

Comparison of Ground-Ant Diversity Between Natural Forests and Disturbed Forests Along a Natural Gas Pipeline Transect in Thong Pha Phum National Park, Kanchanaburi Province

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ABSTRACT

The diversity in a natural forest of ground-dwelling ants was compared with that associated with reforestation following disturbance from the construction of a gas pipeline and its corresponding forest canopy and litter loss. Ground-dwelling ants were collected using a pitfall-trap method from plots in natural forest and also from plots in disturbed forest that were 20 m wide along a pipeline transect located in the Thong Pha Phum National Park, Kanchanaburi. The results showed that the canopy cover and amount of litter were associated with species richness and abundance of ants. Canopy cover and litter amount were significantly lower in the disturbed plots than the undisturbed plots (natural forest) in hill evergreen forest plots, but no significant difference was detected between disturbed plots and undisturbed plots located in mixed deciduous forest. Ant species and abundance were significantly higher in undisturbed plots than in disturbed plots in hill evergreen forest, but no statistical difference was found between plots in mixed deciduous forest. Ant species were found to be more similar between plots in mixed deciduous forest than between plots in hill evergreen forest. The results indicated that to maintain ant diversity, the permanent trees in the disturbed area along a pipeline transect are very important.

Key words: ground ants, diversity, natural gas pipeline, western forest complex, disturbed forest, replanted

INTRODUCTION

The demand for natural energy is an important factor behind the agreement on natural gas trade between Thailand and Myanmar. A gas pipeline transect was constructed in February 1995 and has been delivering natural gas to Thailand from Thailand's border point at Ban Itong, in the Thong Pha Phum district, Kanchanaburi province.

The pipeline route for its first 50 km

passes through natural forest in the Thong Pha Phum National Park and A1 classified watershed areas, which resulted in the forest within a twenty-meter corridor along the pipeline transect being cleared during the construction phase, with a consequent impact on local biodiversity. Replanting of native and exotic trees after clear cutting along the transect was conducted by PTT Public Company Limited (PTT) with the aim to reduce the impact of the clearing.

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The effects of disturbance and reforestation after the gas pipeline construction were investigated. Ants (Hymenoptera: Formicidae) were selected for the study as they form a large component of the arthropod community on the ground (IBOY, 2000). They perform a wide range of ecological functions, as predators, prey or mutualists with plants or animals (Schultz and McGlynn, 2000). They are relatively sensitive and responsive to ecological changes on a small scale both in space and time. Ants have previously been used as the indicator taxon to assess the impact of environmental change on biodiversity (Hölldobler and Wilson, 1990; Toda and Kitching, 1999; Agosti *et al.*, 2000).

This study aimed to compare the species diversity, abundance and composition of ground-dwelling ant communities in the forest to that in adjacent, cleared areas along a pipeline transect, taking into account two factors of the environmental condition (canopy cover and litter mass) at each site as indicators of habitat change at selected pipeline sites in the Thong Pha Phum National Park, Kanchanaburi province.

MATERIALS AND METHODS

Site description

Thong Pha Phum National Park (TPP) was designated on May 18, 2000, with the aim of conserving the forests and their biodiversity in this region. TPP has a total area of 1,250 km² and is an important part of the western forest complex of Thailand.

The weather in TPP is influenced by the south eastern monsoon in the rainy season and by the north-eastern monsoon. The topography ranges between 100–1,249 m above sea level. The average yearly temperature is 25°C and the annual rainfall is 2,200 mm. TPP comprises two major natural forest types. The first type is hill evergreen forest (HEF), which extends from the Thailand-Myanmar border (in the west) to the eastern part of TPP with an altitude ranging between 800-1,000 m. The important tree species in HEF are *Dellinia obovata*, *Eugenia cumini*, *Lithocarpus ceriferus*, *Vatica odorata*, *Quercus poilanei* and *Syzygium ricipola*. The second natural forest type is mixed deciduous forest (MDF) which is located at lower elevations than HEF with an altitude ranging between 200-300 m. MDF consists of dominant species such as *Lagerstroemia calyculata*, *L. tomentosa*, *Xylia xylocarpa*, *Microcos tomentosa* and *Croton roxbughii*.

Study sites

Three sampling sites were selected along a pipeline transect, located at the 5th (KM5), 27th (KM27) and 44th (KM44) kilometer points respectively (Table 1; Figure 1). At each site, ants were sampled in a disturbed area along the gas pipeline transect (PL) and in undisturbed forest (natural forest; NF) adjacent to the transect.

