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Response of soil mites to organic cultivation in an ultisol in southeast Brazil

M. ADETOLA BADEJO[1,*], ADRIANA MARIA DE AQUINO[2], HELVECIO DE-POLLI[2] and MARIA ELIZABETH FERNANDES CORREIA[2]

[1]*Department of Zoology, Obafemi Awolowo University, Ile-Ife, Nigeria;* [2]*National Center for Research on Agrobiology (EMBRAPA-AGROBIOLOGIA), Seropédica-RJ, Brazil;* **Author for correspondence (e-mail: mbadejo@yahoo.com; phone: +234-(0)-803-3451-308; fax: +234-(0)36-232-401)*

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Abstract. Soil-dwelling mites of four plots under organic management were investigated in April and December 1998 and in December 1999. Their populations were compared with mite populations in a pasture and forest in the vicinity. It was observed that there was always an initial reduction in the populations of soil mites and in the activity of the epigeic forms whenever a plot was opened up and disturbed mechanically in preparation for cultivation, irrespective of previous organic inputs. With time, the densities and activities of mites recovered under organic management. The uropodine and oribatid mites in particular benefited more from organic management than gamasine and actinedid mites. Uropodine mites increased tremendously under banana where there was fresh cow dung manure. Oribatid mite species *Nothrus seropedicalensis* and *Archegozetes magnus* were dominant in organic plots where the soil was moist and temperatures were lower than the ambient. *Protoribates rioensis* was dominant in organic plots where the soil was drier and temperatures were higher than the ambient. *Galumna* was the most active oribatid taxon on the floor of all plots, with the highest activity recorded under maracuja and in pasture plots. The results suggest that while densities and activities of soil mites increased in the organic plots, the community structure and recruitment period of oribatid mites were altered. Oribatid mite diversity was higher in the organic plots than in the pasture but lower than in the forest, where *Belba* sp. and many Eremobelboid brachypiline genera were present, but absent in the organic plots and pasture.

Introduction

Organic farming is a method of food production that implies less dependence on agrochemical inputs, as the farmer substitutes these for organic inputs, in an attempt to control nature or natural cycles (Lampkin 1994). The primary sources of nutrients to crops under organic management are indigenous soil organic matter, plant residues and animal manure (Guerra et al. in press), all of which must decompose in order to make nutrients available for plant uptake. Research on the mechanism of decomposition, nutrient release and strategies of utilization of these nutrient sources has continued to attract attention in the tropics, while studies on the soil fauna that are the real agents of decomposition have not been given equal attention.

Soil mites are important components of the soil biota whose role in decomposition processes is no longer a subject of controversy. The detritivorous forms which constitute a large majority of their populations (Wallwork 1976) fragment plant litter, and render them readily accessible to microbial populations which subsequently release nutrients to enhance soil fertility (Moore et al. 1984; Lavelle et al. 1997). There are also other non-detritivorous forms whose influence on nutrient release is significant because they feed on dead animal remains, faecal matter, fungi and microorganisms (Allison 1973). It is therefore important that the effect of organic inputs in agriculture on soil mites is included in the overall assessment of the biological effects of organic farming which has been considered inevitable for sustainability of food production in tropical agricultural systems (Altieri and Francis 1992; Oludimu 1998; Van der Werf 1998).

In this study, the populations of soil mites of agroecosystems that have been under organic management in southeast Brazil for about 3–6 years are compared with populations in a pasture and a forest within the same locality to determine the effects of organic management. The hypothesis to be tested is that the mites benefit from organic inputs not only by increasing in numbers but also by increasing their activity on the floor of the organically farmed plots.

Material and methods

Study sites

This study was carried out in plots located within a piece of land of 59 ha which had been reserved for organic farming since 1993 (Almeida 1998) in Seropedica (22°45′S, 43°42′W, 30–70 m a.s.l.), state of Rio de Janeiro, southeast Brazil. The soil of the study area is classified as Ultisol (Typic hapludult, USDA 1975) whose chemical properties at the superficial layer (0–20 cm) are as follows: pH (H_2O) = 5.6; Al^{3+} = 0.0 cmol/kg; Ca^{2+} + Mg^{2+} = 4.4 cmol/kg; K^+ = 72 mg/kg and available P = 2 mg/kg of soil. The area has a bimodal rainfall pattern with an annual mean of 1326 mm. Rainfall is intense in September–March reaching a peak in November/December as well as in February. There is a relatively dry but cool period from April to August. During the raining period, temperature increases gradually and reaches a peak in February after which it decreases gradually (Badejo et al. 2002a).

Altogether, four adjoining organic plots separated by 2 m strips were investigated as well as control plots from a pasture and a forest about 100 and 250 m away from the organic plots, respectively (Figure 1). The records of cultivation activities in the plots 4 years before and during the sampling period are presented in Table 1.

