Article

Canopy ant diversity assessment in the fragmented rainforest of Sabah, East Malaysia

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Abstract

A study on the canopy ant fauna was carried out at a selective logging area in the Danum Valley Concession Area of Sabah, in East Malaysia. Ants were collected from four single and isolated *Shorea johorensis* trees (their crowns are separated by sufficient gaps from other trees). Three sampling techniques were employed: hand sampling, branch clipping, and baited pitfall trapping. The first two methods were carried out in tree crowns that had been cut down, while the third method was done on the ground. Pitfall trapping was employed to eliminate ground-level ants around the tree from the species list of tree crown ants. A total of 160 species (4889 individuals) in 35 genera belonging to 6 subfamilies was collected from canopy strata of the four trees. Among all species collected in this study, only two were common to the four trees. The similarity in species composition between trees was very low (C = 0.09 to 0.26). However, the species diversity in each tree proved relatively high (H'= 2.56 to 3.09). The effect of canopy fragmentation on ant fauna is discussed.

Key words: canopy ants, isolated tree, Borneo

Introduction

Ants (Hymenoptera: Formicidae) are one of the ecologically important animals in the tropical forest canopy (Majer, 1983; Maschwitz et al., 1984; Holldobler and Wilson, 1990; Stork, 1998; Brühl et al., 1998). This group makes up a large important component of the arthropod community in the canopy stratum (Sudd, 1967; Erwin, 1983; Stork, 1987). Ants are most commonly involved in predatory interactions (Gunarson and Hake, 1999; Whitmore, 1984) with other canopy arthropods, but many mutualistic interactions involving ants are also occurring (Hölldobler and Wilson, 1990; Ozanne, 2000). As a key animal, canopy ants have had a strong effect on the framework of arthropod species composition and other aspects of biodiversity in tropical rainforests (Majer, 1993).

In tropical primary forests, tree crowns overlap each other to form a closed forest canopy (Hill, 1999). However, disturbances such as selective logging creates fragmentation of the forest canopy. Some typical results of selective logging include complete isolation of trees in a site (i.e., their crowns are separated by gaps) caused by tractor tracts and roads, to areas of minimal disturbance as relict patches of primary forest (Hill, 1999). The isolation of trees produces considerable microclimatic changes in the canopy stratum (Ozanne, 2000), such as decreases in humidity levels, temperature fluctuations, and exposure to strong winds that may limit insect population growth. Thus, changes of forest architecture by selective logging may reduce arthropod diversity in the canopy stratum.

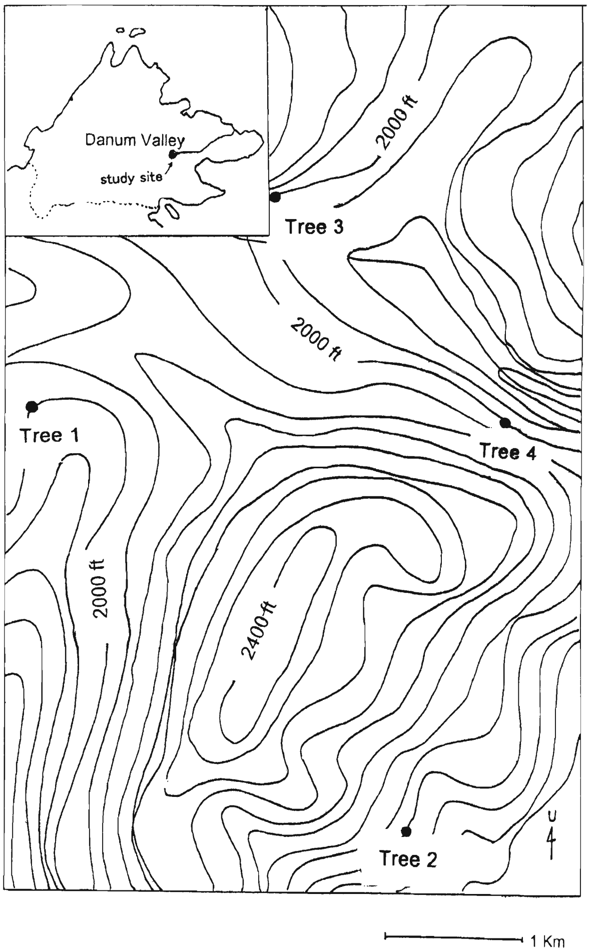

Fig. 1. Location of study site (positions of isolated trees).

