ANTS AS INDICATOR TOOLS FOR TROPICAL FOREST REGENERATION: A CASE STUDY FROM ULU MUDA FOREST RESERVE

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ABSTRACT

A pilot study on ants as bioindicators of the forest restoration in selected production forest of Peninsular Malaysia was conducted at Ulu Muda Forest Reserve, Baling, Kedah. Ants from three forest compartment with different logging history which are non-logged forest (CONTROL), 1 to 5 years after logging (LF1) and 5 to 10 years after logging (LF2) were sampled using arboreal pitfall traps, ground pitfall traps, baiting and leaf litter sifting. Ant diversity showed no difference from inside CONTROL, LF1 and LF2 (F = 0.56; df = 2 & 203; P = 0.56), which indicates that species diversity did not represent the forest regeneration. Species composition was found to provide a better information on the regeneration process. Forest specialist ants such as *Proatta butelli* in particular were found in the CONTROL, while generalist species such as *Anoplolepis gracilipes* was easily found in LF1 where areas are opened compared to LF2 and CONTROL. On the other hand, ant abundance was found to be higher at the recently LF1 compared to the CONTROLs (F = 2.95, df = 2 & 203, P < 0.05).

Key words: Ants, bio-indicator, species composition, regeneration

ABSTRAK

Kajian awalan terhadap semut sebagai sebagai bioindikator kepada proses pemuliharaan hutan pengeluaran di Semenanjung Malaysia dijalankan di Hutan Simpan Ulu Muda, Baling, Kedah. Persampelan semut dijalankan di tiga bahagian dengan sejarah pembalakan yang berbeza iaitu hutan dara (CONTROL), pembalakan kurang dari 5 tahun (LF1) dan kawasan dibalak lebih dari 5 tahun (LF2) dengan menggunakan kaedah persampelan perangkap lubang arboreal, perangkap lubang tanah, umpanan dan mengayak serasah daun. Tiada perbezaan signifikan terhadap kepelbagaian semut di kawasan CONTROL, LF 1 dan LF2 (F = 0.56; df = 2 & 203; P = 0.56), yang memberikan kesan bahawa kepelbagaian spesies tidak memberikan gambaran tehadap proses regenerasi yang berlaku. Perbezaan komposisi spesies pula memberikan kesan yang lebih baik seperti spesies khas hutan seperti *Proatta butelli* didapati banyak di kawasan CONTROL berbanding spesies umu, seperti *Anoplolepis gracilipes* yang mudah ditemui di kawasan LF1 yang merupakan kawasan yang lebih terbuka berbanding LF2 dan CONTROL. Kelimpahan semut di kawasan yang baru dibalak didapati lebih tinggi secara signifikan berbanding kawsan CONTROL (F = 2.95, df = 2 & 203, P < 0.05).

Kata kunci: Semut, penunjuk biologi, komposisi spesies, pertumbuhan semula

INTRODUCTION

Ant species composition and abundance changes rapidly in response to forest fragmentation and disturbance (Andersen 1997; Majer 1983), thus ants are good candidates as bioindicators of habitat change (Castano-Meneses & Palacios-Vargas 2003; Ruiz et al. 2006; Samways et al. 1997). Ants are widely used as ecological indicators in studies on forest clearing (Majer et al. 1997), land management (Andersen et al. 2002), habitat fragmentation (Brühl et al. 2003), mine site rehabilitation (Andersen et al. 2002) and general anthropogenic disturbances (Floren & Linsenmair 2001). Ant diversity decreases as the disturbance level increases (Watt et al 2002) and disturbed forest tends to have less diversity than pristine forest (Brühl 2001). A study in the Atlantic Forest showed a significant loss of ant diversity in regrowth forest as compared with mature forest indicating that only primary forests and old secondary forests can maintain a substantial proportion of the biodiversity (Silva et al. 2007).

Much less is known about how ant species composition changes in relation to habitat gradients that represent different stages of forest succession after logging. Regenerated forests may resemble mature forests 20–40 years after a disturbance event, and may show recovery of species richness, but recovery of ant species composition may take longer (Dunn 2004).