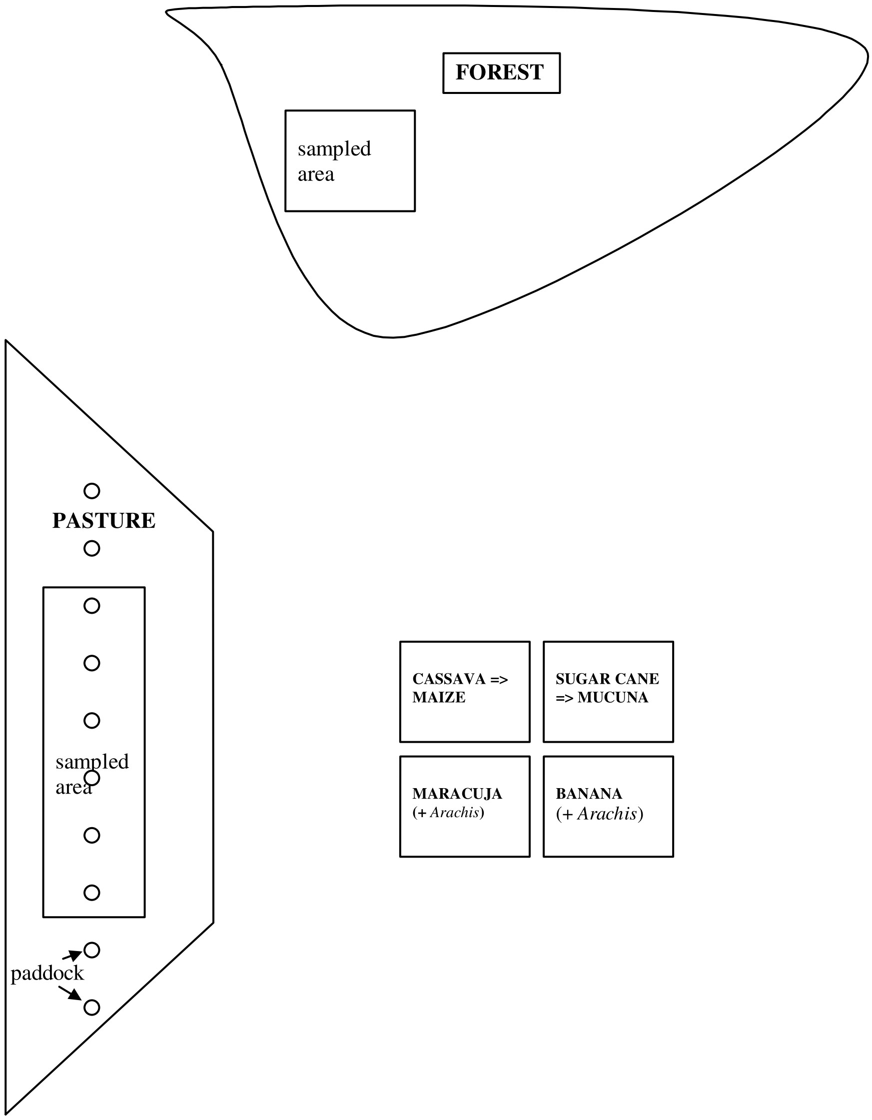

Figure 1. A simplified representation of the experimental plots (not strictly to scale).

Maracuja

In 1994, Passion fruit (*Passiflora edulis*, common name Maracuja) was planted in a plot of 540 m^2 simultaneously with forage groundnut, *Arachis pintoi*, a leguminous cover crop, After planting, organic fertiliser made up of 10 L cow dung manure, 200 g ash from burnt wood used for stoves in the restaurant of the Rural University in Seropedica and thermophosphate mixture (1:1 w/w), 10 g fritted trace elements (FTE) BR10 (formula), and 100 g lime and gypsum

Table 1. History of the organic plots.

Experimental plots	1994	1995	1996	1997	1998	1999
Maracuja (+ *Arachis*)	First planting **F**		Second planting **F**			Third planting **F**
Banana (+ *Arachis*)			*Arachis* planted in January	Banana planted **F**	**F**	**F**
Cassava ⇒ Maize	Cassava planted in November **F**	Cassava	Cassava harvested in March before ploughing and preparing the plot for another planting	Cassava, okra, beetroot, pumpkin, and maize planted at various times	Maize planted in June and in November	Pumpkin planted in March, maize, cucumber and beetroot in August **F**
Sugarcane ⇒ Mucuna	Cassava planted	Sugar cane planted in August **F**				Sugar cane harvested in November; mucuna planted in December **F**

F, Fertilisation.

mixture (3:1) was applied per plant by introducing it into a 20 cm deep pit dug round each maracuja stand. The *Arachis* cover crop was pruned regularly about three times every year. In 1996, another set of maracuja was planted again after the first set of fruits had been harvested. The same fertilisation was done and the next set was harvested in September 1999 after which another set of maracuja seedlings were planted and fertilised as usual.

Banana
This plot where *A. pintoi* was first planted in January 1996 without any fertilisation was also 540 m^2. In April 1997, Banana (*Musa paradisiaca*) was planted in pits. Ten litre of cow dung manure and 20 g of a mixture of 150 g lime, 50 g gypsum and 50 g limed algae (cocinal) were applied per pit, each of which contained one sucker. This fertilisation was repeated in March 1998 and November 1999.

Cassava/maize
This plot of 615 m^2 has experienced more crop varieties than the rest. Cassava (*Manihot utilissima*) was first planted in November 1994 at a spacing of 1.0 m × 0.5 m and mulched with 500 kg of fallow vegetation. The plot was maintained as a cassava plot till March 1996 when the cassava was harvested and the soil was ploughed in preparation for further cultivation. In 1997, cassava was replanted in part of the plot while various annual crops were planted in other parts. These include okra (*Abelmoschus esculentus*) and beetroot (*Beta vulgaris*) in January, pumpkin (*Curcubita moschata* variety *Menina brasiliera*) and maize (*Zea mays*) in February, and the same variety of pumpkin again in June. The subplots were fertilised with 1 or 2 L cow dung manure per pit, depending on the crop. In June 1998, the cassava planted in 1996 and all standing crops were harvested and the whole plot was ploughed again for further cultivation. Maize was planted in a large subplot of 400 m^2 at seed spacing of 1.20 m × 0.40 m and again in November 1998 but it was not fertilised. In March 1999, pumpkin was planted again, followed by cucumber (*Cucumis anguria*), maize and beetroot in August. Pumpkin was planted at a spacing of 2 m × 1.5 m while cucumber was planted at a spacing of 1 m × 0.5 m. The plot was fertilised on both occasions by 1 L cow dung manure per plant. Another subplot (100 m^2) where beetroot was planted received 'green pepper' fertilisation of 6 L/m^2 of cow dung manure, 220 kg/ha thermophosphate, 1 ton/ha rock phosphate and 60 kg/ha K_2O (as ash with 5% K).