In this study, only those ants collected from the fallen tree crowns were considered as canopy ants. We studied canopy ant diversity using four isolated trees in a logging area of Danum Valley, Sabah to find the effects of forest canopy fragmentation on the arthropod community. Ants were selected since it is very difficult to assess all arthropods (Yamane et al., 1996; Berkov and Tavakilian, 1999), and might be a good model to value the canopy ecosystem as a whole.

Study Site and Methods

This study was conducted at a selective logging area in the Danum Valley Concession Area, Borneo at 4°54'N - 117°48'E (Fig. 1) from August to November 1993. The area is located in a disturbed tropical hill forest (600 m alt.) mainly comprising dipterocarp trees. We chose four *Shorea johorensis* trees taller than 30 m that were isolated from each other by sufficient gaps. These trees were then cut down to collect the canopy ants.

Hand collecting and branch clipping were used to collect ants from the crown of the fallen trees. Hand collecting using forceps and an aspirator was conducted for about 4 to 6 hours per day on three consecutive days on each tree. Branch clipping was done by cutting and removing parts of the tree (stems, branches, and leafs), which were immediately put into a large plastic bag with a size of 1.2 m × 1.0 m. The specimens were then sorted and identified in the laboratory. To avoid contamination of the canopy fauna by ground-level ants, the ground ant survey was conducted using baited pitfall traps on two previous consecutive days before felling the trees. Twenty-five cups filled with a soap water solution were set on the ground surrounding the fallen trees. If the species sampled by pitfall trapping were found in the list of species sampled from the crown of fallen trees, they were excluded from the list. Specimens from this study have been deposited in the Borneensis Museum at IBTP, Universiti Malaysia Sabah.

We compared the ant species composition, species diversity, and similarity of ant fauna between isolated individual trees. Diversity was measured using the Shannon-Wiener diversity Index (H'), and the similarity between trees was estimated using the index of similarity (C) (Maguran, 1988).

Results

Species composition and similarity

A total of 160 species in 36 genera belonging to 6 subfamilies were collected (Appendix). Among them, the most predominant subfamily was Formicinae (10 genera, 77 species), followed by Myrmicinae (13 genera, 42 species); Ponerinae (6 genera, 14 species), Dolichoderinae (4 genera, 18 species), Pseudomyrmicinae (1 genus, 7 species), and Cerapachyinae (1 genus, 2 species), which constituted the minority (Fig. 2; Appendix 1). At the genus level, the six most species-rich groups were *Polyrhachis* (43 species), *Camponotus* (15 species), *Crematogaster* (15 species), *Colobopsis* (12 species), *Dolichoderus* (9 species), and *Myrmicaria* (7 species) (Fig. 3).

The relative dominance of subfamilies as measured by both species number in each tree and is shown in Fig. 2. Two subfamilies, Myrmicinae and Formicinae, were dominant in the species number for all trees, but the sub-dominant subfamilies varied between trees. At the genus level (Fig. 3), *Polyrhachis* (Formicinae) was the most species-rich genus in all the trees. However, the second most species-rich genus was different among trees: *Crematogaster* and *Camponotus* for Tree 1,