The first site, KM5 was established in hill evergreen forest. At KM5, the PTT Public Company Limited (PTT) had replanted forest species in the disturbed area after construction.

Table 1 Description of the study sites in natural and disturbed forest along a pipeline transect.

Site	Plot	Habitat	Altitude (m)	GPS
KM5	NF5	Hill evergreen forest	986	47P 0435765UTM 1624055
	PL5	Weeds, small shrubs	903	47P 0434833UTM 1621739
KM27	NF27	Mixed deciduous forest	280	47P 0449800UTM 1613456
	PL27	Young forest plantation	284	47P 0450676UTM 1613278
KM44	NF44	Mixed deciduous forest	201	47P 0460591UTM 1606490
	PL44	Young forest plantation	367	47P 0463805UTM 1605960

See site abbreviation in Figure 1.

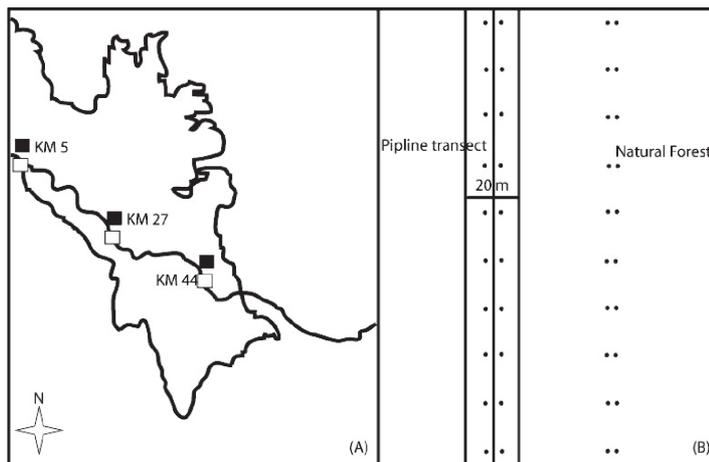


Figure 1 Location map of Thong Pha Phum National Park and study sites along a pipeline transect (A). ■, natural forest (NF) and, □ disturbed forest. KM5, 5th kilometer site; KM27, 27th kilometer site; KM44, 44th kilometer site. Placement of pitfall traps in the study site (B).

Some native and exotic species, such as *Syzygium* spp., *Dillenia obovata*, *Pterocarpus indica*, *Acacia mangium*, *A. auriculaeformis* and *Schima wallichii* had been planted, but most of these replanted trees were unsuccessful due to the high soil erosion and the competition of weeds such as *Melastoma* sp., *Saccharum procerum*, *Chromolaena odorata* and *Cyperus* sp. During the sampling period, the landscape along the pipeline transect at KM5 could be described as a weedy field.

The second site, KM27, was established in mixed deciduous forest on a relatively drier site than the other two sample sites. The forests at this site were patchy and mixed with different ages of teak plantations (*Tectona grandis* L.). This landscape could be described as deteriorated forest.

The last site, KM44, was established in mixed deciduous forest dominated by bamboo and some deciduous tree species. The PTT also replanted the same forest tree species mentioned in the description of KM5 above at sites KM27 and KM44. At these two lower sites, at the time of this study, the trees had successfully grown for about ten years and were getting to the sapling stage (Table 1).

Ant sampling

Ant sampling was carried out at the three sites along the pipeline transect from the north to the south of TPP (Figure 1a). At each site, ants were collected in the disturbed area and in the adjacent forest, which was located at least one kilometer away from the pipeline collecting point to avoid any edge effect. Pitfall traps were placed along two sides of the transect (100 m length) with 10 m between each trap. In the natural forest, placing of traps was conducted using the same method as in the disturbed forest (Figure 1b). Twenty traps were filled with 2/3 ethylene glycol (20%), and left in place for seven days. After seven days, trapped ants were transferred to glass bottles and preserved with 80% ethanol for later sorting and identification in the laboratory. Sampling was conducted during the period March 8-14, 2005.

All ants collected were identified to the level of genera using the key of Bolton (1994) and Hashimoto (2003), and later on to the species and morphospecies level, using the reference collection of the Thailand National Science Museum. Voucher specimens were deposited in the Thailand National Science Museum and the Forest Insect Museum of the National Park, Wildlife and Plant Conservation Department, Thailand.

Measurement of environmental variables

The proportion of canopy cover was estimated along the transect (200 m length) in each plot using a spherical densiometer. Litter depth was also measured in centimetres at each site. Both canopy cover and litter depth were measured at 36 points along the pipeline transect and at 36 points in the natural forest sites.