Management of forest logging in Malaysia aims to minimize negative environmental impacts while conserving biodiversity. To date, few studies have been done to evaluate the effectiveness of the logging process in aiding recovery of biodiversity in regenerated logged over forests (Bruhl et al 2003; Floren 2005; Widodo et al 2004). No information exists on whether production forests that were logged over 30 years ago have recovered species richness and abundance. It is generally known that regeneration of forest after clear-cutting results in decreased insect diversity (Floren 2005). However, forest regeneration and diversity in selectively logged forests, such as practiced in Malaysia, has not been studied at depth. Thus this study aimed to explore the ant’s colonisation and diversity variation during the forest regenerations.

METHODOLOGY

Study Site

Sampling was conducted Ulu Muda Forest Reserve (5° 51' 29.71' N, 100° 54' 58.2912" E), Baling, Kedah. Three forest compartment adjacent to each other were selected as study area to represent three forest regeneration category namely CONTROL (pristine/unlogged forest), LF1 (recently logged over forest, less than 5 years after logging) and LF2 (logged over forest, 5 to 10 years after logging).

Sampling Method

Nine transect of 300 m long has been established at each three compartment with different logging history. At each transect, 10 pitfall traps, 10 arboreal pitfall trap were set, baiting and leaf litter sifting were conducted at every 30 m interval.

Data Analysis

The data collected from these samples were analysed using Margalef index (measure species richness), Shannon Wiener diversity index (measure species diversity) and Pielou evenness index (measure species evenness) for the diversity and distribution between forest regeneration categories. All analyses were carried out using R statistical software.

RESULT AND DISCUSSION

There was no apparent difference in the species richness with logging history with LF1 yielding 93 species to CONTROL's 70 species and LF2's 81 species. While estimated total species richness was highest for CONTROL, the species accummulation curves showed that LF1 yielded more species per sampling effort (Figure 1).

At the subfamily level, Myrmicinae was represented by significantly higher number of species than the Ponerinae, Dolichoderinae and Formicinae subfamilies (F = 0.65, df = 3 & 12, P < 0.01). There were significantly more Myrmicinae in LF1 as compared to LF2 and CONTROL's (F = 0.55, df = 2 & 203, P < 0.05). Apart from that, other subfamilies logging history (F = 0.83, df = 3 & 12, P = 0.93) (Figure 2). A significantly higher number of Myrmecinae were found at LF1 of which species under this subfamily was mostly generalist ants and easily found at the disturbed areas (Stuart & Alloway 1985). In contrast, Formicinae and Ponerinae were higher in CONTROL. Formicinae are mostly forest specialists which were very susceptible to forest changes. Ponerinae, the generalized foragers ants are capable of foraging in the forest in a large radius for food and nesting and easily impaired by the event of logging due to stress of obtaining food source (Floren & Linsenmair 1998). Higher presence of Dolichoderinae in logged over forest (LF1 and LF2) were expected as in the logged over forest due to the opening of canopy. A rapid adaptation of Dolichoderinae ants facilitate the ability of these species to survive under stress. Dominant Dolichoderinae such as *Dolichoderus* sp., can easily adapted to the enviromental stress and able to survive the extreme changes of the environment (Andersen 2000).