Sugar cane/mucuna
This plot (950 m^2) was an unfertilised cassava plot in 1994 before it was ploughed and sugar cane (*Saccharum afficinarum* cv. CB45-3) was planted in August 1995. The plot was thereafter fertilised with 1 ton/ha lime + gypsum (3:1), 80 kg/ha P_2O_5 as thermophosphate, 40 kg/ha K_2O as KCl and 40 kg/ha cocinal (limed algae). Additional fertiliser (1 L chicken manure per meter of

row) was applied in April 1997. Harvesting and regrowing of sugar cane occurred once each year up till November 1999 when it was finally completely harvested and the plot was ploughed and prepared for mucuna (*Mucuna aterrima*, common name velvet bean).

Pasture
The pasture is an extensive open grassland occupying an area of 17.5 ha and dominated by the grasses: *Cynodon* sp., *Digitaria decumbens*, *Panicum maximum*, *Paspalum notatum*, and the weed smutgrass (*Sporobolus poiretii*). It was moderately grazed by cattle, which grazed elsewhere and returned to their paddocks within the pasture in the evening.

Forest
The forest is primary and located on a higher altitude than the rest of the plots. Attempts are made to prevent human interference in this forest but it experiences fire of unknown source about once in a year. One of such fire incidents occurred a few months before sampling in December 1999 in the sampled area. The forest vegetation is dominated by 29 tree species belonging to 18 families. The most abundant species in the sampled plot are *Sparattosperma leucantum* (Bignoniaceae), *Piptadenia* sp., *Piptadenia gonoacantha* (Leg. Mimosaoideae) and Solanaceae (sp. not identified) (Bloomfield et al. 1997). The forest vegetation is far from reaching climax. Shrubs and climbers, which make passing through the forest difficult, are a notable feature of the physiognomy of the forest. There are also undergrowths and a moderate litter cover.

Sampling and extraction techniques

Sampling took place on April 28, 1998, December 2, 1998 and December 3, 1999. Since the experimental plots differ in size, the size of the smallest plot (480 m^2) was marked out from each plot (including the pasture and forest) for sampling. The marked out plots were further subdivided into four equal subplots for sampling purposes. During each sampling occasion, a soil core was taken from the top 10 cm of the soil from each subplot in each plot without removing the litter cover. The soil cores, which were collected with a bucket-type auger, were taken to the laboratory immediately after collection, where a modified Berlese–Tullgren funnel extractor was used to extract microarthropods from them using heat and light as repellents (Lasebikan 1974). The extraction lasted seven days and mites were kept in 70% ethanol.

Pitfall traps were set at the exact spots where soil cores were taken by sinking plastic dishes of mouth diameter 9 cm and depth 11 cm in such a way that their rims were at the same level with the soil surface. Each trap was filled to a depth of about 3 cm with 4% formalin and left in place for 7 days so as to monitor the activities of mites at the soil surface.

The extracted and trapped arthropods were sorted, identified and counted accordingly. Identification was done to generic level where possible for oribatid mites only. The Gamasida were sorted into the two suborders, Uropodina and Gamasina while the Actinedida were treated as a single group. Identifications were made using keys and illustrations provided in Norton (1990) and Balogh and Balogh (1992) for Oribatida, Kethley (1990) for Actinedida, and Krantz and Ainscough (1990) for Gamasida. Confirmation of the identified specimens was made in the Laboratory for Systematics and Ecology of Microarthropods in Obafemi Awolowo University, Ile-Ife, in Nigeria as well as the Museum of Natural History, Karlsruhe in Germany.

During each sampling occasion, soil temperature was taken at each sampling spot with a digital thermometer while 20 g of topsoil was set aside from each soil core for moisture content determination using the oven-drying method. Data for the ambient temperature and rainfall during each of the months when sampling took place were obtained from a meteorological station in the study area.

Investigation area

During the first two sampling occasions in April and December 1998, the maracuja plot was covered with matured maracuja and *A. pintoi*. In December 1999 however, it was a freshly cultivated maracuja plot but still with heavy cover of *A. pintoi*. The cassava plot that was sampled in April 1998 was already overdue for harvest. In December 1998, this plot had turned into a one month-old maize plot that was not fertilized and in December 1999, it was a matured maize plot intercropped with cucumber and beetroot with fertilization. By December 1999, the sugar cane plot of April and December 1998 had turned into an exposed plot on which seedlings of mucuna had just been planted. The banana plot was maintained as a banana plot throughout the period of this study.

Monthly mean of ambient temperature and total monthly rainfall in the study area (Figure 2) reveal that April 1998 was warmer but drier than December 1998 and 1999. The highest rainfall was recorded in December 1998, thus making this month wetter than the equally cool December 1999. Inside the experimental plots, temperature was always lower in the banana and forest plots than the ambient (Figure 3). Under maracuja, temperature was slightly higher than the ambient but sufficiently lower than the temperatures recorded under maize, sugar cane/mucuna and pasture. Thus, the experimental plots could be divided into two groups with different microclimate for soil fauna. The maracuja and banana plots were cool and moist like the forest, while the maize and sugar cane/mucuna plots were drier and warmer like the pasture. Although soil temperature and moisture content data were not taken in April 1998, the categorisation of plots would not have been different because the soil of the cassava plot that later changed into a maize plot was not as protected

