ORIBATID MITE (ACARI: ORIBATIDA) CONTRIBUTION TO DECOMPOSITION DYNAMIC OF LEAF LITTER IN PRIMARY FOREST, SECOND GROWTH, AND POLYCULTURE IN THE CENTRAL AMAZON

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(With 3 figures)

ABSTRACT

We studied the contribution of oribatid mites in the dynamics of litter decomposition in an experiment using litterbags of three different mesh sizes (20 μm, 250 μm, and 1 cm). The experiment was carried out at a primary forest (FLO), a secondary forest (SEC), and at two polyculture systems (POA and POC). We compared the weight loss of the leaves of *Vismia guianensis* and the changes of the oribatid mite species community. We processed the samples after 26, 58, 111, 174, 278, and 350 days from the beginning of the experiment by using the Berlese-Tullgren to extract the animals. We hypothesized that: 1. the abundance and diversity of oribatid mites would exert an influence in the decomposition process; 2. there would be a successional changing of the species during decomposition; and 3. there would be differences in the colonization of species in relation to the mesh size of the litterbags. A total of 95 species of oribatid mites was found. The biomass data was the first registered for the Amazon region. The great dominance of oribatid mites did not exert an influence in the decomposition process. There was not a successional changing of the species during the course of the decomposition process, unlike those shown by results obtained in the temperate forest, because we found neither early colonizers nor species that prefer advanced decomposition stages. The oribatid mite community, which developed in the litterbags under tropical conditions, was atypical of the normal stages of leaf litter breakdown and decomposition. There were differences in the colonization of species in relation to the mesh size of the litterbags. These differences were very closely related to the specific habits and habitat of the dominant species.

Key words: Central Amazon, soil invertebrates, Acari: Oribatida, colonization, litter decomposition.

RESUMO

Contribuição dos ácaros oribatídeos (Acari: Oribatida) para a dinâmica de decomposição de folhas de serapilheira em floresta primária, floresta secundária e policultivo na Amazônia Central

A contribuição da comunidade de ácaros oribatídeos na dinâmica da decomposição de folhas foi estudada em experimentos com sacos de náilon com três tamanhos de malhas (20 μm, 250 μm e 1 cm). O experimento foi efetuado em floresta primária (FLO), secundária (SEC) e em dois sistemas de policultivo (POA e POC). Comparamos a perda de peso de folhas de *Vismia guianensis* com as mudanças da comunidade de espécies de oribatídeos após 26, 58, 111, 174, 278 e 350 dias de início do experimento. Utilizamos o aparelho de Berlese-Tullgren para extrair os animais. Hipotetizamos que: 1. a dominância e a diversidade dos oribatídeos influenciariam o processo de decomposição das folhas; 2. haveria mudanças na sucessão de espécies durante o curso da decomposição; e 3. registraríamos

diferenças na colonização de espécies em relação ao tamanho da malha do saco de náilon. Registramos um total de 95 espécies de oribatídeos. Os dados de biomassa foram os primeiros registrados para a região. A grande dominância de oribatídeos não exerceu influência no processo de decomposição das folhas, não havendo mudanças na sucessão de espécies durante o curso da decomposição. Nesse aspecto, nossos resultados foram diferentes dos obtidos em florestas temperadas, uma vez que não registramos espécies colonizadoras primárias ou espécies que preferiram estágios mais avançados de decomposição. A comunidade de ácaros oribatídeos que se desenvolveu nos sacos de malha nas condições tropicais foi atípica em relação aos estágios normais de quebra e decomposição da serapilheira. Registramos diferenças na colonização de espécies em relação ao tamanho da malha; essas diferenças estão diretamente relacionadas ao hábito e ao habitat específico da espécie dominante.

Palavras-chave: Amazônia central, invertebrados do solo, Acari: Oribatida, colonização, decomposição de serapilheira.

INTRODUCTION

The decomposition of plant residues is broadly influenced by substrate quality, climatic conditions, and decomposer biota (Anderson & Swift, 1983). The substrate, which the litter decomposers may influence, has a reservoir of organisms which can colonize the litter. Stands in different areas may have climatic differences affecting the rates of decomposition (Howard & Howard, 1980). According to these premises, any effort to restore or rehabilitate degraded soils in the humid tropics is going to fail unless optimum levels of root and invertebrate activities are promoted.

Recuperation of degraded land for sustainable use in the future is the focus of several projects in the German-Brazilian SHIFT Program (Studies of Human Impact on Forest and Floodplains in the Tropics). The aim of this program is to develop economically and ecologically viable polyculture systems of fruit trees and timber producing species. A large experimental area was established on the site of the Brazilian Research Center for Agroforestry in Western Amazonia (Lieberei & Gasparotto, 1998). The central idea was to enrich the plantation by controlled growth of secondary vegetation after the initial slash-and-burn treatment. In 1997, another project on soil fauna and litter decomposition was established (SHIFT ENV 52 "Soil Fauna and Litter Decomposition in Primary and Secondary Forest and a Mixed Culture System in Amazonia") which was closely related to the existing SHIFT projects in Manaus. Parameters such as the quantity and quality of the litter produced in the systems; the decomposition rates; the abundance, biomass, and

respiration of microorganisms; and the soil animals, were simultaneously and comparatively studied in the primary and secondary forest and in one polyculture system (Höfer *et al.,* 2001).

Soil invertebrates make an ideal focus for a study of the effects of disturbance in fragmented habitats. They are an important component of native ecosystems, sensitive to changes in the habitat, and easily sampled in large numbers (Bromham *et al.,* 1999). Nevertheless, in studying the invertebrate community, two aspects must be taken into consideration. The first is the size and abundance of the components, which are divided in micro-, meso- and macrofauna (Petersen & Luxton, 1982). The function of each group in the decomposition process is very differentiated (Höfer *et al.,* 2001). Also, the mobility of the invertebrates generally increases with body size (Wikars & Schimmel, 2001) and some ecological processes are dependent on the size of the animal at several scales of time and space (Jiménez *et al.,* 2000). Size may have an overriding effect on ecological relationships (Jiménez *et al.,* 2000; Wikars & Schimmel, 2001). This is specially important for Collembola and Acari, groups in which the mean size is so small that individuals can find refuge in soil interstices, and which may not subjected to predation by larger predators even when they occur in the litter layer. The numerical dominance of certain invertebrate groups can result in opposite patterns of response to environmental factors and the habitat (Bromham *et al.,* 1999). The second aspect is that ground invertebrates form an abundant and diverse component of the fauna, and fill a variety of ecological roles (Abbott *et al.,* 1979; Majer, 1989). Recently, because of these features,

the Acari have been analyzed separately from the total invertebrate catch (Wikars & Schimmel, 2001).