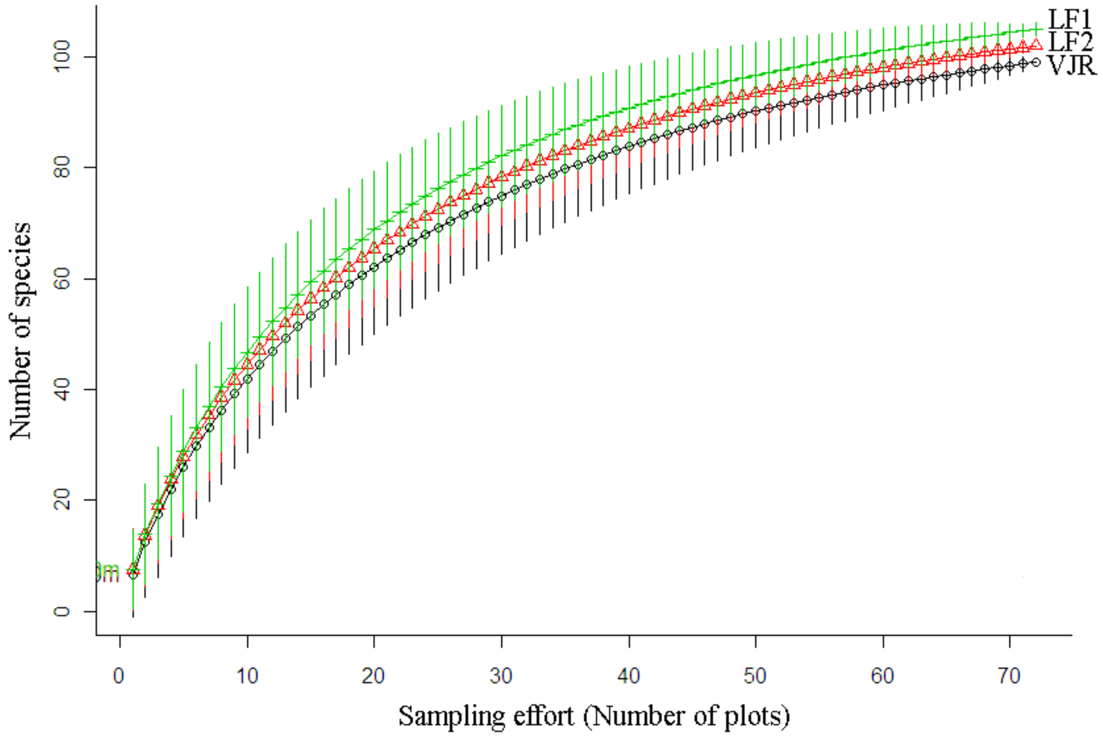

Figure 1. Species accumulation curve in relation to forest regeneration.

Total abundance of ants was significantly higher in LF2 compared to CONTROL (F = 2.96; df = 2 & 203; P < 0.05). Evenness (E') in CONTROL was significantly higher as compare to LF2 (F = 4.75, df = 2 & 199, P < 0.01). There was no significant different of diversity represented by Shannon Index (H'; F = 0.58 ; df = 2 & 203 ; P = 0.56)), and species richness (R'; F = 1.65 ; df = 2 & 203 ; P = 0.19). That there was no significant difference in the ant diversity in relation to the regeneration time (Table 1) concurred with Widodo et al (2004) where similar selective logging practices preserved total species richness in logged forest. High ant's abundance in LF1 supported results obtained in other fragmentation study of which obtained higher ant abundance in a secondary forest (Golden & Crist 2000). Most ants are dietary generalists and in logged areas there seem to be more herbaceous plants that provide nectar and herbivorous insects that feed on the growth in open areas (Menhinick 1963). The food availability to ants may facilitate and cause the high abundance of ants in the sites with more disturbances (Majer & Delabie 1999). The small in size and mobility also facilitate their ability to re-colonize the area after disturbances. Both pasture and young regrowth forest exhibited a distinct ant species composition compared to mature forest, whereas species composition in the old regrowth forest showed greater similarity to that of mature forest (Neumann 1991).

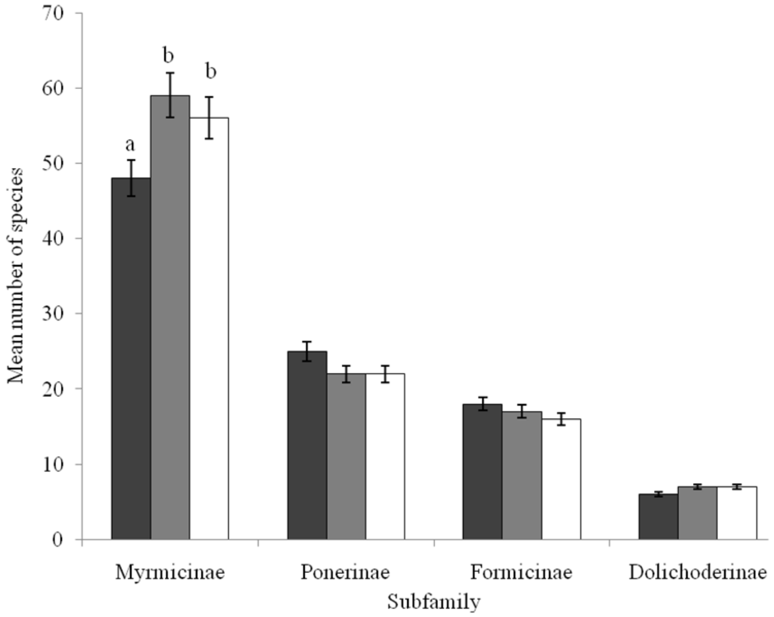

Figure 2. Mean number of species by subfamily collected at according to subfamily in relation to forest regeneration. in CONTROL (■), LF1 (■) and LF2 (□).