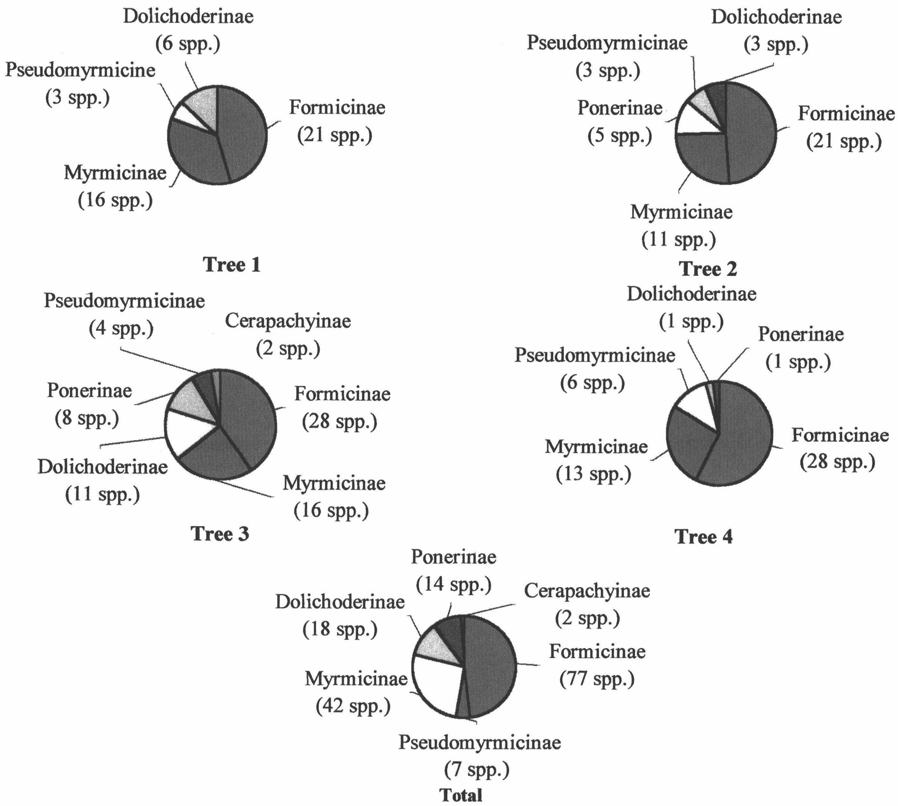

Fig. 2. Relative subfamily dominance as measured by number of species.