Data analysis

Statistical testing used the Systat Software Program (1998). A t-test was applied between pairs of NF and PL values at each site for the environmental variables, number of ant species and individuals. The t-test was performed on the mean number of species and individuals per trap. Similarity composition between pairs of NF and PL at each site was performed using Sørensen similarity indices (QS), based on the formula $QS = 2c/(a+b)$, where a is the number of species in sample a ; b is the number of species in sample b ; c is the number of species found in both samples (Wolda, 1981).

RESULTS

Canopy cover and litter in natural-forest and disturbed-forest plots

Canopy cover was much greater and

significantly different in natural forest than disturbed forest along a pipeline transect at KM5 ($t = 50.36, p < 0.01$ and KM27 ($t = 5.43, p < 0.01$) but not significantly different at KM44 ($t = 1.36, p > 0.05$) (Table 2, Figure 2).

The mean depth of leaf litter at each site was much greater and significantly different in natural forest than in disturbed forest along the pipeline transect at KM5 ($t = 6.78, p < 0.01$), but not significantly different at KM27 and KM44 (Table 2, Figure 3).

Species richness

A total of 87 morphospecies of ants, with 9,692 individuals in five subfamilies was collected from all sites (Table 3). There was a greater number of ant species in natural forest than in disturbed forest along the pipeline transect at KM5. At KM5, the total number of species was 39 and 30 in NF and PL, respectively. At KM27, 30 and 24 species were collected in NF and PL, respectively. Contrarily, species richness was higher in disturbed forest than in natural forest at KM44, with 19 and 32 species collected in NF and PL, respectively. A comparison between plots of the number of species showed a significant difference at KM5 between NF and PL ($t = 3.37, p < 0.01$), but no significant difference was detected between NF and PL at KM27 and KM44, respectively (Table 2, Figure 4).

Table 2 T-test between pairs of plot (NF and PL) for environmental variables, number of species and number of individuals of ants at each site.

Source of variation	T-test	KM5		KM27		KM44	
		NF5	PL5	NF27	PL27	NF44	PL44
Canopy cover (%)	t	50.36**		5.43**		1.36ns	
	df	70		70		70	
Depth of litter	t	6.78**		0.92ns		0.54ns	
	df	70		70		70	
Number of species	t	3.37**		0.7ns		-1.17ns	
	df	38		35		38	
Number of individuals	t	1.42ns		1.25ns		1.73ns	
	df	38		35		38	

Remarks: * < 0.05, ** < 0.01 and ns = non significant. See site abbreviation in Figure 1.

Abundance

In Table 3, the highest number of individuals was collected at site KM44, with 5,153 and 1,752 individuals per plot in PL and NF, respectively. The lowest number of individuals was found at KM27 with 491 and 315 in NF and PL, respectively. However, there was no significant difference among the mean number of individuals per trap for all plots (Table 2).

Dominant species

Dominant species were found to be different between NF and PL at the KM5 site. *Pheidologeton affinis* was the most dominant ant species at KM5 with 1,200 individuals in NF (73.80% of total individuals in NF), while *Pheidole* sp. 5 was the most abundant species in the disturbed area along the pipeline (Table 4).

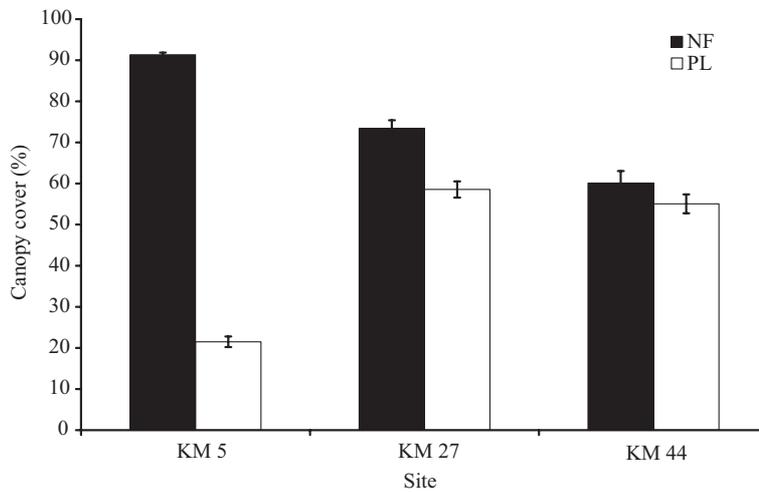


Figure 2 Variation of canopy cover (%) with standard error (SE) in natural forest and disturbed forest along a pipeline transect. See site abbreviations in Figure 1.