In the primary and secondary forests and flooded forest of Central Amazon, the mesofauna, principally Acari and Collembola, are the most abundant and frequent groups (Franklin *et al.,* 1997, 2001b). The oribatid mites are very abundant, have a great richness of species in the soils of different types of forest, and participate in all stages of decomposition of organic material (Hågvar & KjØndal, 1981). Furthermore, litter quality exerts influence on their community (Henaghan *et al.,* 1999). The succession of these species of mites in decomposing leaf litter was already demonstrated in the soil of European forests (Wallwork, 1983; Wunderle *et al.,* 1989). In Central Amazon, their high dominance in relation to the total invertebrate community, and great specie diversity was already confirmed (Franklin *et al*., 2001a). But their participation in the decomposing process is still unclear (Ribeiro & Schubart, 1989).

In keeping with the aim of the SHIFT ENV 052, the importance of the different size classes of fauna in litter decomposition was studied in an experiment using litterbags of three different mesh sizes (20 µm, 250 µm, and 1 cm). In most cases the meso- and macro-invertebrates were sorted to higher taxa representing functional groups and only a few taxa were classified to genera and morphospecies. The first results have already been published (Höfer *et al.,* 2001). In the present work, the sub-order Oribatida was identified at the specie or morphospecies level. We compared the weight loss of leaves of *Vismia guianensis* with the changing of the oribatid mite species community. We addressed the following questions: 1. Do the great abundance and diversity of oribatid mites exert influence in the decomposition process of the leaves? 2. Was there a successional changing of the species during the course of the decomposition? 3. Was there any difference in the colonization of species in relation to the mesh size of the litterbags?

METHODS

Site description

The studied sites are located in central Amazonia, about 30 km from Manaus, within the experimental area of the Brazilian Research Institute Embrapa-Amazonia Ocidental (02°53'S, 59°59'W). The region is dominated by dense primary lowland rainforest (*terra firme*) (Klinge *et al.,* 1975) on nutrient-poor soils classified as yellow clayey latosol (FAO: xanthic Ferralsol). Average annual rainfall is 2,107 mm (Irion *et al.,* 1997) and climate is characterized by a short dry season (monthly precipitation below 100 mm) from July to September; monthly temperatures average between 25 and 27°C.

The investigations took place on an abandoned rubber tree plantation (*Hevea brasiliensis*; "Seringueira") which has been used as a polyculture forestry research area since 1992. Originally, the area was cleared of primary rain forest in 1979/1980, and in 1984 the rubber tree plantation was abandoned, after having been affected by the fungus *Microcyclus ulei*. Thereafter, the neglected plantation naturally transformed itself into secondary growth. In 1992, the secondary vegetation that had established itself was newly cut and burned to set up an experimental area divided into 90 plots of 32 x 48 m each. Two of these plots (called POA and POC) of a polyculture system were planted with 4 tree species (rubber tree – *Hevea* spp., one low-quality wood species – *Schizolobium amazonicum,* and two native high-quality wood species – *Swietenia macrophylla* and *Carapa guianensis*) and were studied from July 1997 to March 1999. In these plots, spontaneous secondary vegetation (mainly *Vismia* spp.) was allowed between the rows of trees. One plot of the secondary forest left over in 1992 as a control area (called SEC) and one plot of primary forest (called FLO) in the vicinity close to the experimental sites were studied during the same period.

In April 1998 (rainy season), the litterbags were exposed at randomized points within the plots in groups of three, each of a different mesh size: fine (20 µm; only microflora allowed), medium (250 µm; included mesofauna), and coarse (1,000 µm; microflora, meso- and macrofauna allowed). Each bag was filled with 7.5 g of air-dried *Vismia* leaves, a typical tree leaf of secondary vegetation occurring in primary forests. The experiment was implanted in April 1998 (wet season). Samplings were done after 26 (wet season), 58, 111, 174 (dry season), 278, and 350 (wet season) days from the beginning of the experiment. The Berlese-Tullgren was used as the extraction method. The experiment was carried out in four sites: at a primary forest (FLO), at a secondary forest (SEC), and at two polyculture systems (POA and POC).

Because of the great number of non-described species and the uncertainty of diagnoses, that are short and mostly incomplete, in the literature, the majority of the oribatid mites were classified as morphospecie. To estimate biomass, live animals were collected from Berlese-Tullgren extractions of soil and litter. To have a complete estimation, we selected all types of forms and sizes of oribatid mites. Each individual was weighed live (wet weight), and then dried for 72 hours and weighed again (dry weight). The factor of correction obtained to calculate the biomass of the oribatid mites was 0.08422 ($\pm$ 0.1018) to estimate the wet weight, and 0.03373 ($\pm$ 0.04155) to estimate the dry weight.

RESULTS

In all sites and for all mesh sizes, less than 30% of the original leaf litter had disappeared after the first 26 days of exposure. The greatest weight loss occurred with the leaves enclosed in the coarse mesh litter bags, where faunal activity was not excluded, in the FLO (Kruskall-Wallis; H = 52.58; p < 0.001), SEC (Kruskall-Wallis; H = 15.41; p < 0.001), and POA (Kruskal-Wallis; H = 6.14; p = 0.046. Less than 25% of the leaf material remained after one year in the primary forest in the coarse mesh bags. When macrofauna was excluded, no difference was detected between the decomposition rates of the leaves enclosed in the fine and medium mesh litterbags. (Data of Luizão, F., INPA, Manaus, SHIFT Project ENV 052) (Fig. 1).

Therefore, contrary to what was expected, the highest oribatid mites density and diversity were registered in the medium mesh size and not in the coarse mesh size. It was evident that the fine mesh bags were not completely successful in excluding arthropods. Around 23% of the mean density was registered in the fine mesh bags ($\cong$ 769 individuals), 49% in the medium ($\cong$ 1,588), and 28% in the coarse mesh bags ($\cong$ 913 individuals). The biomass data was the first registered for the Amazon region (Tables 1 and 2).
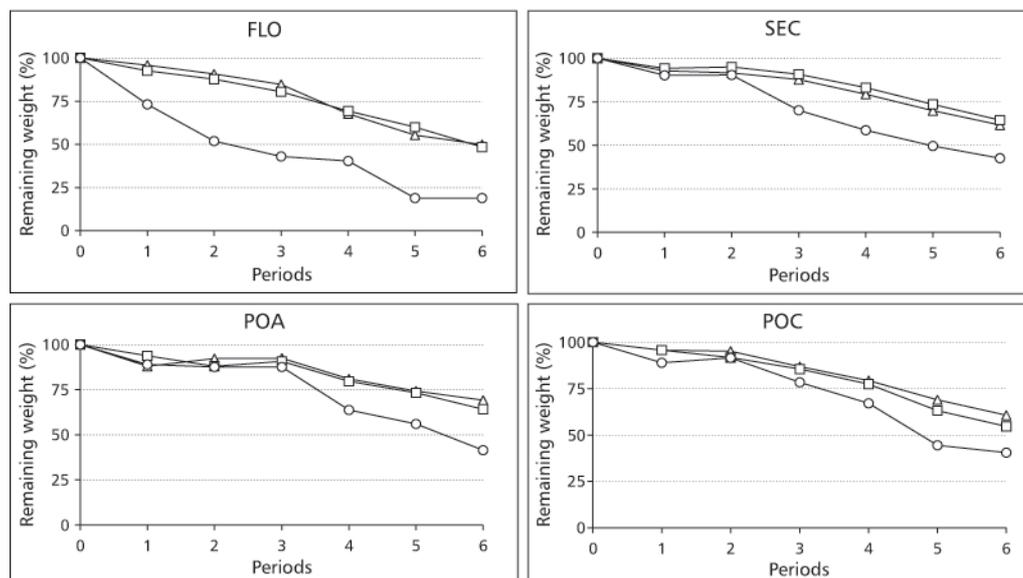