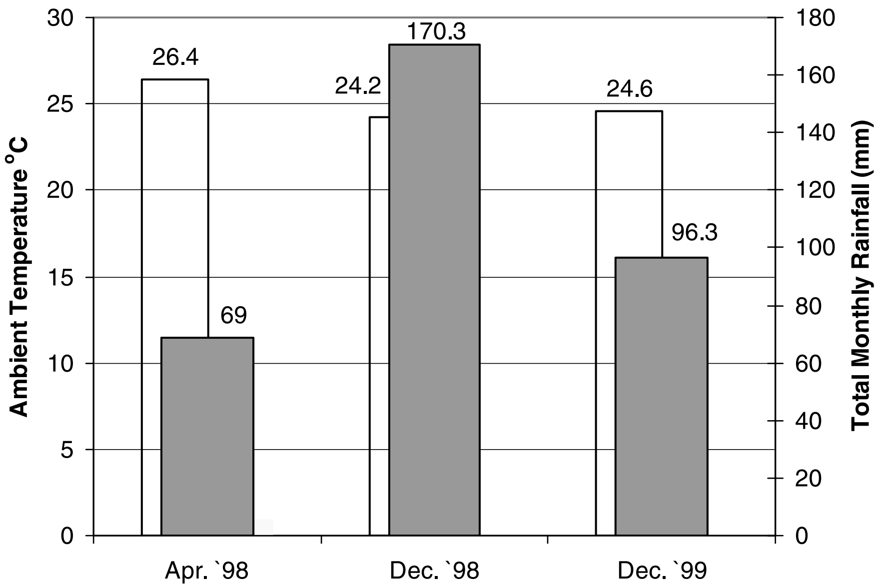

Figure 2. Ambient temperature (open bars) and rainfall (grey bars) in the study area in the three experimental periods.

from direct insolation from the sun as the soil of the maracuja and banana plots.

Data analysis

The raw data were normalised by $\log(x+1)$ transformation and subjected to analysis of variance and Duncan's multiple range test using the SAS package (SAS 1985). The dominance of taxonomic groups, expressed as the ratio of the number of individuals collected on each sampling occasion (Southwood 1978) was calculated to compare differences in diversity and relative abundance of oribatid mite genera between the experimental plots and also between them and the control plots.

Results and discussion

In April 1988, the maracuja and banana plots supported more oribatid and uropodine mites than the pasture and forest plots (Table 2). There was no significant difference in the densities of Gamasina and Actinedida between the organic plots on the one hand and the pasture and forest on the other on this first sampling occasion. This clearly shows that oribatid and uropodine mites benefited more than Gamasina and Actinedida in these organic plots in April

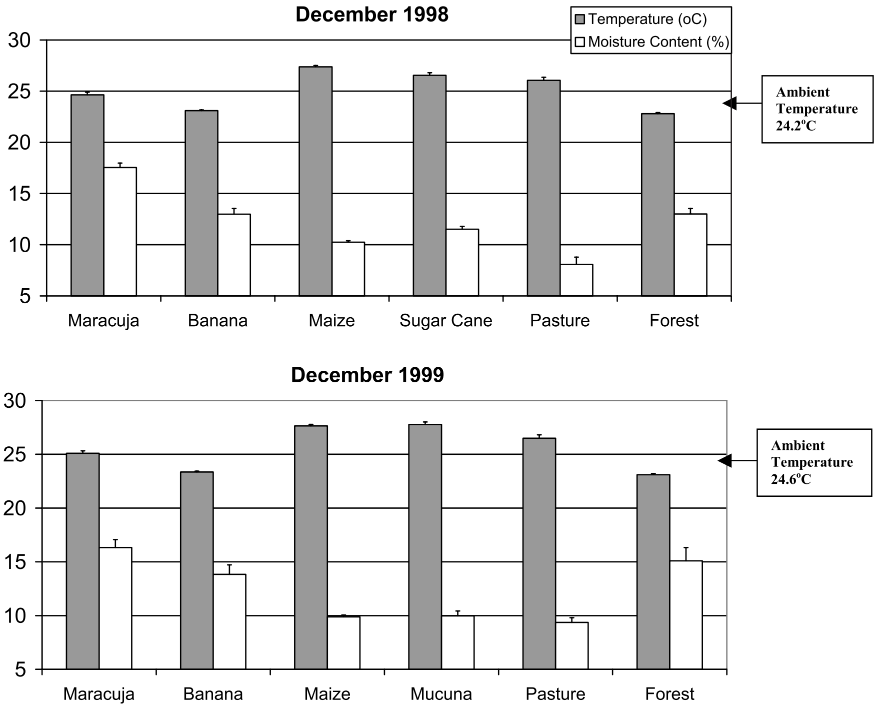

Figure 3. Soil temperature and moisture conditions (±SE) in the experimental plots in December 1998 and 1999.

1998. Similar results were obtained in December 1998 and 1999 with a notable exception in December 1998 when the differences in the densities of oribatid mites in all the organic and control plots were not significantly different. The freshly cultivated maize and mucuna plots supported relatively low populations of mites when compared to other plots probably because of the deleterious effects of ploughing. All forms of mechanical disturbance of the soil are known to reduce the populations of soil microarthropods tremendously (Huhta et al. 1967; Butcher et al. 1971; Badejo 1987; Hendrix et al. 1990; Badejo and Olaifa 1997). The results of April 1998 sampling when none of the experimental plots had recently experienced mechanical disturbance therefore offer the best opportunity for comparing the soil fauna of the experimental and control plots. Table 2 reveals further that the densities of oribatid mites in the cassava and sugar cane plots were not significantly different from the densities in the maracuja and banana plots. Densities of uropodine mites in the cassava and sugar cane plots were lower than in the maracuja and banana plots, which were not only cooler and moister but had also received more cow dung manure than the other plots. The cassava plot had not received cow dung manure since it was established in 1994 while the sugar cane plot received chicken manure only in April 1997, a year before sampling. On the other hand, the banana plot which

Table 2. Comparison of the densities (individuals per m^2) of different mite groups in the soil of the experimental plots, based on the mean of four desiccated soil cores.