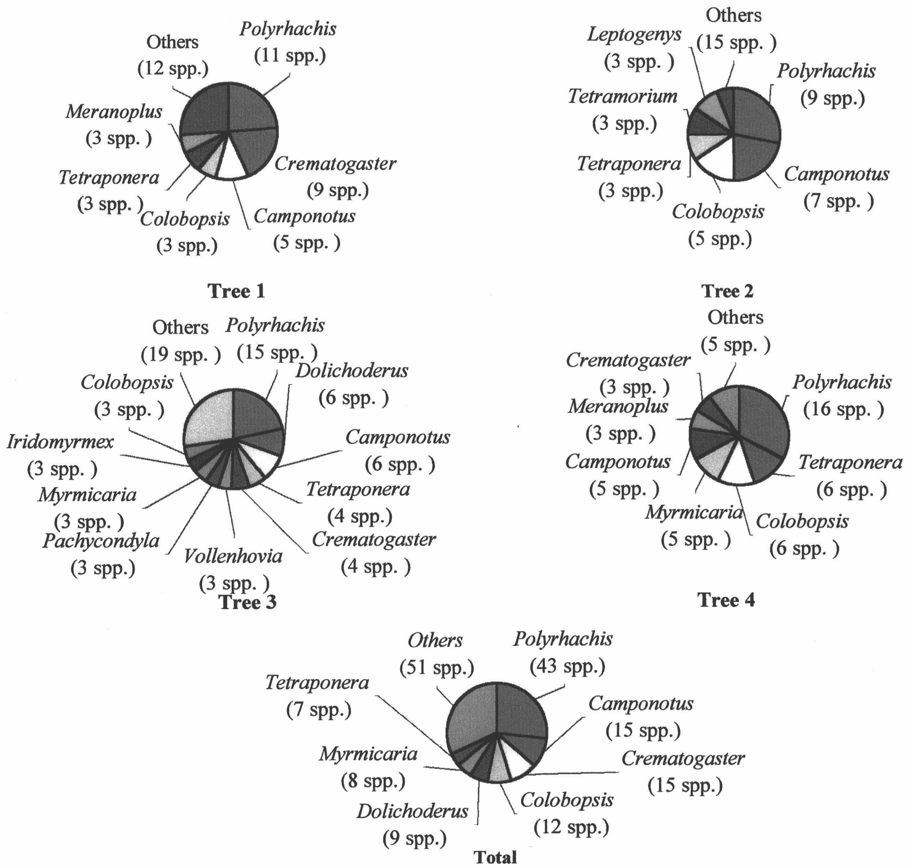

Fig. 3. Relative genus dominance as measured by number of species.

Table. 1. Complementarity (C) of paired isolated trees*

Tree 1				
Tree 2	0.09			
Tree 3	0.19	0.20		
Tree 4	0.26	0.22	0.22	
	Tree 1	**Tree 2**	**Tree 3**	**Tree 4**

* Mean C between trees is 0.20.

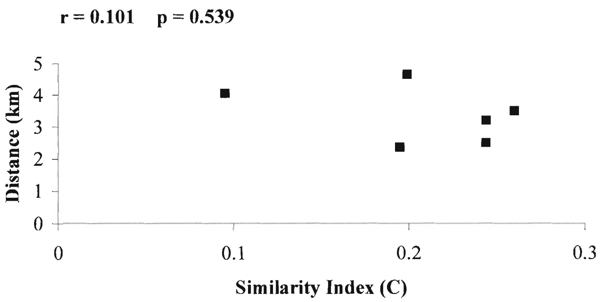

Fig. 4. Index of similarity in ant species composition between paired trees and the distance between the trees.

Camponotus and *Colobopsis* for Tree 2, *Dolichoderus* and *Camponotus* for Tree 3 and *Tetraponera* and *Colobopsis* for Tree 4.

The number of species per tree was relatively similar. Forty-six species were collected from Tree 1, 43 species from Tree 2, 69 species from Tree 3, and 48 species from Tree 4 (Appendix 1). The difference in species composition among the trees was more pronounced than genera and subfamily composition, but only two species, *Camponotus* sp. 10 and *Tetraponera* sp. 6, were common to all four trees. The index of similarity (C) of canopy species in each pair of trees ranged from 0.09 (Tree 1-Tree 2) to 0.26 (Tree 1-Tree 4) (Table 1). The mean value of C for all pairs was 0.20. The relationship between the index of similarity (C) and the distance between trees is shown in Fig. 4. No correlation was found between them (r= 0.10, p= 0.54).

Species diversity and abundance

The relative dominance of abundant subfamilies is shown for each tree in Fig. 5. Myrmicinae dominated Trees 1 and 4, while Trees 2 and 3 were dominated by Formicinae. The six most abundant genera were *Crematogaster* (904 individuals), *Camponotus* (846 individuals), *Dolichoderus* (665 individuals), *Colobopsis* (560 individuals), *Polyrhachis* (470 individuals), and *Myrmicaria* (357 individuals). The sum of these occupied 79.9% of the total number of individuals.

Among the 4889 total ant individuals collected from the four trees, the most abundant subfamily was Formicinae (1920 individuals, 39.3%), followed by Myrmicinae (1880 individuals, 39.2%), Dolichoderinae (799 individuals, 16.3%), Pesudomyrmicinae (182 individuals, 2.9%), Ponerinae (101 individuals, 2.1%), and Cerapachyinae (6 individuals, 0.1%). At the genus level for each of the four trees, *Crematogaster* was the most dominant in Trees 1 and 4, *Colobopsis* in Tree 2, and *Dolichoderus* in Tree 3 (Fig. 6). At the species level, the crowns of four trees had different dominant species. The most abundant species was *Camponotus rufifemur* in Tree 1 (120 individuals, 15.2% of total individuals from the tree), *Colobopsis* sp. 9 (379 individuals, 31.5%) in Tree 2, *Dolichoderus cuspidatus* (418 individuals, 22.7%) in Tree 3, and *Crematogaster* sp. 2 (372 individuals, 35.4%) in Tree 4 (Appendix 1).