Fig. 1 — Decomposition rates of *Vismia guianensis* at FLO, SEC, POA, and POC (circle = coarse mesh; square = medium mesh; triagle = fine mesh). The six periods are: 26, 58, 111, 174, 278, and 350 days of exposure.

TABLE 1
Mean density and mean diversity of oribatid mites in litter bags. FLO, SEC (n = 10); POA, POC (n = 5).

Study site	Mesh size	Density	%	Diversity	%
FLO	Fine	214.8		5.9	
	Medium	458.0	28%	14.0	39%
	Coarse	256.9		12.9	
SEC	Fine	201.5		3.3	
	Medium	487.6	28%	9.2	30%
	Coarse	214.6		4.8	
POA	Fine	240.8		4.3	
	Medium	405.9	29%	6.3	19%
	Coarse	301.8		5.7	
POC	Fine	112.6		3.7	
	Medium	236.2	15%	8.4	22%
	Coarse	140.4		6.7	

TABLE 2
Variation of the mean density (D) and biomass (B; mg dry/weight) of oribatid mite.

	FLO		SEC		POA		POC	
	D	B	D	B	D	B	D	B
Fine	12.9-102.0	0.4-3.4	3.3-79.4	0.1-2.7	2.0-69.2	0.07-2.7	9.2-32.2	0.3-1.1
Medium	53.4-94.7	1.8-3.7	25.0-189.0	8.8-6.4	8.6-135.5	0.3-4.6	26.4-56.0	0.9-1.9
Coarse	32.6-59.3	1.1-2.32	18.0-66.0	0.6-2.2	4.6-101.2	0.2-3.5	11.2-49.0	0.4-1.6

In the four plots, aclear pattern can be detected related to dominance. A standard colonization of oribatid mites, common to the four sites and mesh sizes, was not detected (Fig. 2).

Contrary to what we detected for density, in all sites the highest number of species occurred in the three latest periods, showing that the community migrated successfully from the adjacent habitat. The migration phase continued into the latest period (Fig. 3).

A total of 95 species of oribatid mites was found (Appendix I) to be organized into distinct communities in relation to the identity of the dominant species in each site and each litterbag mesh (Table 3). We detected a high degree of similarity between the species participating in the colonization of the three mesh sizes and the high degree of dominance of the common species. The lowest values were registered in POC (Table 4).

The pattern of development of the mite community in the litterbags is also shown by the species' diversity and equitability indices (Table 3). The forest (FLO) was the most stable environment where we registered the highest indices of diversity and equitability. The lowest diversity indices were obtained in the fine mesh bags.
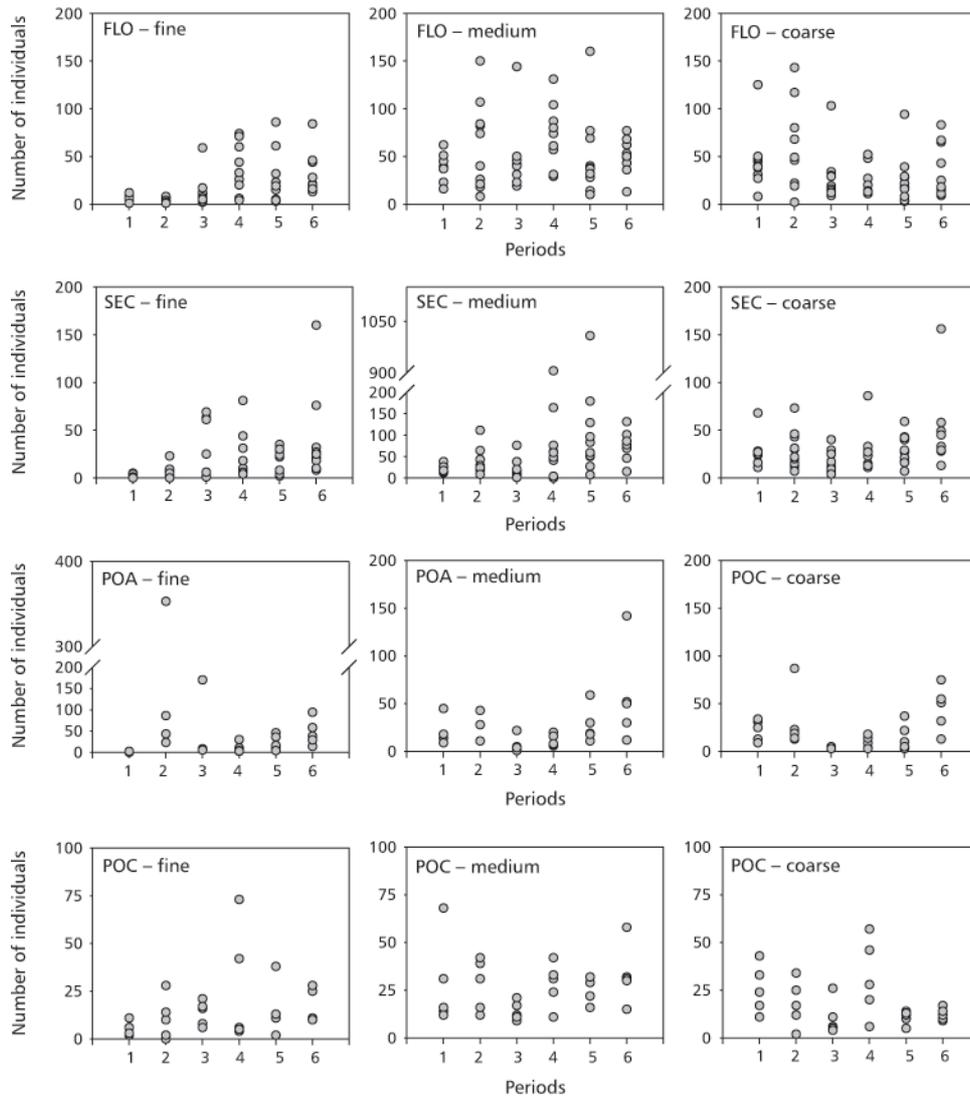
Fig. 2 — Number of individuals of oribatid mite adults colonizing the litterbags. The six periods are: 26, 58, 111, 174, 278, and 350 days of exposure.