Experimental plots	Oribatida			Uropodina			Gamasina			Actinedida		
	4/98	12/98	12/99	4/98	12/98	12/99	4/98	12/98	12/99	4/98	12/98	12/99
Organic plots												
Maracuja	15,042a	4083a	3250a	8167a	6583a	4833a	1042a	2708a	1125bc	42a	83a	0a
Banana	23,833a	2083ab	2542a	13,792a	1500b	17,875a	3917a	1417ab	5125a	125a	167a	208a
Cassava ⇒ Maize	10,917ab	0c	10,375a	250b	42c	542bc	1458a	167c	4042ab	125a	0a	1291a
Sugarcane ⇒ Mucuna	9833ab	1208b	1375a	167b	208c	0c	1417a	1333abc	583c	167a	83a	0a
Control plots												
Pasture	7250bc	583bc	3708a	291b	0c	125c	542a	208bc	3750c	208a	0a	1000a
Forest	2625c	485bc	7167a	125b	42c	1000b	1833a	958abc	2833ab	291a	0a	125a

Similar letters indicate that there are no significant differences within a column after ANOVA and Duncan's multiple range test.

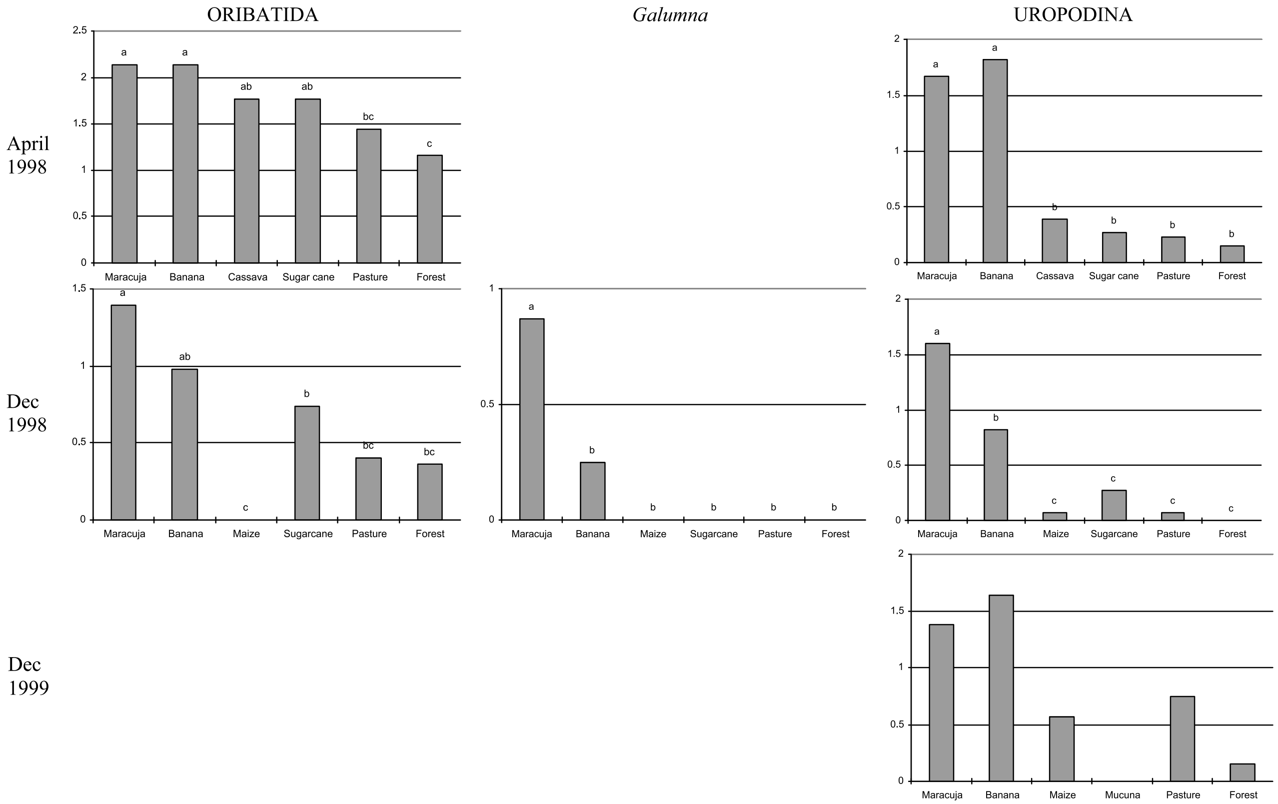

Figure 4. Relative activity in different taxa of epigeic mites trapped from the experimental plots, based on soil data. The numbers on the *y*-axes indicate the numbers ($\log(x+1)$) per soil core.

Table 3. The dominance index (taxon/number ratio expressed in percentage) of soil Oribatida in dessicated soil cores from the experimental plots.

