

ANTS OBTAINED FROM TREES OF A "JACAREÚBA" (*Calophyllum brasiliense*) FOREST PLANTATION IN CENTRAL AMAZONIA BY CANOPY FOGGING: FIRST RESULTS

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ABSTRACT — Canopies of the locally occurring Amazonian tree species *Calophyllum brasiliense* Camb. (Guttiferae, height 10 m) were fogged after dawn on the same day at five adjacent localities in a 20-year-old plantation at the Adolpho Ducke Forest Reserve near Manaus/Brazil, using natural pyrethrum (0.5%, 1.0%, 1.5%), Baythroid (0.3%) and diesel oil, respectively. The 1152 ants collected represented 52 species, 17 genera and five subfamilies. The highest number of ant species was obtained with the synthetic pyrethrum Baythroid 0.3% and with natural pyrethrum 1.5%. About 46% of the total ant species were only collected in the first hour after fogging, and 17% only during the second hour, after trees had been heavily shaken. About 73% of the total ant specimens dropped in the first hour. Data on alpha-diversity, evenness and frequency of ants indicated a rapidly decreasing knock-down effect of both the synthetic and natural pyrethrum after application. The ant fauna in the canopy of *C. brasiliense* is somewhat distinct compared with that of *Goupia glabra* Aubl. (Celastraceae, height 45 m) from the primary forest of the reserve.

Key Words: ants, canopy fogging, pyrethrum, forest plantation, Amazon, Neotropics.

Formigas Obtidas de Árvores numa Plantação de "Jacareúba" (*Calophyllum brasiliense*) na Amazônia Central Através da Nebulização de Copas: Primeiros Resultados.

RESUMO — As copas de uma espécie de árvores de ocorrência local, *Calophyllum brasiliense* Camb. (Guttiferae, altura 10m), foram nebulizadas depois do amanhecer do mesmo dia, em cinco localidades adjacentes, numa plantação com 20 anos de idade na Reserva Florestal Adolpho Ducke perto de Manaus/Brasil, usando-se piretro natural (0,5%, 1,0%, 1,5%), Baythroid (0,3%) e óleo diesel, respectivamente. As 1152 formigas coletadas representaram 52 espécies, 17 gêneros e cinco subfamílias. O maior número de espécies de formigas foi obtido com o piretro sintético Baythroid 0,3% e com piretro natural 1,5%. Cerca de 46% de todas as formigas foram coletadas somente na primeira hora depois da nebulização, e 17% somente durante a segunda hora, depois das árvores serem fortemente sacudidas. Cerca de 73% de todos os indivíduos de formigas caíram durante a primeira hora. Dados sobre a alfa-diversidade, uniformidade e frequência de formigas indicam um rápido efeito decrescente de caída, tanto do piretro sintético quanto do piretro natural depois da sua aplicação. A fauna de formigas na copa de *C. brasiliense* de certa forma é distinta em comparação com a fauna de *Goupia glabra* Aubl. (Celastraceae, altura 45 m) da floresta primária na reserva.

Palavras chave: formigas, nebulização de copas, piretro, plantação de floresta, Amazônia, Neotrópicos.

INTRODUCTION

Ants represent in most cases the dominant arthropod taxon in the canopies of Central Amazonian forests (Adis & Schubart, 1984; Adis *et al.*, 1984; Erwin,

1983, 1989; Harada & Adis, 1997).

A total of 100 species and 21 genera were obtained from the canopy of *Goupia glabra* Aubl. (Celastraceae; common name "Cupiuba") in Central Amazonia during the dry and rainy sea-

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sons (Harada & Adis, 1997). Wilson (1987) found 43 species representing 21 genera on a single tree in Western Amazonia.

This contribution is concerned with the knock-down efficiency of natural and synthetic pyrethrum, as well as of diesel oil, in a forest plantation of *Calophyllum brasiliense* Camb. (Guttiferae; common name "Jacareúba") in Central Amazonia during the rainy season. In addition, data on ant richness, frequency and species similarity among plots are given.

STUDY SITE AND METHODS

The study area (Adolpho Ducke Forest Reserve) belongs to the National Institute for Amazonian Research (INPA), and is located about 26 km northeast of Manaus (02°55'S, 59°59'W). This reserve has been intensively studied for more than 20 years (e.g. Willis, 1977; Penny & Arias, 1982; Adis & Schubart, 1984; Adis, 1988; Hero, 1990; Prance, 1990; Höfer *et al.*, 1994; Adis *et al.*, 1997).