The lower diversity indices obtained at the secondary forest (SEC) in the third and fourth periods (fine mesh bags) were conditioned by the high dominance of *Afronothrus* sp. *A* (93% and 83%, respectively). This specie also dominated in POA in the fine mesh bags, resulting in lower diversity indices (67% in the third and 97% in the fourth periods). In POC, the lowest diversity indices were also conditioned to the highest dominance of *Afronothrus* sp. *A* from the second to the fifth periods (89%, 66%, 68%, and 80%, respectively). Therefore, only one specie, *Afronothrus* sp. *A*, was clearly dominant in the fine mesh bags. In the medium and coarse mesh sizes, the dominance was divided between *Scheloribates* sp. *A*, *Rostrozetes foveolatus,* and *Afronothrus* sp. *A*. Nevertheless, early colonizers or species preferring the more advanced decomposition stages were not detected.
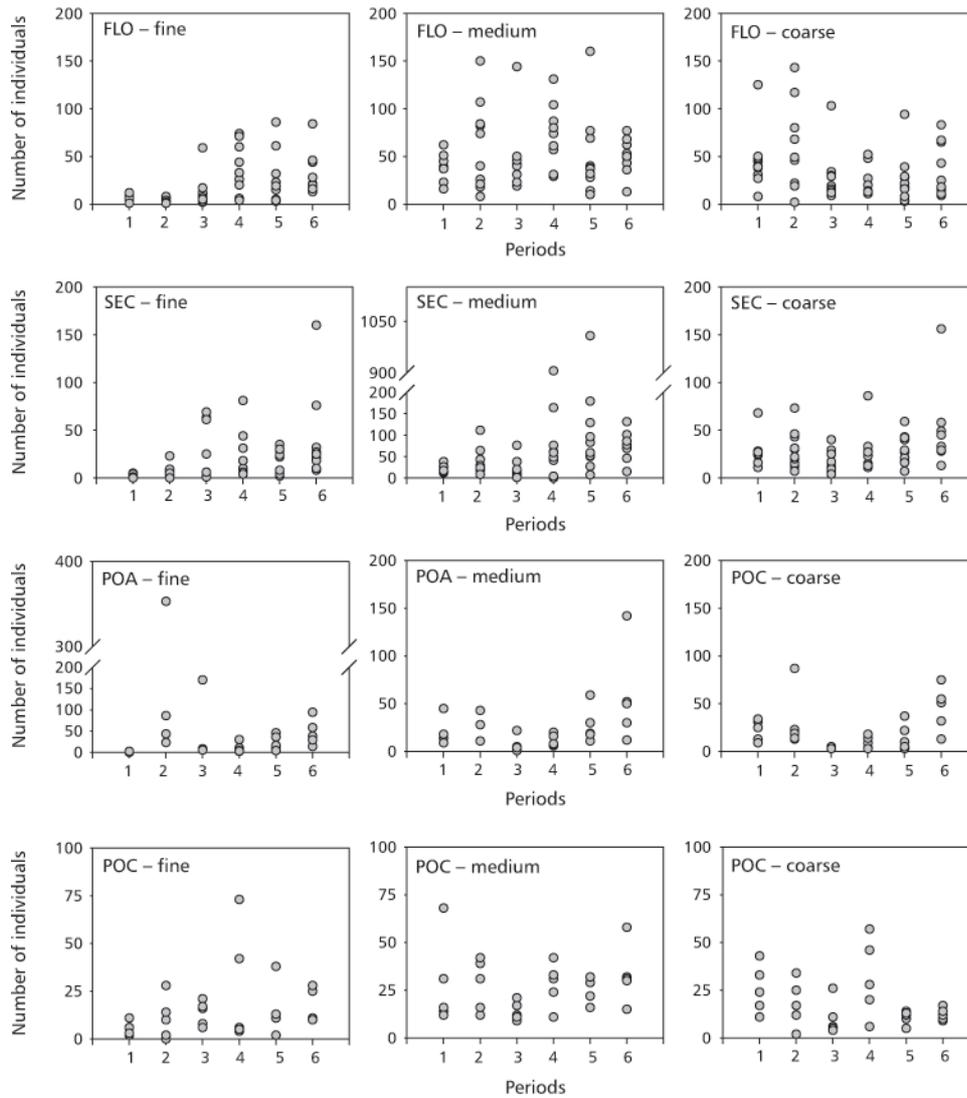
Fig. 3 — Number of species of oribatid mite adults colonizing the litterbags. The six periods are: 26, 58, 111, 174, 278, and 350 days of exposure.

DISCUSSION

The oribatid mites were capable of penetrating even into the fine mesh litterbags through holes caused by biological factors, like root penetration and invertebrate action. Contrary to what was expected, the highest abundance of mites was not detected in the litter enclosed in the coarse mesh size litterbags, but in those of medium size. This can be attributed to a protective effect produced by the fine and medium mesh bags that did not allow the entrance of predator groups (principally Araneae and Pseudoscorpiones). Another factor was the entrance of immature forms of mites and Collembola that could not escape the litterbag after reaching the adult phase.

TABLE 3
Colonization of the oribatid mites in the litter bags.