Taxonomic group	April 1998						December 1998						December 1999					
	Mar	Ban	Cas	Sug	Pas	For	Mar	Ban	Mai	Sug	Pas	For	Mar	Ban	Mai	Muc	Pas	For
Macropyline																		
Cosmochthionidae	0	0	0	0	0	3.2	0	0	0	0	0	0	0	0	0	0	0	0
Phthiracarus sp.	0.2	0.3	1.5	0.5	0	1.6	0	0	0	0	0	0	0	0	0	0	0	0
Indotritia sp.	0	0	0	0	0	0	0	0	0	3.5	0	0	2.6	1.6	0.5	3.0	0	1.7
Annectacarus sp.	0.2	0.2	3.8	1.0	0.5	15.9	0	24.0	0	10.3	0	36.4	21.8	11.5	1.2	6.1	0	2.3
Mixacarus sp.	0	0	0	0	0	1.6	0	0	0	0	0	0	0	0	0	0	0	0
Epilohmania sp.	0	0	0	0	0	0	0	0	0	6.9	0	0	0	0	0	0	0	0
Nanhermannia sp.	0	0	0	0	0	0	0	0	0	0	0	0	2.6	1.6	0	0	0	0
Nothrus seropedicalensis	1.7	26.4	0	1.0	1.7	0	33.7	2.0	0	6.9	0	9.1	12.8	1.6	31.7	6.1	21.4	0.5
Parallonothrus brasiliensis	0	0	0	0	0	0	0	0	0	0	0	0	7.6	0	0	0	0	0
Archegozetes magnus	41.8	0.2	0	0	3.5	1.6	0	0	0	0	0	0	5.1	5.0	0	0	0	24.0
Brachypiline																		
Galumna sp1	15.0	4.9	3.1	3	17.3	4.7	32.6	10.0	0	0	0	0	6.4	8.2	0.5	0	5.6	0
Galumna sp2	8.0	3.3	1.1	3	2.3	1.6	0	0	0	0	0	0	0	0	0	0	0	0
Haplozetes sp.	11.6	12.9	1.1	2.9	30.0	19.0	29.6	4.0	0	0	28.6	18.2	5.1	1.6	10.8	0	1.1	16.3
Scheloribates brasilosphericus	0.5	4.3	10.7	7.1	4.0	1.6	0	6.0	0	6.9	0	0	2.6	1.6	4	0	0	1.2
Scheloribates brasilocompressus	4.2	12.2	4.96	20.0	12.0	3.2	0	0	0	0	0	0	0	11.5	7.6	6.1	22.5	0
Protoribates rioensis	4.7	21.4	60.3	55.8	5.2	11.1	3.1	44.0	0	58.6	71.4	9.1	7.6	39.3	34.1	12.1	28.1	13.0
Tectocepheus sp.	2.5	0.2	6.1	1.7	4.0	0	1.0	2.0	0	6.9	0	0	3.8	3.3	2.0	9.1	10.1	1.2
Oppia sp.	0	0	0	0	0.5	3.2	0	0	0	0	0	0	2.6	8.2	4.8	42.4	0	1.2
Basilobelba sp1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5
Basilobelbs sp2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5
Belba spp.	0	0	0	0	0	20.6	0	0	0	0	0	0	0	0	0	0	0	23.8
Machadobelba sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.3
Eremulus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.2
Dolicheremaeus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5
Liacaridae	0	0.5	0	1.5	0	0	0	0	0	0	0	0	1.3	5.0	0	0	0	0
Xenillidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.7

Carabodidae	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	1.2
Unknown (a)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6.4
Unknown (b)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5
juveniles	9.6	13.2	7.3	2.5	18.5	11.1	0	8.0	0	0	0	27.3	1.3	0	0	0	0	0
No. of taxonomic units*	11	12	9	11	12	13	5	7	0	7	2	4	13	13	10	7	6	19
No. of codominants (>10)	3	4	2	2	3	4	3	3	0	2	2	2	2	3	3	2	4	4

Mar, Maracuja; Ban, Banana; Sug, Sugar cane; Muc, Mucuna; Cas, Cassava; Mai, Maize; Pas, Pasture; For, Forest.
*Excluding juveniles.

supported the highest populations of uropodine mites received cow dung manure a few months before sampling. These results suggest that uropodine mites may be indicative of the presence of faecal matter in the soil. Since there was no clear difference in the densities of oribatid mites in the organic plots, data for each genus of Oribatida were transformed and subjected to further analysis of variance. In December 1998 only *Galumna* was more in the maracuja plot than in the rest of the plots where they were completely absent (Figure 4). Since the cassava and sugarcane plots did not support *Galumna* during this sampling period, the higher densities recorded in the maracuja and banana plots cannot be attributed to organic management. It is likely that *Galumna* had preference for the lower temperature and higher humidity under maracuja and banana plots when compared with the cassava and sugar cane plots.

The community structure of oribatid mites in each plot was assessed by calculating the dominance index of each taxon. This revealed that each experimental plot had a unique composition of oribatid mites (Table 3). In April 1998 for instance, the more primitive macropyline mites (e.g. *Nothrus seropedicalensis*; *Archegozetes magnus*; *Annectacarus* sp.) were dominant in the maracuja and banana plots as well as in the forest where microclimatic conditions were similar. The similarity between the warmer and drier cassava and sugar cane plots on the one hand and the pasture on the other is expressed more in the lack of dominance of these primitive macropyline mites than in their own dominant groups. *Galumna* and *Haplozetes* were dominant in the pasture but not in the cassava and sugar cane plots where *Protoribates rioensis* (Badejo et al. 2003) accounted for more than half of the oribatid mites. Such differences were also observed in the organic plots with cool and moist microclimate when compared with the forest. *Belba*, the most dominant genus in the forest, was completely absent from the banana and maracuja plots. These results indicate that the community structure of oribatid mites in April 1998 was altered completely by organic farming in favour of *N. seropedicalensis* and *A. magnus*, (Badejo et al. 2002b, c) under maracuja and banana and in favour of *P. rioensis* under cassava and sugar cane. *N. seropedicalensis* and *A. magnus* are parthenogenetic taxa (Grandjean, 1954; Palmer and Norton, 1991) whose populations can explode when conditions are favourable. *P. rioensis* on the other hand is bisexual (Grandjean 1954). Its abundance in the cassava and sugarcane plots may indicate a preference for fairly exposed conditions under organic cultivation.

In December 1998, when rainfall was highest and temperature was lowest, the dominance of *Annectacarus* had increased in the forest while *Belba* had disappeared completely. Dominance shifts had also occurred in each of the experimental plots. This is expected because seasonality of the populations of mites is a natural phenomenon. Mite genera in both tropical and temperate environments are known to reach single or multiple peak populations at different times of the year depending on temperature and moisture conditions in the soil (Usher 1975; Badejo 1990), as well as their mode of reproduction (Butcher et al. 1971; Mitchell 1977). In December 1999 when temperature was

Table 4. The dominance index (taxon/number ratio expressed in percentage) of Oribatida found in pitfalls in the experimental plots.