The ants and other arthropods were sampled from the canopy in a 20-year-old forest plantation of the locally occurring tree species Jacareúba (*Calophyllum brasiliense* Camb., Guttiferae) during the rainy season (February, 1992) with fogging (for details see Adis *et al.*, 1997).

In five selected plots, each covering an area of 32 m² and about 50 m apart, the tree canopies were fogged from the ground at the same time at dawn of the same day. The trees were about 10 m in height, the diameter of the tree trunks was about 16 cm (dbh) and canopy diameter was about 4 m.

The five plots were fogged for 3 minutes with 0.5%, 1.0% and 1.5% natural pyrethrum (diluted in diesel oil; without synergist), the synthetic pyrethrum Baythroid (0.3%, diluted in diesel oil; with synergist) and diesel oil, respectively. The knock-down effect of the killing agent Baythroid was stated by the manufacturer (Bayer, Leverkusen /Germany, personal communication) to be 10 times more effective than that of the non-killing natural pyrethrum. A sixth plot served as control and was not fogged. For each plot the falling ants were collected in six funnel-shaped trays as described in Adis *et al.* (1997). The trays were randomly distributed along horizontally extended ropes within the plots. Ants were collected for 1 hour after fogging, the trees on all plots were then heavily shaken and ants were collected for a further 1 hour. In this way, the efficiency of the knock-down agent used for canopy fogging could be evaluated. Due to technical problems, the fogging machine produced only a weak fog in the plot treated with 1% natural pyrethrum.

RESULTS AND DISCUSSION

Knock-down efficiency of insecticides.

About 73% of all ants (n=1152) dropped in the first hour after fogging and the remaining 27% within sixty minutes after the trees had been shaken (Fig. 1). The highest number of ant species collected in each of the 1 hour drop periods was obtained with the synthetic pyrethrum Baythroid 0.3% (n=19 and 12 species), followed by natural pyrethrum 1.5% (n=18 and 7 species; Figs. 2-4, 7). The highest

relative abundance of ants (54 ind./m²) was observed in the plot treated with pyrethrum 0.5% due to a nest of *Crematogaster* sp. #3 in the canopy. The knock-down effect of diesel oil was lowest and comparable with the control plot, with regard to both species number and abundance of ants (Figs. 2-4). The relatively low drop rates of ants obtained with natural pyrethrum 1.0% (Fig. 4) are attributable to technical problems during fogging.

Species richness, frequency and taxonomic composition.

The 1152 ants collected represented 52 species, 17 genera and five subfamilies (Myrmicinae, Formicinae, Dolichoderinae, Ponerinae and Pseudomyrmecinae; Tab. 1, Fig. 1). Species richness was highest in the Myrmicinae (33 species of 7 genera), the Formicinae (17 species of 5 genera) and the Dolichoderinae (8 species of 3 genera; Tab. 1). Similar results were obtained by Wilson (1987) in Peru and by Harada & Adis (1997) in Central Amazonia.

The most common genera were *Camponotus* (10 species), *Crematogaster* (7 species), *Dolichoderus* (4 species), *Procryptocerus* (4 species), *Zacryptocerus* (4 species), and *Solenopsis* (4 species; Tab. 1). Results are comparable with those for ants fogged from the canopy of Cupiuba in the same forest reserve (Harada & Adis, 1997).

Twenty-four out of 52 species (46.2%) were solely collected in the first hour after fogging, and 9 species (17.3%) only during the second hour, after trees had been shaken (Tab. 1, Fig. 1).

The cumulative number of species obtained from 35 collecting trays

(Fig. 5) indicated that at least 25 trays were necessary to obtain most of the ant species from the canopy of the Jacareúba plantation, covering 192 m² of ground. Only 18 collecting trays were sufficient to collect the ant species of two Cupiuba trees in the same reserve (Harada & Adis, 1997). These two trees represented the uppermost canopy of the forest: they had a crown diameter of 14 m and 15 m, covering an area of about 331 m², and a height of 38 m and 45 m, respectively.

