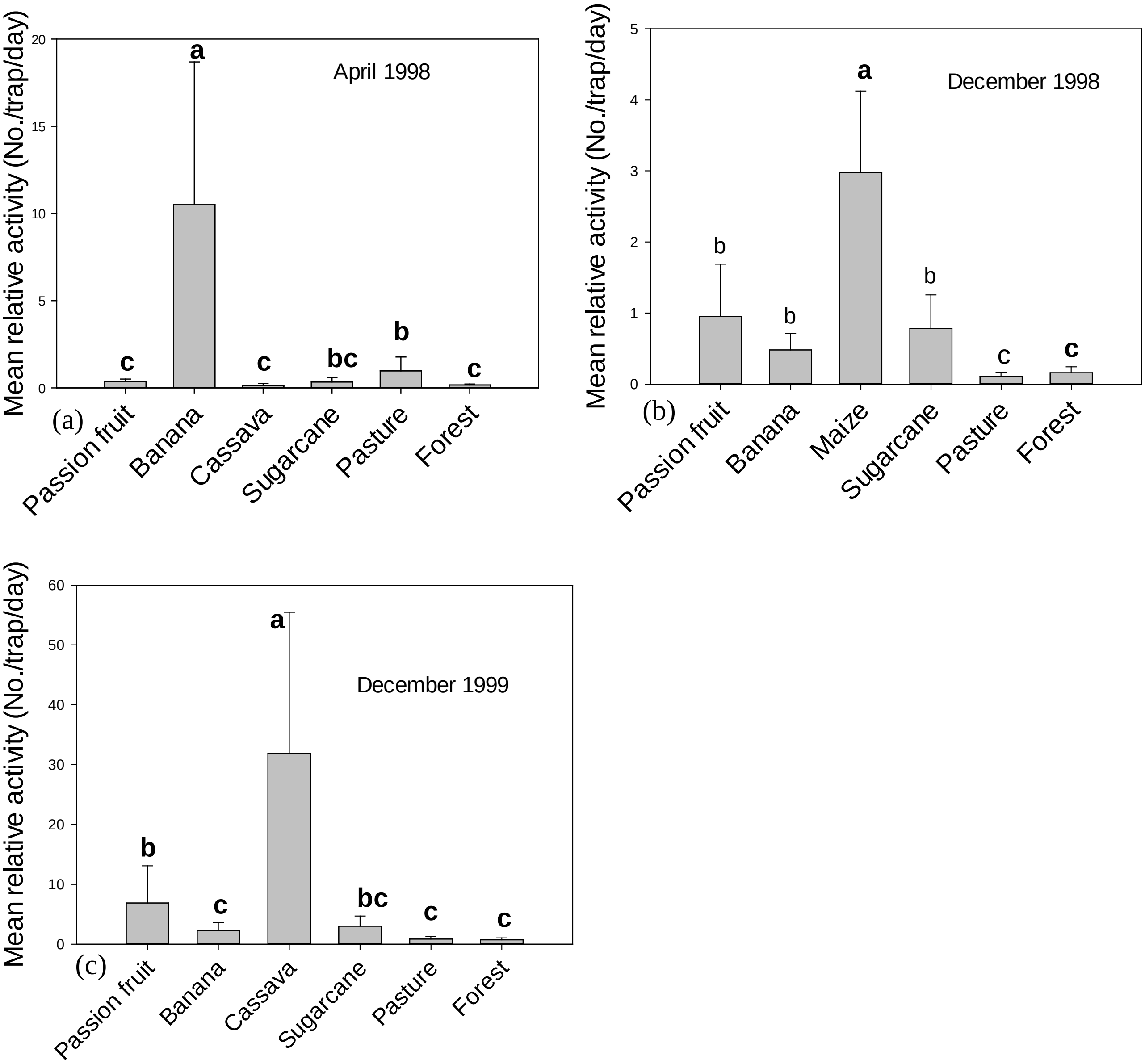

Fig. 1: Mean relative activity (No./trap/day) of epigeic springtails (including juveniles) across experimental plots. The mean (s) with same letter(s) in common are not significantly different at 5% probability level according to Duncan Multiple range test.

Discussion

The study was carried out in an Ultisol which is a low status base soil. The soil in the study area had a pH of 5.6 which indicates that the soil is weakly acidic and consequently has good nutrient relations. Soil fertility was aided in the agro-ecosystem by mulching, ploughing, organic fertilizer application, use of leguminous cover crop(*Arachis pintoi*), crop rotation system and application of organic residues. Mulching consists of covering the soil surface to protect it against erosion and to enhance its fertility. It serves initially to warm the soil by helping it retain heat and moisture (Khursheed, 2016). In this study, the Cassava/Maize plot was mulched with 500kg of fallow vegetation and crop rotation was practiced in this plot. Apart from Cassava, other annual crops like okra and beetroot, pumpkin (*Menina brasiliera* variety) and maize were also planted. The essence of crop rotation was to improve soil fertility as the planting of deep rooted crops were followed by shallow rooted crops. This agricultural practice also increases soil biodiversity as it helps to avoid the build-up of pathogens and pests as the alternation of crops modifies the associated communities of biological regulators (Khursheed, 2016). Organic fertilizers were applied to all the experimental plots and the leguminous cover crop (*Arachis pintoi*) was planted in the Passion fruit and Banana plots respectively. Thismust have been responsible for thehigher diversity and relative activity of epigeic springtails in the experimental plots when compared with the Pasture and Forest plots.The legumes are natural fertilizers which improve the nitrogen concentration in the soil because of the symbiotic relationship they have established with *Rhizobium* (Khursheed 2016). This is vital as tropical ecosystems need more nitrogen than is presently available for use. This nitrogen must come from biological agents. Intensive cultivation of leguminous plantsto enhance biological nitrogen fixation has been suggested as a way by which productivity problems in tropical moist savanna can be solved and degraded agro ecosystem can be restored (Badejo, 1998).The results obtained from this study reveals that the relative activity of epigeic springtails varied considerably between the sampling occasions. This is a reflection of their seasonality which has been reported by Hale, (1966), Joose, (1981) and Badejo and Van Straalen (1993). As a result of their morphology, the furcula (springing organ) of epigeic springtails are well developed and attributed to their ability to recolonize burnt plots.

The abundance of epigeic springtails in the experimental plots may also be due to the effect of mulch application in the plots and the composition of the organic fertilizer applied. This is not surprising as it has been reported that ecosystems including soil surface protection and more organic resources tend to have higher soil animal populations (Lavelle *et al.*, 2001). Three genera of epigeic springtails stand out clearly as beneficiaries of the organic fertilization in agro-ecosystems. These are: *Pseudachorutinae, Cryptopgus, Ceratophysella* and *Entomobrya*. These monospecific genera will be good experimental tools in laboratory studies on the response of epigeic springtails under organic management.

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