Soil Fauna and Litter Decomposition in Primary and Secondary Forests and a Mixed Culture System in Amazonia

Final Report 1996-1999

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Soil ants

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Abstract

Between July 1997 and March 1999 ants of soil and litter were taken every three months with core samplers (21 cm Ø) in a primary rain forest, a secondary forest and two different systems of polycultures in Central Amazonia and extracted in Berlese funnels. Greatest generic diversity was found in primary forest, while in secondary forest and the two polycultures it was about 20 and 30% lower, respectively. Biomass and median density of ants were also highest in primary forest followed by secondary forest and one of the polycultures, whereas the lowest number and biomass of ants was found in the second polyculture. The predatory species of *Hypoponera* represented the biggest part of ant biomass in all areas (20-33%), whereas the very abundant mostly tiny species (< 2mm) of *Solenopsis* made up only 1,4 – 3,9% of the ant biomass. In spite of the biology of these tiny species remains poorly known, some species have been related as predators and other acting as decomposers.

1. Introduction

Ants are an important component of the natural forests and managed agricultural systems in amazon region. They contribute to soil processes and nutrient cycling in ecosystem by transposition of soil and affecting the water movement. Some species can significantly alter soil moisture and water infiltration characteristics. The soil nearby the ants nests has a very intensive turnover of nutrients. The material carried by ants to their nests is concentrated in one place and this led to a high concentration of nutrients. The microclimatic conditions in the nests can accelerate the decomposition processes of plant litter used in some species as building material (e.g. Petal, 1978; Haines, 1978 e Moutinho, 1998).

Despite the fact that many ants may not act directly on organic matter decomposition like the termites and millipedes, the ant fauna composition, e.g. high density of predatory species, might influence the fauna of decomposers.

Taking into account the relative role of ants in decomposition, a study of the abundance, biomass and genera diversity of ants in litter and soil were carried out in a primary rain forest, a secondary forest and two different systems of polycultures.

2. Material and Methods

The samples were taken 1996-1999 on four sites belonging to three different ecosystems: one primary and one secondary forest site (FLO and SEC, respectively), and a mixed culture system (areas POA and POC). Samples were taken with a soil core borer (21 cm diameter) and extracted in a Berlese funnels. The ant biomass was determined by separating all the collected individuals into size classes (by body length) according to generic level. The average fresh and dry weight was calculated for each genus. Individuals of each genera were died at freezer temperature in order to weight and measure them separately. Later, the specimens were dried at 65 °C and weighted once more. In some genera that was not possible to take the measurements, the average weight was taken from another genus with same length. The total biomass, in each genus were calculated by multiplying the number of individuals by its average weight. In the genus *Hypoponera* which has more variability in length, three size classes were created (Table 5).

3. Results and Discussion

Diversity, Density and Biomass

In all areas were recorded 49 genera including two unknown species of Ponerinae and Leptanilloidinae. In primary forest (FLO) were found the largest number of genera (42), followed by secondary forest (SEC) (35 genera) and the polycultive areas (POA and POC) (28 genera) (Table 1). Greatest generic diversity was found in primary forest, while in secondary forest and the two polycultures it was about 20 and 30% lower, respectively. Most frequent in all areas were ants of the genera *Solenopsis* (subfam. Myrmicinae) and *Hypoponera* (subfam. Ponerinae) (Tables 4a and 4b). The predatory species of *Hypoponera* represented the biggest part of ant biomass in all areas (20-

33%), whereas the very abundant mostly tiny species (< 2mm) of *Solenopsis* made up only 1,4 – 3,9% of the ant biomass (Table 3). Biomass and median density of ants were also highest in primary forest (1322 ± 611 ind/m² and 187,9 ± 93,3 mg/m²; n=160 samples) followed by secondary forest (865 ± 378 ind/m² and 87,8 ± 33,5 mg/m²; n=160) and one of the polycultures (782 ± 284 ind/m² and 91,3 ± 39,8 mg/m²; n=80), whereas the lowest number and biomass of ants was found in the second polyculture (574 ± 299 ind./m² and 45,9 ± 15,9 mg/m², n= 80) (Table 1). There is no statistically significant difference in biomass and density of ants between litter and soil samples for all study areas (Table 2).