The higher alpha-diversity of ants found one hour after fogging and before shaking trees, as well as their higher evenness and lower frequency observed 60 min after shaking of trees (Tab. 2, 3; Fig. 7) suggest that the knock-down effect of both synthetic and natural pyrethrum decreased rapidly after application. Further interpretation of the indices will only be possible after the fogging experiment has been repeated.

Only 21 ant species (21%) obtained from the canopy of the Jacareúba plantation during the rainy season in 1992 were found in common when compared to the 100 ant species fogged from the two Cupiuba trees during the dry and rainy seasons 1991/92 (cf. Table 17.1 in Harada & Adis, 1997). Only 37% of the ant species were the same as those obtained from the two Cupiuba trees fogged during the rainy season in 1992 (n=51). Data indicate that the ant fauna in the canopy is, to a large extent, distinct in both the Jacareúba plantation and the Cupiuba trees. Differences might be due for example to the different height of the two tree species and the monoculture effect. This has to be confirmed by

Table 1. Ant species obtained from the canopy of a Jacareúba (*Calophyllum brasiliense*) forest plantation near Manaus/Brazil during the rainy season (February, 1992). 1st = catch 60 min after fogging and before shaking trees; 2nd = catch 60 min after shaking trees; Σ = total catch.

Ant species	1st	2nd	Σ
Subf. Dolichoderinae			
<i>Azteca</i> #1	---	2	2
<i>Azteca</i> #2	4	---	4
<i>Azteca</i> #3	21	1	22
<i>Dolichoderus bidens</i>	92	25	117
<i>Dolichoderus bispinosus</i>	5	3	8
<i>Dolichoderus haradae</i>	52	15	67
<i>Dolichoderus lutosus</i>	1	---	1
<i>Tapinoma</i> sp. #1	1	---	1
Subf. Formicinae			
<i>Acropyga</i> sp. #1	1	---	1
<i>Acropyga</i> sp. #5	1	---	1
<i>Camponotus alboannulatus</i>	1	---	1
<i>Camponotus bidens</i>	72	11	83
<i>Camponotus brasiliensis</i>	1	---	1
<i>Camponotus butoni</i>	---	1	1
<i>Camponotus nr. fastigatus</i>	1	---	1
<i>Camponotus godmani</i>	---	1	1
<i>Camponotus iridis</i>	1	---	1
<i>Camponotus latangulus</i>	2	1	3
<i>Camponotus pittieri</i>	1	---	1
<i>Camponotus trapezoideus</i>	2	---	2
<i>Dendromyrmex chartifex</i>	1	---	1
<i>Myrmelachista</i> sp. #3	29	11	40
<i>Myrmelachista</i> sp. #4	5	2	7
<i>Myrmelachista</i> sp. #5	1	---	1
<i>Paratrechina</i> sp. #12	---	2	2
Subf. Myrmicinae			
<i>Crematogaster</i> sp. #1	3	---	3
<i>Crematogaster</i> sp. #2	8	---	8
<i>Crematogaster</i> sp. #3	362	96	458
<i>Crematogaster</i> sp. #7	63	52	115
<i>Crematogaster</i> sp. #8	32	51	83
<i>Crematogaster</i> sp. #10	4	5	9
<i>Crematogaster</i> sp. #12	7	8	15
<i>Cyphomyrmex striagatus</i>	1	2	3
<i>Leptothorax brasiliensis</i>	---	2	2
<i>Leptothorax</i> (N.) sp. #2	1	---	1
<i>Procryptocerus clathratus</i>	---	1	1
<i>Procryptocerus cf. gracilis</i>	1	---	1
<i>Procryptocerus pictipes</i>	5	2	7
<i>Procryptocerus subpilosus</i>	2	---	2
<i>Solenopsis</i> sp. #10	17	---	17
<i>Solenopsis</i> sp. #17	1	---	1
<i>Solenopsis</i> sp. #18	25	11	36
<i>Solenopsis</i> sp. #19	1	1	2
<i>Zacryptocerus laminatus</i>	2	1	3
<i>Zacryptocerus notatus</i>	---	1	1
<i>Zacryptocerus similimus</i>	---	2	2
<i>Zacryptocerus solidus</i>	---	1	1
Subf. Ponerinae			
<i>Pachycondyla nr. arhuaca</i>	1	---	1
<i>Pachycondyla crenata</i>	4	---	4
<i>Platythyrea angusta</i>	1	---	1
Subf. Pseudomyrmecinae			
<i>Pseudomyrmex gracilis</i>	2	---	2
<i>Pseudomyrmex terminalis</i>	2	1	3
Number of individuals	840	312	1152
Number of species	43	27	52
Number of genera	16	12	17

Table 2. Richness of species and diversity indices of ants obtained by fogging the canopy in a Jacareúba (*Calophyllum brasiliense*) forest plantation near Manaus/Brazil during the rainy season (February, 1992). 1st = 60 min after fogging and before shaking trees; 2nd = 60 min after shaking trees.