	Sampling periods	FINE mesh bag Dominant specie	%	S	H	MEDIUM mesh bag Dominant specie	%	S	H	COARSE mesh bag Dominant specie	%	S	H
FLO	1	Afronothrus sp. A	19	20	3.9	Scheloribates sp. A	26	30	3.7	Scheloribates sp. A	20	32	3.8
	2	Afronothrus sp. A	28	17	3.3	Scheloribates sp. A	15	31	3.5	Scheloribates sp. A	19	37	3.9
	3	Allonothrus sp. A	43	17	3	Scheloribates sp. A	19	31	3.8	Solenozetes sp. A	12	25	3.9
	4	Allonothrus sp. A	26	17	2.9	Rostrozetes foveolatus	19	37	3.9	Rostrozetes foveolatus	31	33	3.8
	5	Oxyoppia sp. A	26	34	3.9	Rostrozetes foveolatus	20	40	4.2	Rostrozetes foveolatus	21	44	4.5
	6	Scheloribates sp. A	14	37	4.5	Rostrozetes foveolatus	22	44	4.4	Rostrozetes foveolatus	20	48	4.6
SEC	1	Afronothrus sp. A	24	9	2.8	Scheloribates sp. A	22	20	3.5	Scheloribates sp. A	32	21	4.3
	2	Haplozetes sp. A	24	15	3	Scheloloribates sp. A	29	24	3.2	Scheloloribates sp. A	24	28	3.7
	3	Haplozetes sp. A	33	6	0.5	Archegozetes sp. A	35	20	2.7	Tegeozetes sp. A	30	18	2.9
	4	Afronothrus sp. A	93	14	1.2	Rostrozetes foveolatus	30	26	3.6	Rostrozetes foveolatus	25	32	3.8
	5	Afronothrus sp. A	83	21	3.2	Scheloribates sp. A	21	32	4	Spathulocepheus sp. A	22	30	4
	6	Afronothrus sp. A	38	28	3.2	Rostrozetes foveolatus	25	38	3.9	Rostrozetes foveolatus	21	42	4
POA	1	Haplozetes sp. A	33	3	1.6	Afronothrus sp. A	57	15	2.3	Afronothrus sp. A	45	10	2.3
	2	Scheloribates sp. A	33	5	1.6	Archegozetes sp. A	28	10	2.7	Archegozetes sp. A	42	19	2.9
	3	Afronothrus sp. A	67	6	0.3	Archegozetes sp. A	61	10	2.2	Hoplophorella sp. B	22	8	2.5
	4	Afronothrus sp. A	97	18	3.1	Liochthonius sp. A	12	20	4.0	Rostrozetes foveolatus	42	14	2.9
	5	Afronothrus sp. A	35	11	1.9	Rostrozetes foveolatus	19	24	3.9	Rostrozetes foveolatus	34	15	3.2
	6	Afronothrus sp. A	67	31	1.2	Mesoplophora sp. A	21	25	3.4	Lohmannia sp. A	20	29	3.8
POC	1	Afronothrus sp. A	21	15	3.6	Afronothrus sp. A	30	15	2.8	Afronothrus sp. A	34	15	3.1
	2	Afronothrus sp. A	89	5	0.7	Afronothrus sp. A	19	18	3.6	Afronothrus sp. A	26	14	3.3
	3	Afronothrus sp. A	65	11	1.7	Afronothrus sp. A	18	15	3.3	Afronothrus sp. A	33	12	2.7
	4	Afronothrus sp. A	68	11	1.8	Eohypochthonius sp. A	45	18	2.7	Eohypochthonius sp. A	44	20	2.9
	5	Afronothrus sp. A	80	6	1.1	Shiatoppia sp. A	15	30	4.3	Eohypochthonius sp. A	31	17	3.3
	6	Afronothrus sp. A	28	16	3.3	Phthiracarus sp. B	15	24	3.9	Eohypochthonius sp. A	24	20	3.7

% = dominance in relation to total number of individuals; S = Total number of species; H = Shannon-Weaver diversity indice.

TABLE 4

Specie similarity indice of Sörensen (%; italic) and dominance coeficient of Renkonen (%; bold).

FLO	Medium	Coarse		POA	Medium	Coarse
Fine	*81*	*79*		Fine	*81*	*82*
Medium		*84*		Medium		*83*
Coarse	**52**	**51**		Coarse	**43**	**31**
Medium		**59**		Medium		**33**
SEC	Medium	Coarse		POC	Medium	Coarse
Fine	*77*	*75*		Fine	*67*	*65*
Medium		*81*		Medium		*75*
Coarse	**34**	**38**		Coarse	**25**	**22**
Medium		**43**		Medium		**29**

It was very clear in our results that the greatest abundance of oribatid mites did not exert influence on the decomposition process of the leaves. Indirect evidence from litter-bags studies showed that meso-fauna (Acari and Collembola) may be more important in mobilizing nutrients than in contributing to mass loss, and that they act principally as "grazing arthropods" (Hanlon & Anderson, 1979).

Examining the macro- and mesofauna of the litterbags of this same experiment, sorted to a higher taxa representing functional groups, Höfer *et al.* (2001) concluded that the macrofauna determines the decomposition process in all studied plots. Because of the macrofauna action, the greatest decomposition occurred in the coarse litterbags. When faunal activity was not restricted (coarse mesh), decomposition rates were between 0.6 and 1.4 (kg year^{-1}) in the three anthropogenic sites, and 2.3 and 3.1 in the primary forest. The authors cited above also registered that the differences in N-content and C/N ration between mesh sizes over all areas were highly significant (p < 0.001). Also, the litter exposed in bags with coarse mesh size had a higher relative N-content (1.5%) and lower C/N ratio (34) than that found in litter in bags from which macrofauna and mesofauna were excluded (N 1.1%-1.3%, C/N 40). Under tropical conditions (Nigeria), decomposition and nutrient release were studied using rectangular stainless steel litterbags with two mesh sizes: 7 mm (coarse, including macrofauna) and 0.5 mm (fine, excluding macrofauna). Irrespective of soil degradation, macrofauna-mediated decomposition and nutrient release, higher decreases in leaf litter decomposition, and nutrient release in the degraded soil were observed when macrofauna were excluded (Tian, 1998).

In spite of the higher density, the oribatid biomass was very low. Our results for the Acari Oribatida individual (dry and wet weight) are the first biomass results based on concrete measures for the central Amazon region. Our values for wet weight (0.08422 ± 0.1018) were close to those obtained for temperate regions: 0.11675 (Luxton, 1975) and 0.053 (Petersen, 1982). The value obtained by Luxton (1975) for the dry weight estimates was of 0.0295 and, therefore, very close to ours (0.03373 ± 0.04155). However, since the average individual weights have only been measured on only one occasion, which ignored changes in relative population with time (Petersen, 1982), our results of biomass need to be interpreted with caution. The most recommended procedure would be the estimation for each sampling period of the year in a long-term study.

Succession is generally related to an increase in both number of species and the density of most groups of the soil fauna (Usher, 1975). In our experiment, only a few species dominated in all sampling periods. The high degree of similarity between the species that made up the colonization in the three mesh sizes and the high degree of dominance of the common species reflect a great capacity in mobility and the high tolerance of some species to the microhabitat. Otherwise, these findings nullify our hypothesis that there was successional changing of the species during the course of de-

composition. In this successional aspect, our results differed from those obtained in the temperate forest, because in the Central Amazon forest, we found neither early colonizers nor species that prefer more advanced decomposition stages.

In the temperate region, the fauna associated with the decomposition of grassland herbage decaying in the soil, showed quite marked changes in the main specie of the principal invertebrate groups and in the main species of Acari and Collembola. None of the four taxa dominant in the surface coarse bags in the first recovery data was also dominant on the final date. Only one of the three, which were dominant on the first recovery data in the surface medium bags, was also dominant on the final date (Curry, 1969). Species such as *Oribatella quadricornuta, Chamobates cuspidatus,* and *Damaeus* spp. that inhabit the litter layer of European forests are early colonizers of confined litter. They are succeeded, as litter decay proceeds, by species that naturally occur in humus layers (oppiids and suctobelvids) (Croslley & Hoglund, 1962; Lebrun & Mignolet, 1974). In England, in stands of sweet chestnut, with a thin shrubby understorey of beech trees, the succession of oribatid mites in decomposing leaf litter (beech and chestnut) was demonstrated. The 12 most abundant species were present in the bags throughout the study and showed marked changes in their feeding habits with time (Anderson, 1975). In a five-year study of a temperate forest in Germany, the distribution of oribatid mites in decomposing beech leaves was related to their distribution along the organic layers of the soil. The first colonizers were *Oppiella ornata* and some species of Pterogasterina, replaced later by other species of Oppiidae, principally *Suctobelba*, whose registered dominance reached more than 50% in some periods (Wunderle *et al*., 1989). Three pioneer species, *Oribatula tibialis, Autogneta trägårdhi,* and *Eupelops duplex* dominated the first phase of a succession of microarthropods in decomposing birch leaves in Norway (Hågvar & KjØndal, 1981).