The role of ants in organic matter decomposition

Many ant species utilize plant resources especially nectar from extrafloral nectaries or honeydew from homopterans beside their predatory activities thus acting as least partly as herbivores (see Tobin, 1994). These are often arboreal species like *Camponotus*, *Cephalotes* or *Pseudomyrmex* which are clearly underrepresented in our soil samples. Whereas the carnivory is the principal foraging strategy in some soil dwelling ants (e.g. Ponerinae and Ecitoninae), there is no clear pattern for many species. In all studied areas the genera *Solenopsis* and *Hypoponera* were most frequent. *Hypoponera* species are known by its predatory habit whereas the biology of *Solenopsis* is poorly known. They might be predominantly acting as predators including on brood of other ant species (lestobiosis) but there might be also a lot of scavenging on dead animals (decomposing activity). Among the many predatory species are a good number that as far as known are highly specialized in their type of prey, e.g. *Thaumatomyrmex* (polyxenid millipedes), *Cylindromyrmex*, *Acanthostichus*, *Centromyrmex* (termites) *Discothyrea* (arthropod eggs) or *Smithistruma* and *Strumigenys* (mainly collembolans), but indeed observations for many of these species are very scarce because of their rarity. These specialized predators are more than twice are frequent in primary and secondary forests than in polycultures. Army ants have been registered only in the forests by the method used.

Up to now no quantitative studies exist for these species that investigate the proportions of the different utilized food sources. Subterranean species of the genus *Acropyga* predominantely depend on honeydew of subterranean Coccidae, Homoptera. Other plant resources known to be exploited by ants of this study are pollen (*Cephalotes,* probably *Pseudomyrmex*), probably seeds (several genera), and leaves and leaf sap (leaf cutter ants of the genera *Atta* and *Acromyrmex*). Although leaf cutter ants do not ingest leaves directly but cultivate with them a fungus in their nests which they eat (fungivory), their ecosystematic effect is that of a herbivore, not a detritivore or decomposer. The latter role play the small species of other attine genera like *Cyphomyrmex*, *Apterostigma,* or *Trachymyrmex* which collect plants residues, arthropod corpses and insect faeces on which they cultivate their fungus. Many predatory or „omnivorous" species (utilizing plant and animal resources more or less alike) also act as detritivores by their scavenging activity on invertebrate and vertebrate carcasses. So far no studies exist for Amazonian ants that evaluate the importance of these resources for the entire diet of the species.

Relation of ant biomass and abiotic factors

Rainfall: There is not a statistically significant correlation ($P \leq 0,05$) between the ant biomass and the daily rainfall averages at 3, 5, 10 e 30 days before sampling.

Relative humidity: a statistically significant and negative correlation ($P \leq 0,05$) were observed in FLO (at 3, 5, 10 and 30 days before sampling) and in POA (at 5 and 10 days before sampling) between the ant biomass and the relative humidity. No statistically significant correlation were found in SEC and POA areas.

Soil and litter temperature: Only in POA were observed a statistically significant and positive correlation ($P \leq 0,05$) between the ant biomass and the soil temperature (at 3 days before sampling); and the litter temperature (at 3, 5, 10 e 30 days before sampling).

4. References

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6. Annex

Table 1: Ants in the study areas: Total of individual number, density, biomass and number of genera.

Local	N°. of samples per collection/Total N°. of samples 1997-99	Total N°. of individuals (Litter + Soil 0-5cm)	Average density over months ± Standard deviation (ind/m^2) (n=8)	Average biomass over months ± Standard deviation (mg/m^2) (n=8)	N°. of Genera
FLO	20/160	7329	1322 ± 611	187,9 ± 93,3	42
SEC	20/160	4798	865 ± 378	87,8 ± 33,5	34
POA	10/80	1591	574 ± 299	45,9 ± 15,9	28
POC	10/80	2167	782 ± 284	91,3 ± 39,8	28

Table 2: Ants in the study areas: Density and biomass in soil and litter samples.