Sample	S	N	A	D	H _s	E	Dominant species	Density	
								sp.	Total
1st	43	840	9.6	0.22	3.18	0.59	Crematogaster #3	10.34	24.03
							Dolichoderus bidens	2.63	
							Camponotus bidens	2.06	
2nd	27	312	7.1	0.16	3.27	0.69	Crematogaster #3	2.74	8.94
							Crematogaster #7	1.49	
							Dolichoderus bidens	1.46	

S = number of species

N = number of specimens

A = alpha index

Diversity: $D = 1 - 1/p_i^2$ (Simpson)

$H_s = -p_i \log_2 p_i$ (Shannon-Wiener)

Evenness: $E = H_s/H_{s_{max}}$ (Pielou)

$H_{s_{max}} = \log S$

Density = ind/m²

Table 3. Richness of species and frequency indices of ants obtained by fogging the canopy in a Jacareúba (*Calophyllum brasiliense*) forest plantation near Manaus/Brazil during the rainy season (February, 1992). 1st = 60 min after fogging and before shaking trees; 2nd = 60 min after shaking trees.

Sample	S	N	A	D	H _s	E	Dominant species	Density	
								sp.	Total
1st	43	122	24.9	0.06	4.73	0.87	Crematogaster #3	0.34	3.28
							Dolichoderus bidens	0.34	
							Camponotus bidens	0.40	
2nd	27	72	15.5	0.06	4.35	0.92	Crematogaster #3	0.29	2.08
							Crematogaster #8	0.20	
							Dolichoderus bidens	0.17	

S = number of species

N = number of frequencies

A = alpha index

Diversity: $D = 1 - 1/p_i^2$ (Simpson)

$H_s = -p_i \log_2 p_i$ (Shannon-Wiener)

Evenness: $E = H_s/H_{s_{max}}$ (Pielou)

$H_{s_{max}} = \log S$

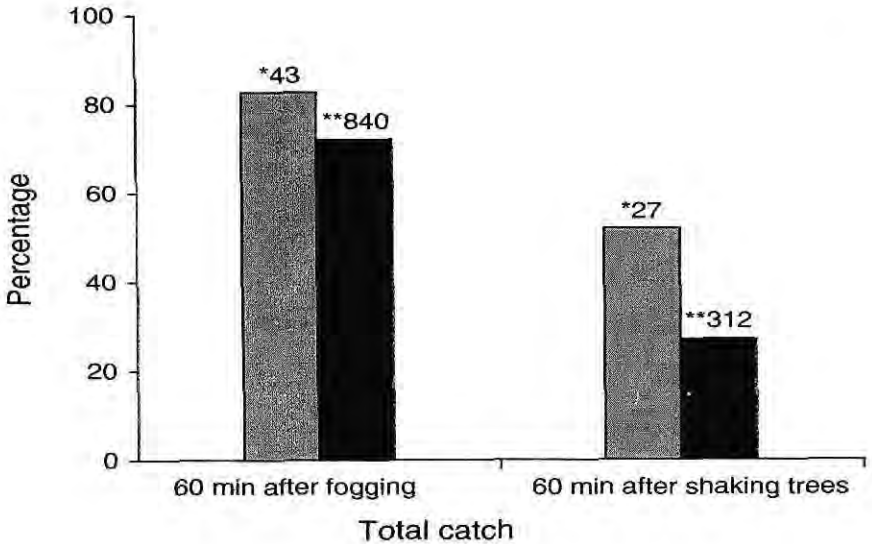
Density = ind/m²

refogging the Jacareúba canopy during the rainy and dry seasons of different years. In addition, the number of tercolous ant species which temporarily forage in the lower canopy should be determined.