Table 1. Number of species, abundance, Margelef Index (R'), Shannon Index (H'), Simpson Index (1-D') and Pielou evenness index (E') of ants in relation to logging history.

Logging history	No of species	Abundance	Margalef index (R')	Shannon-Weiner Index (H')	Simpson Index (1-D')	Evenness Index (E')
CONTROL	93	829^a	7.3 ±0.6	1.4 ± 0.1	0.7 ± 0.1	0.8 ± 0.1^a
LF1	70	1519^b	7.9 ±0.2	1.5 ± 0.1	0.7 ± 0.1	0.7 ± 0.5^b
LF2	81	970^a	8.0 ±0.1	1.4 ± 0.1	0.6 ± 0.3	0.8 ± 0.4^a

Means in columns followed by the same letter are not significantly different ($P<0.05$).

While H was not significantly different for CONTROL, LF1, and LF2, a previous study has reported lower diversity in disturbed forest (Schonberg et al 2004). Ant abundance and diversity increase in forest succession to a climax forest (Floren & Linsenmair 2000). On the contrary, Dejean et al (1994) reported higher ant diversity in disturbed areas. The significantly higher species evenness in CONTROL could be due to the climax vegetation in those primary forest pockets that provide diverse niches for ant species (Chung & Maryati 1996).

Acanthomyrmex, *Eurhopalothrix*, *Aenictus* and *Proatta* were highly associated with CONTROL while species under genera of *Hypoponera*, *Myrmecina*, *Oligomyrmex, Vollenhovia* and *Dolichoderus* were associated with LF2 (Figure 3). Species such as *Proatta butelli* and *Eurhopalothrix* sp A were found only at CONTROL sites. A wider range of ant genera were associated with LF1 including *Discothyrea*, *Recuvidris*, *Calyptomyrmex*, *Crematogaster*, *Secostruma* and *Cerapachys*. *Tetramorium* was found to be associated with LF2 and CONTROL suggesting that species in this genus have a wide range. Species found only in LF1 sites were mainly *Pachycondyla* species.