Local	Average density over months ± Standard deviation (ind/m^2) (n=8)		Average biomass over months ± Standard deviation (mg/m^2) (n=8)	
	Litter	Soil	Litter	Soil
FLO	549 ± 240	774 ± 507	71,9 ± 40,0	116,0 ± 90,7
SEC	545 ± 233	321 ± 185	43,1 ± 12,7	44,8 ± 28,2
POA	245 ± 144	330 ± 195	22,8 ± 10,5	23,1 ± 7,9
POC	339 ± 159	440 ± 218	43,8 ± 21,3	47,1 ± 29,6

Table 3: Ant biomass in study areas according to the genera.

FLO		**SEC**	
Genus	**Biomass average over months ± Standard deviation (mg/m^2) (n=8)**	**Genus**	**Biomass average over months ± Standard deviation (mg/m^2) (n=8)**
Hypoponera	37,42 ± 24,79	*Hypoponera*	21,94 ± 15,76
Pheidole	33,71 ± 49,02	*Pachycondyla*	11,01 ± 15,17
Nomamyrmex	24,11 ± 68,18	*Pheidole*	10,67 ± 16,8
Pachycondyla	18,43 ± 10,26	*Erebomyrma*	7,60 ± 21,47
Solenopsis	6,90 ± 10,48	*Labidus*	5,39 ± 15,24
Trachymyrmex	6,03 ± 12,12	*Discothyrea*	4,58 ± 1,43
Strumigenys	5,99 ± 3,07	*Anochaetus*	3,52 ± 3,44
Blepharidatta	5,33 ± 11,77	*Rogeria*	2,95 ± 1,83
Odontomachus	5,30 ± 3,73	*Solenopsis*	2,86 ± 2,23
Crematogaster	4,75 ± 7,82	*Ectatoma*	2,28 ± 3,14
Atta	4,55 ± 7,07	*Cyphomyrmex*	2,09 ± 3,36
Erebomyrma	4,50 ± 8,34	*Odontomachus*	2,08 ± 4,36
Apterostigma	4,16 ± 7,96	*Acropyga*	1,97 ± 2,49
Tapinoma	3,91 ± 5,06	*Paratrechina*	1,92 ± 2,49
Ectatoma	3,79 ± 6,44	*Tapinoma*	1,77 ± 2,08
Anochaetus	2,87 ± 4,56	More 19 genera	< 1,00 each
Acromyrmex	2,06 ± 3,82		
Megalomyrmex	1,60 ± 2,82		
Cyphomyrmex	1,59 ± 2,84		
Cylindromyrmex	1,42 ± 3,19		
Gnamptogenys	1,38 ± 3,32		
More 21 genera	< 1,00 each		
POA		**POC**	
Genus	**Biomass average over months ± Standard deviation (mg/m^2) (n=8)**	**Genus**	**Biomass average over months ± Standard deviation (mg/m^2) (n=8)**
Hypoponera	9,93 ± 6,43	*Hypoponera*	30,11 ± 20,63
Pheidole	7,52 ± 5,68	*Apterostigma*	11,19 ± 24,31
Ectatoma	4,55 ± 6,28	*Pachycondyla*	12,69 ± 9,27
Pachycondyla	3,40 ± 4,02	*Pheidole*	9,88 ± 15,10
Cyphomyrmex	3,36 ± 4,65	*Rogeria*	5,20 ± 4,16
Leptanilloidinae A	2,41 ± 6,81	*Anochaetus*	3,10 ± 5,75
Tapinoma	2,08 ± 2,81	*Tapinoma*	2,75 ± 3,53
Solenopsis	1,80 ± 1,76	*Paratrechina*	2,20 ± 1,65
Paratrechina	1,75 ± 1,71	*Trachymyrmex*	2,01 ± 5,38
Odontomachus	1,52 ± 4,29	*Cyphomyrmex*	1,82 ± 2,42
Rogeria	1,07 ± 1,23	*Strumigenys*	1,65 ± 1,84
More 17 genera	< 1,00 each	*Dinoponera*	1,52 ± 4,29
		Odontomachus	1,52 ± 4,29
		Azteca	1,46 ± 1,38
		Solenopsis	1,30 ± 0,81
		More 13 genera	< 1,00 each

Table 4a: Frequency of ants in FLO and SEC areas according to the genera.