The diversity index of ants in the trees ranged from 2.59 to 3.09. The index for all the trees combined was 3.77 (Appendix 1).

Discussion

The results indicate that species compositions of canopy ants differ among isolated trees. Among the 160 species collected, only two were common to the four trees. A separate study in a primary forest of Danum Valley (Erwin Widodo, 1999, unpublished data) showed that ant species compositions in non-isolated trees show higher values for similarity (mean C = 0.51) compared to those in isolated trees (mean C = 0.20). The low values for similarities among isolated trees were most probably caused by separation of the tree crowns, through which migration of canopy ants between trees may have been diminished. Some canopy ant species are able to move across the forest floor to reach neighboring canopy trees (Sudd, 1967). The absence of any correlation between distance and similarity in each pair of trees, however, indicates that such migration seldom occurs or often ends in failure.

Isolation of tree crowns also influences the distribution of dominant ants in the canopy (Majer, 1993; Ozanne et al., 2000). The present study indicates that different dominant ants occupied different trees. On non-isolated trees, this type of distribution pattern is less distinctive (Erwin Widodo, 1999, unpublished data). This is probably because dominant ants can share several contiguous trees with other dominant species if the canopy is closed, which prevents ants from migrating by leaving no gaps.

Majer (1993) indicated that the distribution of sub-

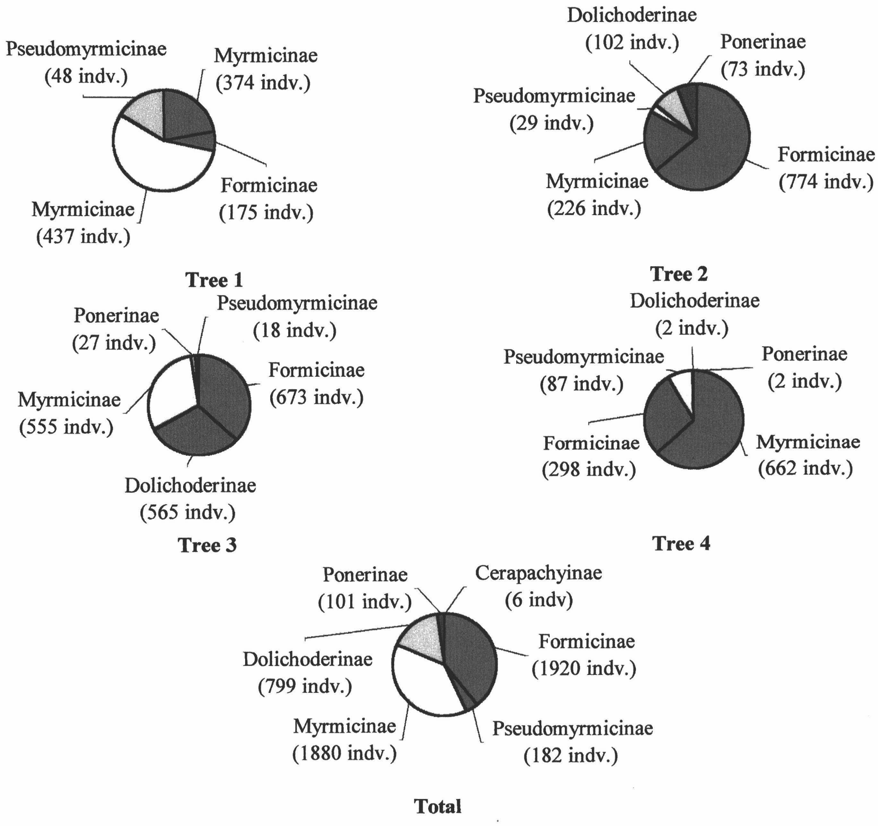

Fig. 5. Relative subfamily dominance as measured by number of individuals.