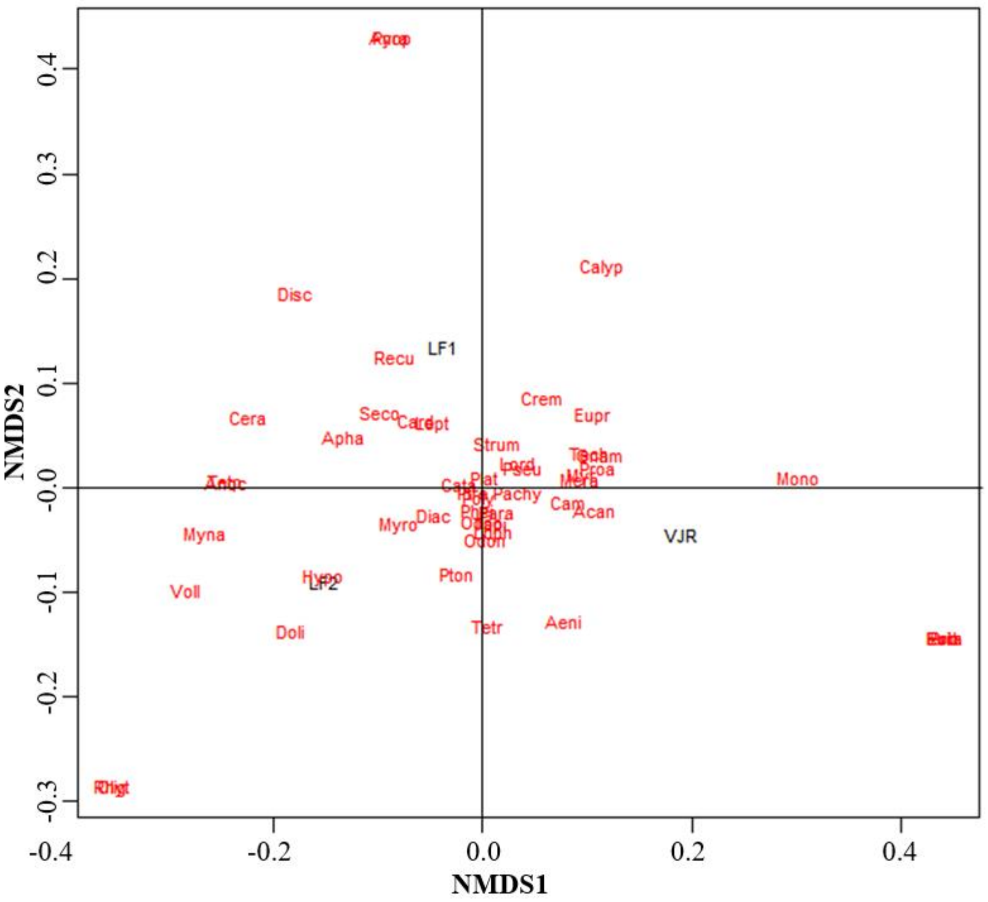

Figure 3. Ordination plot of the ant genera in relation to logging history.

Higher number of species exclusive to CONTROLs, the presence of the rare and cryptic *Proatta butelli* and *Eurhopalothrix* sp. A (Moffett 1987; Deyrup et al. 1997) found only in pristine forest (Floren & Linsenmair 2000) shows that pristine forests are important faunal reservoirs and can hold many more species than adjacent disturbed forest. The abundance of *Pachycondyla* species in LF1 was consistent with their known role as generalist scavengers and arthropod predators (Orivel et al. 2000) and found abundantly in a secondary forest (Orivel & Dejean 2001). Forest specialist ants can persist up to the interior edge of the forests (Majer & Delabie 1999; Watt et al. 2002).

Species that were found in LF2 such as from the genera of *Tetramorium* are also known as oppurtunist which will usually abundant in the logged over area (Fowler et al. 1996). *Tetramorium kraepelini*, which was found solely in LF2, has been reported as a common species in the secondary forest while *Tetramorium bicarinatum* and *Tetramorium curtulum* inhabit primary forest (Bolton 1979; Radchenko et al. 1998). Occurrence of certain species of *Crematogaster* and *Tapinoma* are indicative of relatively undisturbed forest while some *Meranoplus* and *Tetramorium* species indicate a disturbed environment (Burbidge et al. 1992). Species richness, particularly predators was found most affected in the post disturbance assessment. (Campos et al. 2007).

Some particular ant species may need open habitat particularly some of the more invasive species in the tropics like *Solenopsis* spp. (fire ants) and *Anoplolepis gracilipes* (yellow crazy ants). Presence of the *A. gracilipes,* an opportunist species is usually found in disturbed, deforested environment, forest edges and urban areas (Nur-Zati & Ong 2016; Wetterer 2005). Presence of this invasive species may disrupt the indigenous invertebrate fauna and transform the entire ecosystem (Feare 1999).

CONCLUSION

Inconsistency of the species diversity and abundance pattern in relation to the logging history shows that regeneration process is much more complex than just the years after logging. Compositional variation on the species provides a better understanding on the changes occur in the event of regeneration. Sensitive species were unlikely to survive disturbance while generalists' species will likely to take advantage on the area openness and colonised the areas and potentially caused harm to the native community. Further study is needed to incorporate abiotic factors for a better understanding of the interaction as a whole. Replicates from other production forest is also needed to verify the findings.

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APPENDIX

Appendix 1. Ant Species Checklist of Ulu MUda FR in relation to logging history.

Subfamily	**Species**	**CONTROL**	**LF1**	**LF2**
Dolichoderinae	*Dolichoderus* sp.16	14		
	Dolichoderus sp.4			
	Dolichoderus sp.5	1		18
	Dolichoderus sp.3	1		18
	Tapinoma sp.1		7	
	Tapinoma sp.2		3	2
	Technomyrmex sp.2	22		
	Technomyrmex sp.3		1	2
Ectatomminae	*Gnamptogenys modigliani*	20	8	4
Formicinae	*Anoplolepis gracilipes*	8	119	81
	Camponotus gigas	11	7	1
	Camponotus sp.1		35	7
	Camponotus sp.2	3		
	Camponotus sp.3	12	7	
	Camponotus sp.4			2
	Camponotus sp.5	2		
	Camponotus sp.6	1		
	Camponotus sp.7	35		7
	Camponotus sp.8			
	Camponotus sp.9	12	7	
	Camponotus sp.15			2
	Camponotus sp.16	2		
	Camponotus sp.19	1		
	Camponotus sp.21	1		
	Camponotus sp.25	5		
	Camponotus sp.26			10
	Euprenolepis sp.1		6	
	Euprenolepis sp.2		3	
	Myrmoteras sp.1	2		
	Myrmoteras sp.2	2		
	Myrmoteras sp.3	3		
	Oecophylla smaragdina	9		13
	Paratrechina sp.1	4	22	
	Paratrechina sp.2			197
	Paratrechina sp.3	3		
	Paratrechina sp.4	2		
	Paratrechina sp.5	6		
	Paratrechina sp.6	5	23	
	Paratrechina sp.7	4		