Another aspect that should be considered is that after the 350 days of exposure during our experiment, the expected reduction of the number of species did not happen. Even in FLO, whose remainin material was less than 25% at the end of the experiment, the number of species continued to be high. The C/N content of the leaves used in our experiment is considered to be of low nutritional quality. In a primary forest of Central Amazon, the rate of decomposition of *Clitoria racemosa* leaves (C/N ration of 26.4, considered more palatable) enclosed in nylon bags with 1 mm mesh size, was very significant, with 50% of weight loss after 30 days of exposure (Luizão, 1982; Ribeiro & Schubart, 1989). In comparison, the rate of decomposition of *Vismia guianensis* was very slow, principally during the 26 days of exposure. The decomposition of different leaf types proved to be related to the C/N ratio (Wittich, 1943, 1953; Witkamp & van der Drift, 1961). Other leaf components, such as different types of polyphenols, nitrogen, and lignin are factors that influence litter decomposition (Mellilo *et al.,* 1982). We may conclude that, depending on the characteristics of the leaves, the decomposition process varies in duration.

The third hypothesis, was validated as differences were found in the colonization of species in relation to the litter bag mesh size. These differences were very closely connected to the specific habits and habitat of the dominant species and showed that the fine and medium mesh sized litterbags are not recommended for colonization studies in the Central Amazon. Both mesh sizes are conducive to a very artificial and humid environment. This is confirmed principally by the dominance of *Afronothrus, Archegozetes*, *Eohypochthonius,* and *Lohmannia* sp. Litterbags have been used in studies in temperate forests for more than 40 years (Bocock & Gilbert, 1957). Therefore, until today, any methodology is recommended for tropical forest. However, it is very well known that litterbags represent a nonequilibrated situation because of the guaranteed availability of food as well as refuge in unfavorable environmental conditions (Weigert, 1974) and do not represent the habitat conditions of the surrounding litter (Webb, 1994). Also, doubts exist as to whether the observed faunal changes during decomposition correspond to those found under natural conditions (Hågvar & KjØndal, 1981).

The great dominance registered in our results of *Afronothrus* sp. *A* and *Archegozetes foveolatus* in the fine mesh bags agreed with findings of Woas (2002). According to this author, species of these groups are parthenogenetic and, in some genera (e.g. *Archegozetes*), the females tend to produce a high number of eggs. This favors the distribution of such species and often is accompanied by a remarkable increase in population density. The genera *Afronothrus, Allonothrus,* and *Archegozetes* are restricted to tropical regions and, especially in the

tropics in artificial conditions such as those created by litterbags, notable increases in population numbers can be observed in this group. Species of *Archegozetes* and *Allonothrus s.l.* seemed to reach higher concentrations in areas with more adverse climatic conditions. This was already confirmed in Central Amazônia (Ribeiro & Schubart, 1989; Franklin *et al.,* 1996, 1997).

Obviously, being parthenogenetic, species of the genus *Rostrozetes* may invade very different types of habitat, be it rainforest, secondary forest, or open terrain, e.g., cultivated areas, where this genus may become a dominant element of the fauna (Woas, 2002). Moreover, *Rostrozetes* species occur in periodically flooded areas and are apparently capable of living under water for time intervals longer than 290 days (Franklin *et al.,* 2001a).

Species of the genus *Haplozetes* are distributed distributed worldwide. Haplozetidae seem to be mainly concentrated in circumtropical areas. In the Neotropics, species of the genera *Peloribates, Haplozetes,* and *Protoribates* (*Brasilobates*) have been found in Mexico, the Antilles, Guatemala, El Salvador, Bolivia, Peru, Brazil, Paraguay, and Argentina. Species of *Peloribates* have been recorded in the high Andean belt and elevated areas in Mexico (more than 2,000 m a.s.l.) (Woas, 2002). Another very dominant specie in our work was *Scheloribates* sp. *A*. Extremely rich in species, the Scheloribatidae is a taxon distributed worldwide. The *Sheloribates* group represents the greatest species diversity of the Scheloribatidae. Species from this group tend to invade open terrain such as steppes, prairies, or savannas (Woas, 2002).

The species *Eohypochthonius* sp. *A* and *Lohmannia* sp. *A*, which were very abundant in the medium and coarse mesh size litterbags of our study, belong to the group Hypochthoniidae. Many genera of this group tend to be concentrated in warmer, tropical regions. Species of Lohmanniidae in particular can reach a relatively high degree of population density in Neotropical and other tropical rainforests, which seems especially likely in acid environments with greater concentrations of litter or other decaying plant material. In artificial habitats like litterbags, this might lead to greater concentrations of individuals. The apparently parthenogenetic Lohmanniidae in the tropics tend to reach high population numbers (e.g., in toxicological experiments) in heavily disturbed areas (Woas, 2002).

The three general conclusions arising from our results are:

1) the greatest abundance of the oribatid mites did not exert influence in the decomposition process of the leaves, which reinforces the conclusion that oribatid mites were the most abundant component of the mesofauna, but not the most important agents in the fragmentation of the litter;

2) there was not a successional changing of the species in the course of decomposition. On this point, our results were different from those obtained in the temperate forest, because in the Central Amazon forest we found neither early colonizers nor species preferring more advanced decomposition stages. These findings clearly show that the oribatid mite community, which developed in the litterbags under tropical conditions, was atypical of the normal stages of leaf litter breakdown and decomposition;

3) there were differences in species colonization in relation to mesh size of the litterbag. These differences were very closely related to the specific habits and habitat of the dominant species and show that fine and medium mesh sizes of the litterbags are not recommended for colonization studies in the Central Amazon, since both mesh sizes are conducive to a very artificial and humid environment.