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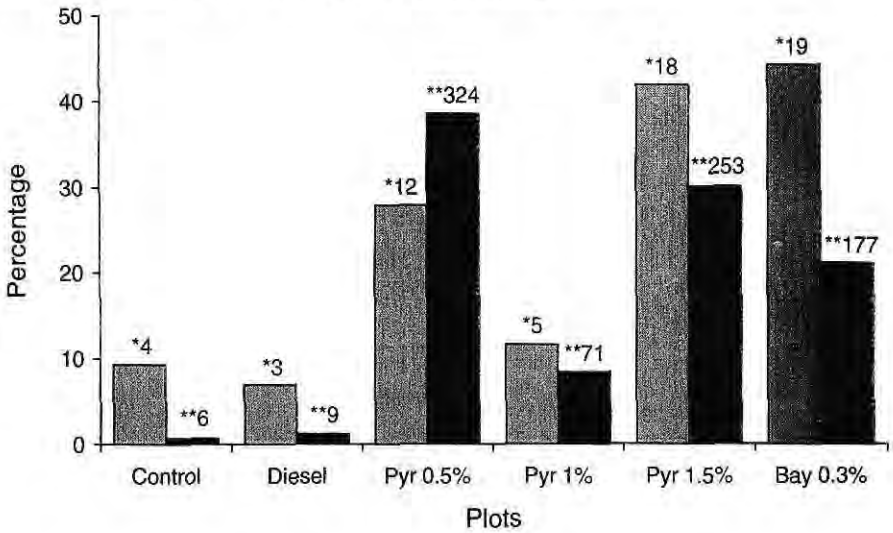
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■ Species ■ Specimens * Total of species ** Total of specimens

Figure 1. Percentage of total species and specimens of ants obtained from the canopy 60 min after fogging and before shaking trees and 60 min after shaking trees in a Jacareúba (*Calophyllum brasiliense*) forest plantation near Manaus/Brazil during the rainy season (February, 1992).



■ Species ■ Specimens * Total of species ** Total of specimens

Figure 2. Percentage of total specimens and species of ants obtained from each of six plots 60 min after fogging the canopy, before shaking trees, in a Jacareúba (*Calophyllum brasiliense*) forest plantation near Manaus/Brazil during the rainy season (February, 1992) with different pyrethrum concentrations and agents. Pyr = natural pyrethrum, without synergist; Bay = synthetic pyrethrum Baythroid, with synergist; Diesel = diesel oil; Control = control plot, no agent used.

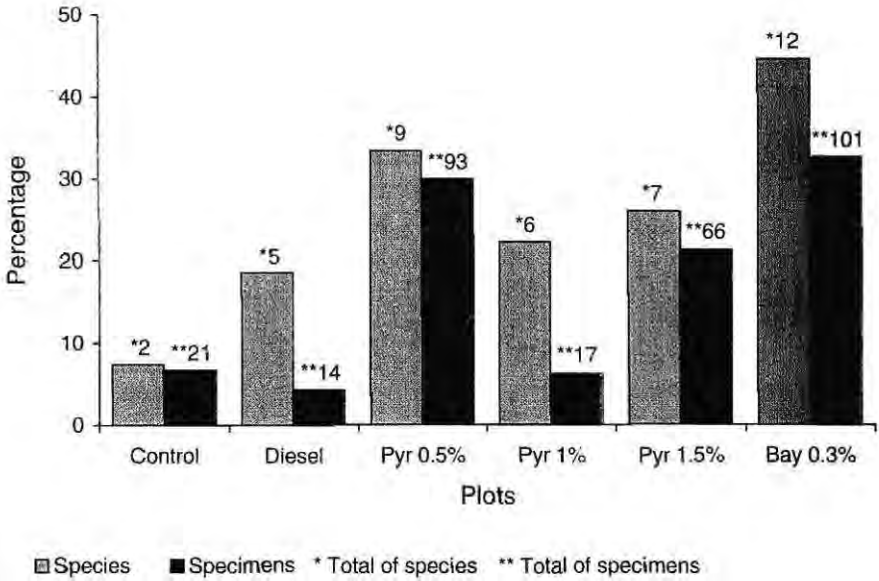


Figure 3. Percentage of total specimens and species of ants obtained from each of six plots 60 min after shaking trees of the fogged canopy in a Jacareúba (*Calophyllum brasiliense*) forest plantation near Manaus/ Brazil during the rainy season (February, 1992) with different pyrethrum concentrations and agents. Pyr = natural pyrethrum, without synergist; Bay = synthetic pyrethrum Baythroid, with synergist; Diesel = diesel oil; Control = control plot, no agent used.