Taxonomic group	April 1998						December 1998						December 1999					
	Mar	Ban	Cas	Sug	Pas	For	Mar	Ban	Mai	Sug	Pas	For	Mar	Ban	Mai	Muc	Pas	For
Macrophyline																		
Nothrus seropedicalensis	0	5.8	0	0	0	0	0.3	0	0	0	0	0	0	0.8	0	0	0	0
Parallonothrus brasiliensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0
Archegozetes magnus	2.0	1.0	0	0	15.0	0	35.7	0	16.7	0	0	0	0	0.8	0	0	0.4	0
Brachypiline																		
Galumna sp1	90.7	84.5	93.4		61.5	11.1	46.7	53.8	66.6	18.3	27.8	100.0	92.8	56.0	57.8	60.0	82.5	0
Galumna sp2	0	0	0.8	45.8	0.5	0	10.7	0	0	45.5	0	0	0	0	0	0	0	0
Galumna sp3	0	0	0	0	0	0	0	0	0	0	0	0	0.8	0.8	5.3	0	0.2	0
Haplozetes sp.	0.5	0	0	0	1.1	0	4.4	0	16.7	4.5	0	0	1.2	3.2	0	0	0	44.7
Scheloribates brasilisphericus	0	0	0	0	0	44.5	0	0	0	13.6	0	0	0.6	0	15.8	10.0	0	2.6
Scheloribates brasilocompressus	3.8	7.7	3.3	0	15.0	11.1	1.9	23.1	0	0	33.3	0	1.0	10.4	0	10.0	3.9	5.3
Protoribates rioensis	0.3	0	0	53.0	0.2	0	0	15.4	0	4.5	16.7	0	3.2	18.4	15.8	20.0	3.9	0
Tectocepheus sp.	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oppia sp.	0	0	0	0	1.6	0	0	0	0	0	0	0	0	0	0	0	0	0
Ceratoppia sp.	0	0	0	0	0	11.1	0	0	0	0	0	0	0	0	0	0	0	0
Belba spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20.6
Eremulus sp.	0	0	0	0	1.0	0	0	0	0	0	0	0	0	0	0	0	0	0
Liacaridae	2.2	1.0	0	0	3.8	11.1	0	0	0	0	0	0	0	0	0	0	0	16.2
Xenillidae	0	0	0	0	3.8	0	0	0	0	0	0	0	0	0	5.3	0	0.7	0
Unknown sp. y	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0	0	0	0	0
Juveniles	0	0	2.5	0	0	11.1	0.3	7.7	0	13.6	22.2	0	0.2	9.6	0	0	8.0	10.5
No. of taxonomic units*	7	5	3	2	10	5	6	3	3	5	3	1	7	7	5	4	7	5
No. of codominants (>10)	1	1	1	2	3	5	3	3	3	3	3	1	1	3	3	4	1	3

Mar, Maracuja; Ban, Banana; Sug, Sugar cane; Muc, Mucuna; Cas, Cassava; Mai, Maize; Pas, Pasture; For, Forest.
*Excluding juveniles.

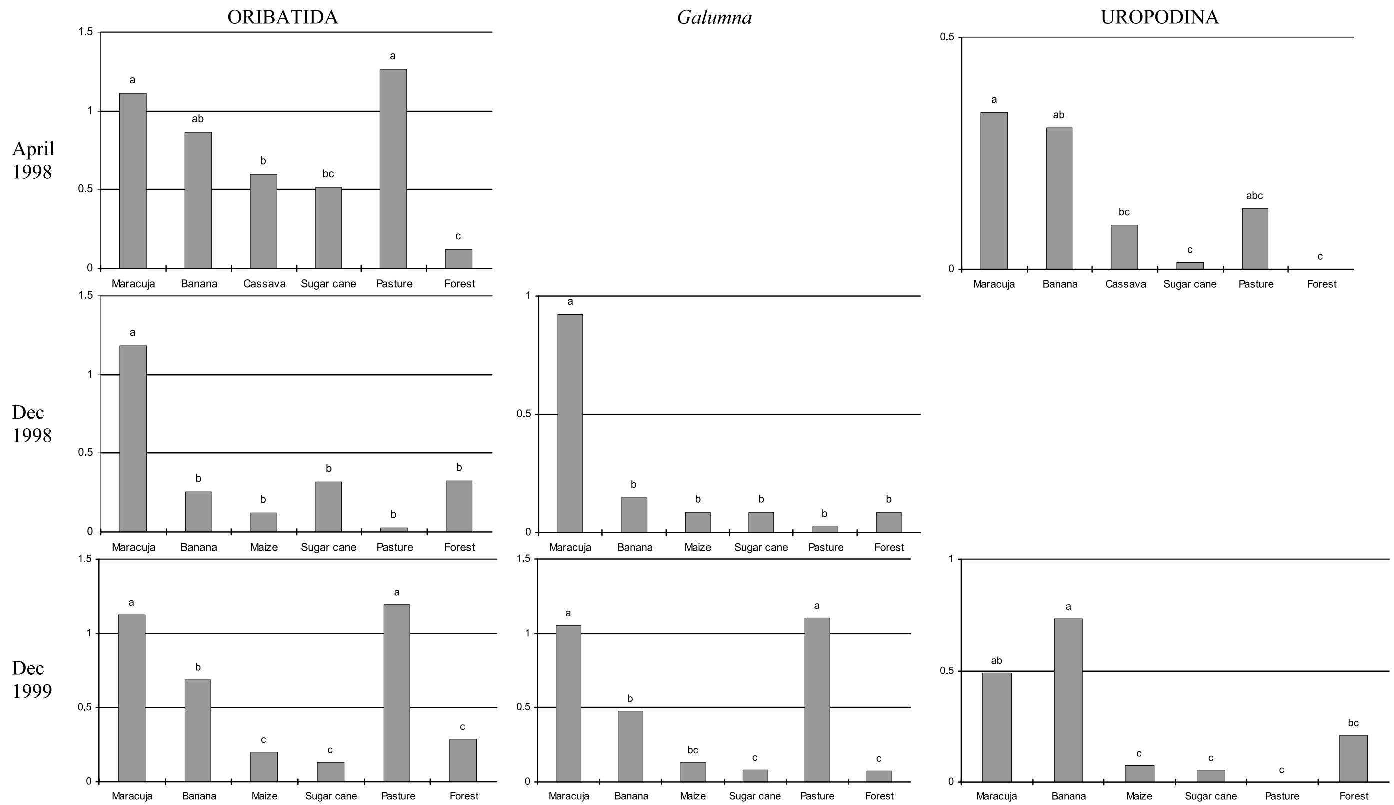

Figure 5. Relative activity in different taxa of epigeic mites trapped from the experimental plots, based on pitfall data. The numbers on the *y*-axes indicate the numbers ($\log(x+1)$) per trap per day.