APENDICE I – LIST OF SPECIES REGISTERED IN THIS STUDY
LOWER ORIBATIDA

PALAEOSOMATA
1. *Acaronychus* sp. *A* (ACARONYCHIDAE Grandjean, 1932; *Acaronychus* GRANDJEAN, 1932)
2. *Loftacarus* sp. *A* (ARCHEONOTHRIDAE Grandjean, 1932; *Loftacarus* LEE, 1980)
3. *Mesoplophora* sp. *A* (MESOPLOPHORIDAE Ewing, 1917; *Mesoplophora* BERLESE, 1904)

ENARTHRONOTA
4. *Malacoangelia* sp. *A* (HYPOCHTHONIDAE Berlese, 1910; *Malacoangelia* BERLESE, 1913)
5. *Brachychthonius* sp. *A* (BRACHYCHTHONIIDAE Thor, 1934; *Brachychtonius* BERLESE, 1910)
6. *Cosmochtonius* sp. *A* (SPHAEROCHTHONIIDAE Grandjean, 1947; *Cosmochthonius* BERLESE, 1910)
7. *Eohypochthonius* sp. *A* (HYPOCHTHONIIDAE Strenzke, 1963; *Eohypochthonius* Jacot, 1938)
8. *Liochthonius* sp. *A* (BRACHYCHTHONIIDAE Thor, 1934; *Liochthonius* HAMMER, 1959)

MIXONOMATA

9. *Afronothrus* sp. *A* (THRYPOCHTHONIIDAE Willmann, 1931; *Afronothrus* WALLWORK, 1961)
10. *Allonothrus* sp. *A* (THRYPOCHTHONIIDAE Willmann, 1931; *Allonothrus* HAMMER, 1953)
11. *Archegozetes longisetosus* (THRYPOCHTHONIIDAE Willmann, 1931; *Archegozetes* GRANDJEAN, 1931)
12. *Archiphthiracarus* sp. *A* (PHTHIRACARIDAE Perty, 1923; *Archiphthiracarus* BALOGH & MAHUNKA)
13. *Epilohmannia* sp. *A* (EPILOHMANIIDAE Oudemans, 1923; *Epilohmannia* BERLESE, 1910)
14. *Hoplophorella* sp. *A* (PHTHIRACARIDAE Perty, 1841; *Hoplophorella* BERLESE, 1923)
15. *Hoplophorella* sp. *B* (PHTHIRACARIDAE Perty, 1841; *Hoplophorella* BERLESE, 1923)
16. *Hoplophorella* sp. *C* (PHTHIRACARIDAE Perty, 1841; *Hoplophorella* BERLESE, 1923)
17. *Lohmannia* sp. *A* (LOHMANIIDAE Berlese, 1916; *Lohmannia* Michael, 1898)
18. *Malaconothrus* sp. *A* (MALACONOTHRIDAE Berlese, 1916; *Malaconothrus* BERLESE, 1904)
19. *Phthiracarus* sp. *A* (PHTHIRACARIDAE Perty, 1841; *Phthiracarus* PERTY, 1841)
20. *Phthiracarus* sp. *B* (PHTHIRACARIDAE Perty, 1841; *Phthiracarus* PERTY, 1841)
21. *Rhysotritia* sp. *A* (EUPHTHIRACARIDAE Jacot, 1930; *Rhysotritia* MARKEL & MAYER, 1959)
22. *Trimalaconothrus* sp. *A* (MALACONOTHRIDAE Berlese, 1916; *Trimalaconothrus* BERLESE, 1916)
23. *Nothrus* sp. *A* (NOTHRIDAE Berlese, 1885; *Nothrus* C. L. Koch, 1836)
24. *Cyrthermannia* sp. *A* (NANHERMANNIIDAE Sellnicks, 1928; *Cyrthermannia* BALOGH, 1958)

ORIBATIDA SUPERIORES BASILARES

25. *Hermanniella* sp. *A* (HERMANNIELLIDAE Grandjean, 1934; *Hermanniella* BERLESE, 1908)
26. *Sacculobates* sp. *A* (HERMANNIELLIDAE Grandjean, 1934; *Sacculobates* GRANDJEAN, 1962)
27. *Baloghacarus* sp. *A* (HERMANNIELLIDAE GRANDJEAN, 1934; *Baloghacarus* GRANDJEAN, 1962)
28. *Cultroribula* sp. *A* (LIACARIDAE SELNICK, 1928; *Cultroribula* BERLESE, 1908)
29. *Arthrovertex* sp. *A* (SCUTOVERTICIDAE GRANDJEAN, 1954; *Arthrovertex* BALOGH, 1970)
30. *Teleiolioides* sp. *A* (LIODIDAE Grandjean, 1954; *Teleiolioides* GRANDJEAN, 1934)
31. *Anakingia* sp. *A* (MICROZETIDAE Grandjean, 1936; *Anakingia* HAMMER, 1961)
32. *Berlesezetes* sp. *A* (MICROZETIDAE Grandjean, 1936; Berlesezetes MAHUNKA, 1980)
33. *Microzetes* sp. *A* (MICROZETIDAE Grandjean, 1936; *Microzetes* BERLESE, 1913)
34. *Schalleria* sp. *A* (MICROZETIDAE Grandjean, 1936; *Schalleria* BALOGH, 1962)
35. *Undulozetes* sp. *A* (MICROZETIDAE Grandjean, 1936; *Undulozetes* BALOGH & MAHUNKA, 1969)
36. *Striatopia* sp. *A* (OPPIIDAE Grandjean, 1954; *Striatopia* BALOGH, 1959)
37. *Stachyoppia* sp. *A* (OPPIIDAE Grandjean, 1954; *Stachyoppia* BALOGH, 1959)
38. *Eremaeozetes* sp. *A* (EREMAEOZETIDAE Balogh, 1972; *Eremaeozetes* BERLESE, 1913)
39. *Microtegeus* sp. *A* (EREMAEOZETIDAE Balogh, 1972; *Microtegeus* BERLESE, 1917)
40. *Rhynchoribates* sp. *A* (RHYNCHORIBATIDAE Grandjean, 1929; *Rhynchoribates* GRANDJEAN, 1929)
41. *Tegeozetes* sp. *A* (TECTOCEPHEIDAE Balogh, 1958; *Tegeozetes* BERLESE, 1913)
42. *Dolicheremaeus* sp. *A* (OTOCEPHEIDAE Balogh, 1961; *Dolicheremaeus* JACOT, 1938)
43. *Cavernocepheus* sp. *A* (OTOCEPHEIDAE Balogh, 1961; *Cavernocepheus* BALOGH & MAHUNKA, 1969)
44. *Beckiella* sp. *A* (DAMPFIELLIDAE Balogh, 1961; *Beckiella* GRANDJEAN, 1964)
45. *Truncozetes* sp. *A* (EPACTOZETIDAE Grandjean, 1930; *Truncozetes* BALOGH & MAHUNKA, 1969)
46. *Sphatulocepheus* sp. *A* (CARABODIDAE C. L. Koch, 1836; *Sphatulocepheus* BALOGH & MAHUNKA, 1969)
47. *Tuberocepheus* sp. *A* (CARABODIDAE C. L. Koch, 1837; *Tuberocepheus* BALOGH, 1961)
48. *Yoshiobodes* sp. *A* (CARABODIDAE C. L. Koch, 1836; *Yoshiobodes* MAHUNKA, 1986)
49. *Austrocarabodes* sp. *A* (CARABODIDAE C. L. Koch, 1836; *Austrocarabodes* HAMMER, 1966)
50. *Gibbicepheus* sp. *A* (CARABODIDAE C. L. Koch, 1836; *Gibbicepheus* BALOGH, 1958)
51. *Carabodoides* sp. *A* (ANDEREMAEIDAE Balogh, 1972; *Carabodoides* JACOT, 1937)
52. *Neocarabodes* sp. *A* (CARABODIDAE C. L. Koch, 1836; *Neocarabodes* BALOGH & MAHUNKA, 1969)
53. *Lamellobates* sp. *A* (ORIBATELLIDAE Jacot, 1925; *Lamellobates* HAMMER, 1958)
54. *Oripoda* sp. *A* (ORIPODIDAE Jacot, 1925; *Oripoda* BANKS, 1904)
55. *Benoibates* sp. *A* (ORIPODIDAE Jacot, 1925; *Benoibates* BALOGH, 1958)
56. *Charassobates* sp. *A* (CHARASSOBATIDAE Grandjean, 1958; *Charassobates* GRANDJEAN, 1929)
57. *Comeremaeus* sp. *A* (METRIOPPIIDAE Balogh, 1943; *Comeremaeus* HAMMER, 1962)
58. *Eremulus* sp. *A* (EREMULIDAE Grandjean, 1965, sensu BALOGH; *Eremulus* BERLESE, 1908)
59. *Mochlozetes* sp. *A* (MOCHLOZETIDAE Grandjean, 1960; *Mochlozetes* GRANDJEAN, 1930)
60. *Solenozetes* sp. *A* (PLASMOBATIDAE Grandjean, 1961; *Solenozetes* GRANDJEAN, 1931)