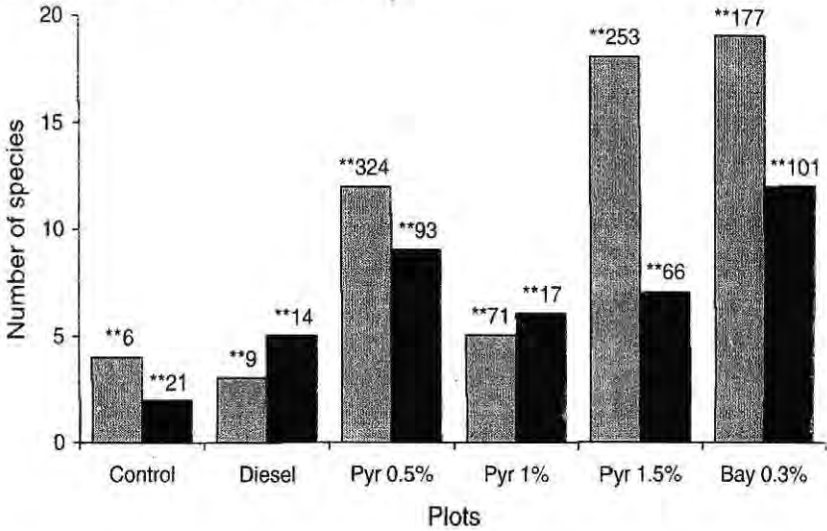


Figure 4. Total number of ant species obtained from each of six plots 60 min after fogging (before shaking trees) and 60 min after shaking trees in a Jacareúba (*Calophyllum brasiliense*) forest plantation near Manaus/ Brazil during the rainy season (February, 1992) with different pyrethrum concentrations and agents. Pyr = natural pyrethrum, without synergist; Bay = synthetic pyrethrum Baythroid, with synergist; Diesel = diesel oil; Control = control plot, no agent used. N = total number of specimens.

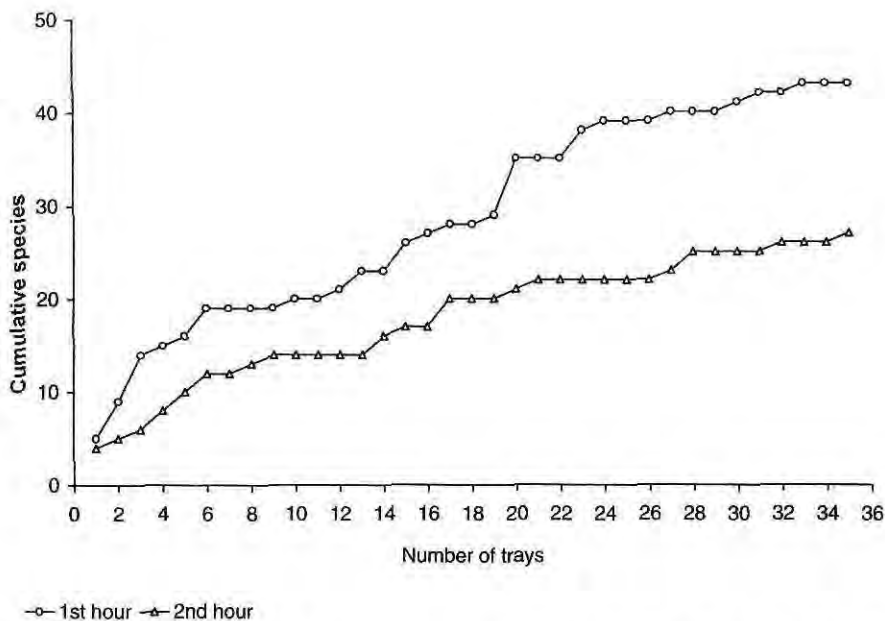


Figure 5. Cumulative number of ant species obtained from 35 collecting trays after fogging the canopy of a Jacareúba (*Calophyllum brasiliense*) forest plantation near Manaus/Brazil during the rainy season (February, 1992). 1st hour = 60 min after fogging and before shaking trees; 2nd hour = 60 min after shaking trees.