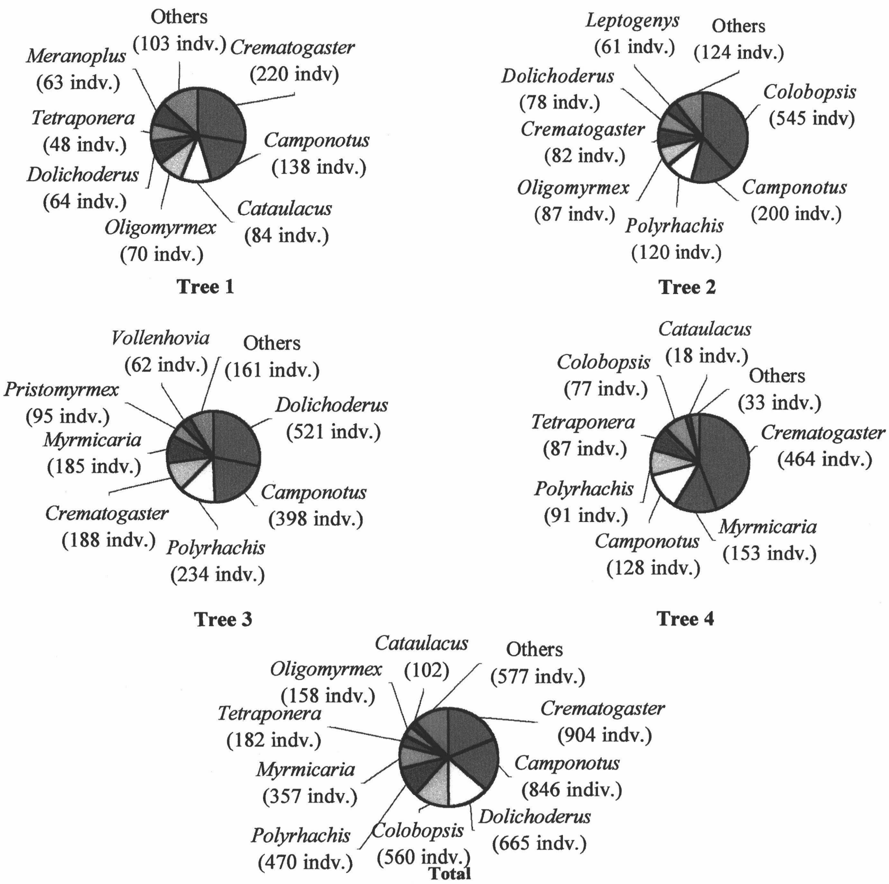

Fig. 6. Relative genus dominance as measured by number of individuals.

dominant and subordinate ants is strongly affected by co-existing dominant ant species. This may be another reason why the species composition of canopy ants in isolated trees was different from each other as demonstrated by an 'ant mosaic'.

The abundance and diversity of canopy ants also affect and control the structure of the other arthropod communities (Majer, 1993). Alterations of dominant species, especially, bring about changes in the composition of associated arthropods such as homopteran insects (Maschwitz, 1984; Majer, 1993). Since the results presented here show that each isolated tree harbors independent ant diversity, this may indicate that species composition and relative abundance of constituting species in an arthropod community also vary among trees. In this sense, an isolated bio-community is easily damaged by severe environmental disturbances, and may contribute to the loss of a large part of biodiversity in the canopy stratum (Basset, 1991, 1992; Recher et al., 1996).

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Appendix 1-1. List of canopy ants from four trees of *Shorea johorensis* (* species common to the four trees)