FLO			SEC		
Genus	**Frequency in 160 samples**	%	**Genus**	**Frequency in 160 samples**	%
Solenopsis	115	71,9	*Solenopsis*	140	87,5
Hypoponera	114	71,3	*Hypoponera*	114	71,3
Strumigenys	104	65,0	*Rogeria*	88	55,0
Tapinoma	71	44,4	*Discothyrea*	85	53,1
Pheidole	46	28,8	*Tapinoma*	54	33,8
Crematogaster	43	26,9	*Paratrechina*	42	26,3
Pachycondyla	32	20,0	*Pheidole*	32	20,0
Rogeria	24	15,0	*Strumigenys*	28	17,5
Cyphomyrmex	21	13,1	*Anochaetus*	23	14,4
Carebara	19	11,9	*Crematogaster*	15	9,4
Acropyga	18	11,3	*Acropyga*	14	8,8
Discothyrea	18	11,3	*Pachycondyla*	11	6,9
Paratrechina	17	10,6	*Cyphomyrmex*	8	5,0
Rhopalothrix	16	10,0	*Gnamptogenys*	7	4,4
Anochaetus	15	9,4	*Carebara*	6	3,8
Hylomyrma	10	6,3	*Trachymyrmex*	5	3,1
Trachymyrmex	10	6,3	*Acromyrmex*	3	1,9
Apterostigma	8	5,0	*Azteca*	3	1,9
Erebomyrma	7	4,4	*Ectatoma*	3	1,9
Smithistruma	7	4,4	*Eurhopalothrix*	3	1,9
Wasmannia	7	4,4	*Mycocepurus*	3	1,9
Gnamptogenys	6	3,8	*Odontomachus*	3	1,9
Odontomachus	6	3,8	*Erebomyrma*	2	1,3
Ectatoma	5	3,1	*Rhopalothrix*	2	1,3
Megalomyrmex	5	3,1	*Acanthostichus*	1	0,6
Atta	4	2,5	*Camponotus*	1	0,6
Azteca	4	2,5	*Hylomyrma*	1	0,6
Acromyrmex	3	1,9	*Labidus*	1	0,6
Camponotus	3	1,9	*Nomamyrmex*	1	0,6
Cylindromyrmex	3	1,9	*Pseudomyrmex*	1	0,6
Eurhopalothrix	3	1,9	*Smithistruma*	1	0,6
Mycocepurus	3	1,9	*Thaumatomyrmex*	1	0,6
Proceratium	3	1,9	*Wasmannia*	1	0,6
Acanthostichus	2	1,3	*Zacryptocerus*	1	0,6
Blepharidatta	2	1,3			
Centromyrmex	2	1,3			
Nomamyrmex	2	1,3			
Thaumatomyrmex	2	1,3			
Oligomyrmex	1	0,6			
Ponerine n. ident.	1	0,6			
Pseudomyrmex	1	0,6			
Quadristruma	1	0,6			

Table 4b: Frequency of ants in POA and POC areas according to the genera.