also low but rainfall was less, nine taxa of higher oribatid mites, though present in the forest, were completely absent from the organic and pasture plots (Table 3). Overall, each plot maintained a unique community structure on each sampling occasion, with a tendency for dominance shift in favour of the thelytokous *N. seropedicalensis* and *A. magnus* as well as the bisexual *P. rioensis* in the organic plots. It is however remarkable to note that *Belba* and many Eremobelbid brachypiline genera which are typical forest dwellers (Badejo 1987; Badejo and Lasebikan 1988; Badejo 1995) were completely absent in the organic plots and the pasture.

Pitfall traps are only capable of assessing the activity of epigeic mites. Not all species extracted from the soil samples are therefore expected to be trapped. The limitations of pitfall trapping have been discussed by Adis (1979). In Table 4, the dominance indices of the trapped oribatid mites are presented. *Galumna* was the most active taxon on the floor of all plots. Interestingly, *Galumna*, which was completely absent from the soil cores of the cassava, sugar cane, pasture and forest plots in December 1998 (Table 3), was trapped from the surface of these plots. In fact, *Galumna* was the only active taxon on the forest floor in December 1998 (Table 4). *Galumna* was also the only oribatid whose activity (i.e. trap catch) was higher under maracuja than in every other plot in December 1998 and 1999 except the pasture in December 1999 (Figure 4). Another interesting observation is the difference in the activity of the two species of the same genus, *Scheloribates brasilospherícus* and *Scheloribates brasilocompressus* (Badejo et al. 2002d) in the organic and control plots. *S. brasilospherícus* was trapped only in the forest in April 1998 while *S. brasilocompressus* was trapped from almost all plots. This suggests that species that are closely related taxonomically may occupy different niches in the same environment. This phenomenon of ecological separation of closely related species which is known as Gause's principle (Harding 1960) has already been reported in oribatid mites of temperate systems (Siepel and Ruiter-Dijkman 1992).

Uropodine mites were more active under maracuja and banana than other plots (Figure 5). Their high activity in these two plots may be attributed to the presence of manure in these plots, more so when similar results were obtained from the soil samples. It is more difficult to explain the high activity of *Galumna* under maracuja and in the pasture where the microclimate is different. This high activity can neither be a direct consequence of organic input under maracuja nor cow dung in the pasture because there was also cow dung manure under banana where their activity was low. *Galumna* has been reported to thrive well on exposed soils with no vegetation cover in the vicinity (Badejo et al. 2002a). This genus can therefore survive under warm conditions and absence of organic inputs. This only partially explains their high activity in the pasture. Previous studies on *Galumna* in a tropical rainforest zone in Nigeria have also revealed that it cannot cope with stress due to human activities such as fire and mechanical disturbance of the soil during cultivation (Badejo and Lasebikan 1988; Badejo and Akinyemiju 1989; Badejo 1994). The complete absence of *Galumna* in the soil and pitfall samples from the forest in December 1999, a few weeks after a fire incident is an indication that *Galumna* in the study area may also not be able to cope with induced stress due to human activities. Its high activity in a particular environment may therefore be an indication of absence of perturbations. A detailed investigation of the population dynamics of *Galumna* in undisturbed fallows and organic systems in the study area is needed to identify the micro environmental preferences of this taxon.

The percentage of juvenile oribatid mites in the soil of the organic and pasture plots was higher in April 1998 than in December 1998 and 1999 (Table 3). In December 1998, juveniles were present in relatively high proportions in the forest, when the overall densities of oribatid mites were extremely low (Table 2). On the other hand, pitfall-trapping data suggest a higher proportion of juveniles at the soil surface under banana, sugar cane and in the pasture in December than in April (Table 4). Care should be taken in interpreting these results because many oribatid mite taxa cannot be easily identified from their juvenile stages. It is certain however that the trapped juveniles belong to different taxa from those extracted from the soil. Perhaps organic management has altered the oribatids' life cycles but its implications can only be known after more intensive sampling.

Oribatid as well as uropodine mites seem to seize the opportunity of abundant food and adequate shelter in organic plots to increase their densities and activities. The implication of this for decomposition processes and the consequent release of nutrients in cultivated systems are potentially enormous. The oribatid taxa, which are likely indicators of organic input in agroecosystems in the study area, include *N. seropedicalensis*, *P. rioensis* and *Galumna* spp. Organic cultivation for up to 6 years has yielded a composition of oribatid taxa that differs from the taxa of the forest. This may be attributed to either the deleterious effects of intensive high-input farming which had occurred in the study area in the past, or simply to the lack of forest conditions in the area for a long time, or both. Some of these forest genera may never be found in the organic plots because their association with trees and epiphytic lichens of the forest suggest that they need forest conditions to thrive (Gjelstrup 1979; Nicolai 1989; Prinzing and Witz 1997). If all that could be achieved under organic management in the short term is restoration of and maintenance of the numbers of mites and their share in decomposition process after the initial deleterious effects, then a lot would have been achieved. High-input farming that is highly dependent on inorganic input was unable to achieve this in a similar tropical environment (Badejo and Akinyemiju 1989).

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