61. *Tecteremaeus* sp. *A* (ARCEREMAEIDAE Balogh, 1972; *Tecteremaeus* HAMMER, 1961)
62. *Xenillus* sp. *A* (LIACARIDAE Sellnick, 1928; *Xenillus* ROBINEAO-DESVOIDY, 1839)

EUPHEREDERMATA
63. *Basilobelba* sp. *A* (BASILOBELBIDAE BALOGH, 1961; *Basilobelba* BALOGH, 1958)
64. *Eremobelba* sp. *A* (EREMOBELBIDAE Balogh, 1961; *Eremobelba* BERLESE, 1908)
65. *Heterobelba* sp. *A* (HETEROBELBIDAE Balogh, 1961; *Heterobelba* BERLESE, 1913)
66. *Heterobelba* sp. *B* (HETEROBELBIDAE Balogh, 1961; *Heterobelba* BERLESE, 1913)

HIGHER ORIBATIDA
Sheloribatidae Haplozetidae type
67. *Haplozetes* sp. *A* (HAPLOZETIDAE Grandjean, 1936; *Haplozetes* WILLMANN, 1935)
68. *Scheloribates* sp.*A* (SCHELORIBATIDAE J. Balogh & p. Balogh, 1984; *Scheloribates* BERLESE, 1908)
69. *Scheloribates* sp. *B* (SCHHELLORIBAATIDAE J. Balogh & p. Balogh, 1984; *Scheloribates* BERLESE, 1908)
70. *Scheloribates* sp. *C* (SCHELORIBATIDAE J. Balogh & P. Balogh, 1984; *Scheloribates* BERLESE, 1908)
71. *Rostrozetes carinarus* sp. *A* (HAPLOZETIDAE Grandjean, 1930; *Rostrozetes* SELLNICK, 1925)
72. *Rostrozetes foveolatus* sp. *A* (HAPLOZETIDAE Grandjean, 1930; *Rostrozetes* SELLNICK, 1925)
73. *Rostrozetes monstruosus* sp. *A* (HAPLOZETIDAE Grandjean, 1930; *Rostrozetes* SELLNICK, 1925)
74. *Rostrozetes rimachensis* sp. *A* (HAPLOZETIDAE Grandjean, 1930; *Rostrozetes* SELLNICK, 1925)

TIPO GALUMNIDAE
75. *Galumna* sp. *A* (GALUMNIDAE Jacot, 1925; *Galumna* VON HAYDEN, 1826)
76. *Galumna* sp. *B* (GALUMNIDAE Jacot, 1925; *Galumna* VON HAYDEN, 1826)
77. *Galumna* sp. *C* (GALUMNIDAE Jacot, 1925; *Galumna* VON HAYDEN, 1826)
78. *Galumna* sp. *D* (GALUMNIDAE Jacot, 1925; *Galumna* VON HAYDEN, 1826)
79. *Galumna* sp. *E* (GALUMNIDAE Jacot, 1925; *Galumna* VON HAYDEN, 1826)

OTHERS NO CLASSIFIED GROUPS
80. *Uracrobates* sp. *A* (MOCHLOZETIDAE Grandjean, 1960; *Uracrobates* BALOGH & MAHUNKA, 1967)
81. *Porozetes* sp. *A* (CERATOZETIDAE Jacot, 1925; *Porozetes* HAMMER, 1962)
82. *Xylobates* sp. *A* (XYLOBATIDAE J. Balogh & P. Balogh, 1984; *Xylobates* JACOT, 1929)
83. *Oribatella* sp. *A* (ORIBATELLIDAE Jacot, 1925; *Oribatella* BANKS, 1895)

84. Oribatulidae sp. *A* (ORIBATULIDAE THOR, 1929)

TIPO OPPIIDAE
85. *Sternoppia* sp. *A* (STERNOPPIIDAE Balogh & Mahunka, 1969*; Sternoppia* BALOGH & MAHUNKA, 1968)
86. *Oxyoppia* sp.*A* (OPPIIDAE GRANDJEAN, 1954; *Oxyoppia* BALOGH & MAHUNKA, 1969)
87. *Oppia* sp. *A* (OPPIIDAE Grandjean, 1954; *Oppia* C. L. KOCH, 1954)
88. *Octoppia* sp. *A* (OPPIIDAE Grandjean, 1954*; Octoppia* BALOGH & MAHUNKA, 1969)
89. *Pulchroppia* sp. *A* (OPPIIDAE Grandjean, 1954; *Pulchroppia* BALOGH & MAHUNKA, 1969)
90. *Aeroppia* sp. *A* (OPPIIDAE Grandjean, 1954; *Aeroppia* HAMMER, 1961)
91. *Multioppia* sp. *A* (OPPIIDAE Grandjean, 1954; *Multioppia* HAMMER, 1961)
92. *Amerioppia* sp. *A* (OPPIIDAE Grandjean, 1954; *Amerioppia* HAMMER, 1961)
93. *Neosuctobelba* sp. *A* (SUCTOBELBIDAE Grandjean, 1954; *Neosuctobelba* BALOGH & MAHUNKA, 1969)
94. *Suctobelbella* sp. *A* (SUCTOBELBIDAE Grandjean, 1954; *Suctobelbella* JACOT, 1937)
95. *Suctobelbella* sp. *B* (SUCTOBELBIDAE Grandjean, 1954; *Suctobelbella* JACOT, 1937)

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