		Tree 1	Tree 2	Tree 3	Tree 4
	Formicinae				
1	*Lepisiota* sp.			3	
2	*Calomyrmex* sp.			1	
3	*Camponotus rufifemur*	120		207	3
4	*Camponotus gigas*		31		
5	*Camponotus* sp. 3		57		
6	*Camponotus* sp. 4		1		
7	*Camponotus* sp. 5	1			
8	*Camponotus reticulatus*		47	2	
9	*Camponotus* sp. 7	1			
10	*Camponotus* sp. 8	1			
11	*Camponotus* sp. 9		54	179	8
12	*Camponotus* sp. 10 *	**15**	**9**	**6**	**115**
13	*Camponotus* sp. 11				1
14	*Camponotus* sp. 12				1
15	*Camponotus* sp. 13		1		
16	*Camponotus* sp. 14			3	
17	*Camponotus* sp. 15			1	
18	*Cladomyrma* sp.	5			
19	*Colobopsis* sp. 1				18
20	*Colobopsis* sp. 2				32
21	*Colobopsis* sp. 3	3			3
22	*Colobopsis* sp. 4	1			
23	*Colobopsis* sp. 5				21
24	*Colobopsis* sp. 6	2			1
25	*Colobopsis* sp. 7		26		2
26	*Colobopsis* sp. 8		47	1	
27	*Colobopsis* sp. 9		379		
28	*Colobopsis* sp. 10			19	
29	*Colobopsis* sp. 11		1	3	
30	*Colobopsis* sp. 12		1		
31	Genus A				2
32	*Gesomyrmex* sp.	1			
33	*Paratrechina* sp. 1			4	
34	*Paratrechina* sp. 2			10	
35	*Polyrhachis inermis*		1		
36	*Polyrhachis* sp. 2			2	
37	*Polyrhachis bicolor*			1	
38	*Polyrhachis* sp. 4			2	7
39	*Polyrhachis nudata*				3
40	*Polyrhachis* sp. 6				1
41	*Polyrhachis* sp. 7				3
42	*Polyrhachis* sp. 8			2	
43	*Polyrhachis* sp. 9	6		7	
44	*Polyrhachis equina*	2			1
45	*Polyrhachis longipes*			3	46
46	*Polyrhachis vindex*		38		
47	*Polyrhachis* sp. 14	3			
48	*Polyrhachis beccarii*	3			
49	*Polyrhachis* sp. 16				4

Appendix 1-2. (to be continued from Appendix 1-1)

		Tree 1	Tree 2	Tree 3	Tree 4
50	*Polyrhachis* sp. 17	1			
51	*Polyrhachis bellicosa*			2	5
52	*Polyrhachis* sp. 19	3			
53	*Polyrhachis* sp. 20				14
54	*Polyrhachis* sp. 21		1		
55	*Polyrhachis calypso*		1		
56	*Polyrhachis illaudata*	3			
57	*Polyrhachis arachne*				1
58	*Polyrhachis* sp. 27				1
59	*Polyrhachis moesta*		5		
60	*Polyrhachis* sp. 29			3	
61	*Polyrhachis* sp. 30			1	
62	*Polyrhachis hector*		67		
63	*Polyrhachis ochracea*			11	
64	*Polyrhachis* sp. 34	1			1
65	*Polyrhachis armata*			3	
66	*Polyrhachis* sp. 36			2	
67	*Polyrhachis* sp. 38	1			
68	*Polyrhachis* sp. 39	1	1		
69	*Polyrhachis gestroi*				1
70	*Polyrhachis laevigata*		4		
71	*Polyrhachis* sp. 43			193	
72	*Polyrhachis* sp. 44	1			
73	*Polyrhachis* sp. 45			1	
74	*Polyrhachis* sp. 46			1	1
75	*Polyrhachis* sp. 47				1
76	*Polyrhachis* sp. 48		2		
77	*Polyrhachis rastellata*				1
	Pseudomyrmicinae				
78	*Tetraponera attenuata*	3		4	18
79	*Tetraponera* sp. 2	17		1	45
80	*Tetraponera* sp. 3				1
81	*Tetraponera* sp. 4				1
82	*Tetraponera* sp. 5		16		
83	*Tetraponera* sp. 6 *	**28**	**12**	**2**	**9**
84	*Tetraponera* sp. 7		1	11	13
	Myrmicinae				
85	*Cataulacus reticulatus*	83			18
86	*Cataulacus horridus*	1			
87	*Crematogaster sp.*(near *C. difformis*)	1			
88	*Crematogaster* sp. 2	16			372
89	*Crematogaster pallipes*	4		7	
90	*Crematogaster* (near *C. borneensis*)		2	100	
91	*Crematogaster* sp. 5	102			
92	*Crematogaster* sp. 6			70	
93	*Crematogaster* sp. 7	13			
94	*Crematogaster* sp. 8			11	
95	*Crematogaster* sp. 9	3			
96	*Crematogaster* sp. 10				70