Subfamily	Species	CONTROL	LF1	LF2
	Paratrechina sp.8			12
	Polyrhachis bellicosa	4	6	3
	Polyrhachis nigropilosa	1		
	Polyrhachis sp.1	2		4
	Polyrhachis sp.2	2		
	Polyrhachis sp.3			5
	Polyrhachis sp.4	1		3
	Polyrhachis sp.5		6	
	Polyrhachis sp.6	2		
Myrmicinae	*Cataulacus* sp.1	3		
	Craematogaster sp.1	1	25	10
	Craematogaster sp.2	4	15	3
	Craematogaster sp.8		18	12
	Craematogaster sp.9	3		3
	Craematogaster sp.14	12		1
	Craematogaster sp.15		11	46
	Lophomyrmex bedoti	92	57	44
	Meranoplus mucronatus	35	25	41
	Meranoplus malaysianus	7	1	3
	Monomorium sp.1		31	
	Monomorium sp.2	25		12
	Monomorium sp.3	17		
	Monomorium sp.4	2	12	
	Monomorium sp.5		11	32
	Monomorium sp.6	1	12	3
	Myrmicaria sp.1	9	15	
	Pheidole longipes	40	6	2
	Pheidole sp.1	12	35	1
	Pheidole sp.2		69	2
	Pheidole sp.3		33	13
	Pheidole sp.4	13	45	29
	Pheidole sp.5	5	21	10
	Pheidole sp.6	8	38	1
	Pheidole sp.7		32	2
	Pheidole sp.8	7	23	10
	Pheidole sp.9	9		1
	Pheidole sp.10	11	8	3
	Pheidole sp.11	4		
	Pheidole sp.12	5		
	Pheidole sp.13	7	44	2
	Pheidole sp.14	6		13
	Pheidole sp.15	9	38	24
	Pheidole sp.16	3		10

Subfamily	Species	CONTROL	LF1	LF2
	Pheidole sp.17	4	18	1
	Pheidole sp.18	4		2
	Pheidole sp.19	6		10
	Pheidole sp.20	2		
	Pheidole sp.21	11	18	3
	Pheidole sp.22	4		1
	Pheidole sp.23	5		2
	Pheidole sp.24	8	43	2
	Pheidole sp.25		23	13
	Pheidole sp.26		60	41
	Pheidole sp.27	13	8	10
	Pheidole sp.28	4	18	1
	Pheidole sp.29		28	2
	Pheidole sp.30	17	23	10
	Pheidole sp.31	5		1
	Pheidole sp.32	11	28	3
	Pheidole sp.33		4	
	Pheidole sp.34		5	1
	Pheidologeton sp.2	30	40	17
	Pheidologeton sp.3		37	
	Proatta butelii			3
	Pseudolasius sp.4	12		24
	Pyramica sp.1	1		
	Strumigenys koningsbergeri	3		
	Strumigenys sp.1	2		
	Strumigenys sp.2	5		
	Tetramorium kraepelini	5		1
	Tetramorium sp.1		15	
	Tetramorium sp.2		4	7
	Tetramorium sp.3		12	5
	Tetramorium sp.4	2	4	2
	Tetramorium sp.5		5	
	Tetramorium sp.6		10	5
	Tetramorium sp.7			4
	Tetramorium sp.8		6	3
	Tetramorium sp.9	4		2
	Tetramorium sp.10		2	
Ponerinae	*Diacamma* sp.1	5	3	3
	Hypoponera sp.1	18	8	1
	Hypoponera sp.2	1	12	
	Hypoponera sp.3	10		1
	Hypoponera sp.4	8	4	
	Leptogenys sp.1	17	29	2

Subfamily	**Species**	**CONTROL**	**LF1**	**LF2**
	Odontomachus rixosus	18	67	13
	Odontoponera transversa	12	88	39
	Pachycondyla astuta	13	11	10
	Ponera sp.1	9		1
Pseudomyrmicinae	*Tetraponera attenuata*	4	1	
Abundance		826	1519	970
Species Richness		93	70	81