POA			POC		
Genus	**Frequency in 80 samples**	%	**Genus**	**Frequency in 80 samples**	%
Solenopsis	54	67,5	*Hypoponera*	62	77,5
Hypoponera	37	46,3	*Solenopsis*	57	71,3
Tapinoma	31	38,8	*Rogeria*	48	60,0
Pheidole	30	37,5	*Tapinoma*	35	43,8
Rogeria	19	23,8	*Paratrechina*	24	30,0
Paratrechina	15	18,8	*Pheidole*	16	20,0
Strumigenys	11	13,8	*Strumigenys*	15	18,8
Wasmannia	11	13,8	*Pachycondyla*	12	15,0
Discothyrea	8	10,0	*Discothyrea*	11	13,8
Cyphomyrmex	7	8,8	*Azteca*	7	8,8
Mycocepurus	5	6,3	*Crematogaster*	7	8,8
Azteca	4	5,0	*Cyphomyrmex*	7	8,8
Pachycondyla	4	5,0	*Apterostigma*	4	5,0
Acanthostichus	3	3,8	*Anochaetus*	3	3,8
Ectatoma	3	3,8	*Mycocepurus*	3	3,8
Quadristruma	3	3,8	*Trachymymex*	3	3,8
Camponotus	2	2,5	*Acropyga*	2	2,5
Gnamptogenys	2	2,5	*Gnamptogenys*	2	2,5
Acropyga	1	1,3	*Quadristruma*	2	2,5
Anochaetus	1	1,3	*Wasmannia*	2	2,5
Carebara	1	1,3	*Brachymyrmex*	1	1,3
Crematogaster	1	1,3	*Cylindromyrmex*	1	1,3
Erebomyrma	1	1,3	*Dinoponera*	1	1,3
Leptanilloidinae A	1	1,3	*Eurhopalothrix*	1	1,3
Megalomyrmex	1	1,3	*Hylomyrma*	1	1,3
Odontomachus	1	1,3	*Odontomachus*	1	1,3
Talaridris	1	1,3	*Smithistruma*	1	1,3
Zacryptocerus	1	1,3	*Thaumatomyrmex*	1	1,3

Table 5. Length classes, average fresh and dry weight of ants according to the genera.

Genus	Length (mm)	Average fresh weight (mg)	Average dry weight (mg)
Acanthostichus	2,0	0,1888	0,0477
Acromyrmex	4,5	0,5283	0,2650
Acropyga	2,0	0,1888	0,0477
Anochaetus	4,0	0,9418	0,3382
Apterostigma	3,0	0,5283	0,2650
Atta	3,0	11,5684	4,2045
Azteca	4,0	0,9418	0,3382
Camponotus	5,0	5,2029	2,2372
Carebara	1,0	0,0225	0,007
Centromyrmex	4,0	0,6462	0,2550
Crematogaster	2,5	0,3626	0,1336
Cylindromyrmex	7,0	4,4961	1,5716
Cyphomyrmex	2,0	0,1888	0,0477
Discothyrea	2,0	0,3626	0,1336
Dolichoderus	8,0	14,8272	5,7093
Ectatoma	10,0	11,5684	4,2045
Erebomyrma	1,5	0,1888	0,0477
Gnamptogenys	5,0	0,6462	0,2550
Hylomyrma	2,0	0,1888	0,0477
Hypoponera	< 2,5	0,3479	0,1571
Hypoponera	3 to 5	0,6462	0,2550
Hypoponera	> 5	2,7744	1,1930
Megalomyrmex	4,0	0,9418	0,3382
Mycocepurus	2,5	0,3626	0,1336
Odontomachus	9,0	11,5684	4,2045
Pachycondyla	6,0	4,4961	1,5716
Paratrechina	2,0	0,1888	0,0477
Pheidole	3,0	0,6772	0,2558
Proceratium	2,5	0,3479	0,1571
Pseudomyrmex	3,0	0,6772	0,2558
Quadristruma	2,0	0,1888	0,0477
Rhopalotrix	2,0	0,1888	0,0477
Rogeria	2,0	0,1888	0,0477
Smithistruma	2,0	0,1888	0,0477
Solenopsis	2,0	0,0225	0,007
Strumigenys	2,0	0,1888	0,0477
Tapinoma	2,0	0,1888	0,0477
Trachymirmex	3,0	0,5283	0,2650
Wasmannia	2,0	0,1888	0,0477
Zacryptocerus	3,0	0,5283	0,2650