Appendix 1-3. (to be continued from Appendix 1-2)

		Tree 1	Tree 2	Tree 3	Tree 4
97	*Crematogaster inflata*	57			
98	*Crematogaster* sp. 12		80		
99	*Crematogaster* sp. 13				22
100	*Crematogaster* sp. 14	15			
101	*Crematogaster* sp. 15	9			
102	*Meranoplus* sp. 1	59	3		7
103	*Meranoplus* sp. 2				2
104	*Meranoplus* sp. 3	3		1	3
105	*Meranoplus* sp. 4	1			
106	*Monomorium* sp.			6	
107	*Myrmecina* sp.		3		
108	*Myrmicaria melanogaster*		18	11	
109	*Myrmicaria luteiventris*		1		2
110	*Myrmicaria subcarinata*			173	
111	*Myrmicaria* sp. 4			1	2
112	*Myrmicaria lutea*				144
113	*Myrmicaria* (near *M. brunnea*)				2
114	*Myrmicaria* sp. 7				3
115	*Oligomyrmex* sp. 1	32		1	
116	*Oligomyrmex* sp. 2	38			
117	*Oligomyrmex* sp. 3		87		
118	*Paratopula* sp.			3	
119	*Pheidologeton* sp. 1			14	
120	*Pheidologeton* sp. 2				15
121	*Pristomyrmex* sp.			95	
122	*Strumigenys* sp.		2		
123	*Vollenhovia* sp. 1		1		
124	*Vollenhovia* sp. 2			1	
125	*Vollenhovia* sp. 3		25	1	
126	*Vollenhovia* sp. 4		4	60	
	Dolichoderinae				
127	*Dolichoderus tuberifer*		78		
128	*Dolichoderus* sp. 2			19	
129	*Dolichoderus* sp. 3			6	
130	*Dolichoderus* sp. 5				2
131	*Dolichoderus cuspidatus*	60		418	
132	*Dolichoderus* sp. 9			15	
133	*Dolichoderus gibbifer*			62	
134	*Dolichoderus* sp. 14			1	
135	*Dolichoderus* sp. 15	4			
136	*Technomyrmex* sp. 1			1	
137	*Technomyrmex* sp. 2			1	
138	*Technomyrmex* sp. 3			3	
139	*Technomyrmex* sp. 4		23		
140	*Technomyrmex* sp. 5	36			
141	*Technomyrmex* sp. 6	23		38	
142	*Tapinoma sp.* 1	3		1	
143	*Tapinoma sp.* 2	4			
144	Genus B		1		

Appendix 1-4. (to be continued from Appendix 1-3)

			Tree 1	Tree 2	Tree 3	Tree 4
	Ponerinae					
145	*Anochetus* sp.1				1	
146	*Anochetus graeffei.*				1	
147	*Hypoponera* sp.			2		
148	*Leptogenys* sp. 1			41		
149	*Leptogenys* sp. 2			19		
150	*Leptogenys* sp. 3			1		
151	*Leptogenys* sp. 4				2	
152	*Leptogenys* sp. 5				3	
153	*Pachycondyla* sp. 1				1	
154	*Pachycondyla* sp. 2				1	
155	*Pachycondyla* sp. 3				17	
156	*Platythyrea* sp. 1			10		
157	*Platythyrea* sp. 2					2
158	Genus C				1	
	Cerapachyinae					
159	*Cerapachys* sp. 1				5	
160	*Cerapachys* sp. 2				1	
	Total (Individual) =4889	Mean = 1,222.5	790	1204	1844	1051
	Total (species) = 160	Mean = 51.5	46	43	69	48
	Total (Diversity Index) H' 3.77	Mean = 2.80	3.09	2.59	2.98	2.56