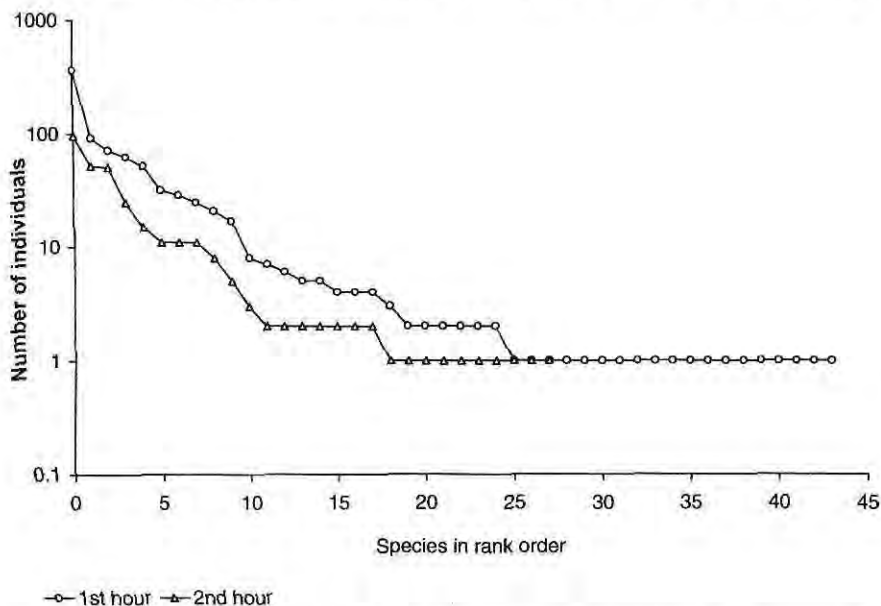
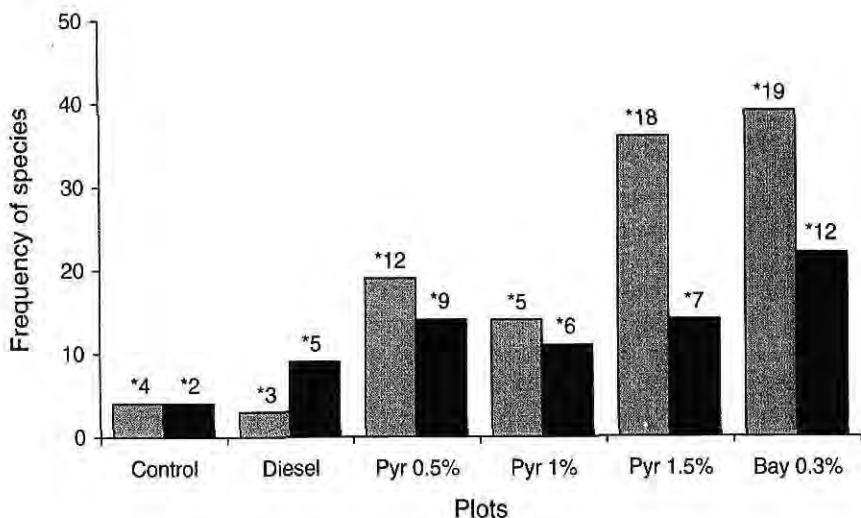


Figure 6. Rank-abundance plots (Whittaker plots, log scale) of ant species based on specimens collected from 36 collecting trays after fogging the canopy of a Jacareúba (*Calophyllum brasiliense*) forest plantation near Manaus/Brazil during the rainy season (February, 1992). 1st hour = 60 min after fogging and before shaking trees; 2nd hour = 60 min after shaking trees.



▨ 60 min after fogging ■ 60 min after shaking trees * Total of species

Figure 7. Frequency of ant species obtained from each of six plots 60 min after fogging (before shaking trees) and 60 min after shaking trees in a Jacareúba (*Calophyllum brasiliense*) forest plantation near Manaus/Brazil during the rainy season (February, 1992) with different pyrethrum concentration and agents. Pyr = natural pyrethrum, without synergist; Bay = synthetic pyrethrum Baythroid, with synergist; Diesel = diesel oil; Control = control plot, no agent used.

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