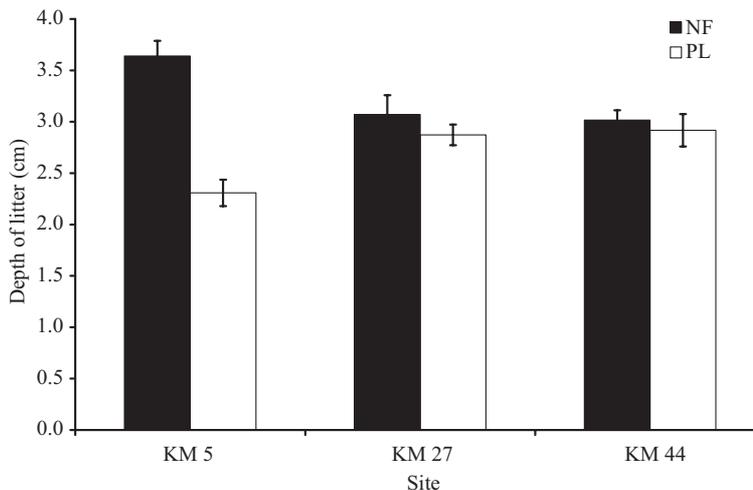


Figure 3 Variation of depth of litter (cm) with standard error (SE) in natural forest and disturbed forest along a pipeline transect. See site abbreviation in Figure 1.

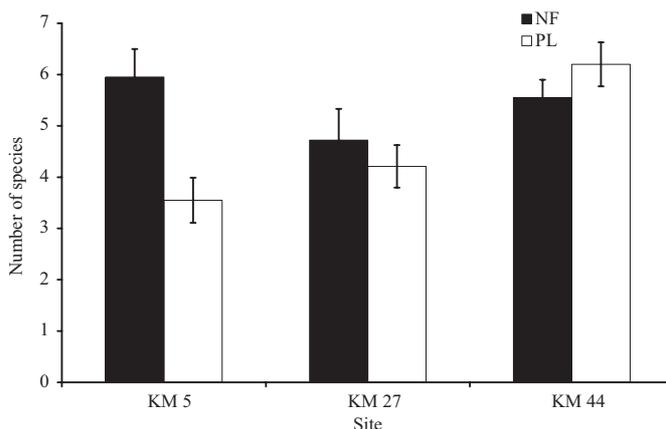


Figure 4 Mean number of ant species with standard error (SE) in natural forest and disturbed forest along a pipeline transect. See site abbreviation in Figure 1.

Table 3 Species and number of individuals of ants collected at each location along a pipeline transect.

Species/sites	KM5		KM27		KM44	
	NF5	PL5	NF27	PL27	NF44	PL44
<i>Acropyga</i> sp. 2			1			
<i>Aenictus ceylonicus</i>	1		1			
<i>Aenictus fergusonii</i>			1	7		
<i>Anochetus graeffei</i>	1					
<i>Anochetus modicus</i>		1				
<i>Anoplolepis gracilipes</i>		5	201		61	20
<i>Aphaenogaster</i> sp. 8	2					
<i>Aphaenogaster</i> sp. 9	1					
<i>Camponotus rufoglaucus</i>				1	4	4
<i>Camponotus</i> sp. 1					13	
<i>Camponotus</i> sp. 2		2	2	1	88	4
<i>Camponotus</i> sp. 4					30	1
<i>Cardiocondyla nuda</i>		2				
<i>Cardiocondyla wroughtonii</i>		7				3
<i>Carebara castanea</i>				1		1
<i>Cataulacus granulatus</i>					1	
<i>Crematogaster coriaria</i>	13			8		
<i>Crematogaster rogenhoferi</i>		7	2	6	1353	872
<i>Diacamma</i> sp. 1	1	1				
<i>Diacamma vargans</i>		1				1
<i>Dolichoderus thoracicus</i>		1				
<i>Dolichoderus tuberifer</i>	1					
<i>Lepisiota</i> sp. 1						2
<i>Leptogenys borennensis</i>					1	
<i>Leptogenys diminuta</i>	10		19	87	7	4
<i>Leptogenys iridescens</i>	5					
<i>Leptogenys</i> sp. 3						8
<i>Lophomyrmex birmanus</i>	127					
<i>Monomorium destructor</i>	2	2		2		
<i>Monomorium floricola</i>						4
<i>Monomorium pharaonis</i>		3	14	18	2	26
<i>Monomorium</i> sp. 1			18	9	1	2

Table 3 (continued).

Species/sites Plots	KM5		KM27		KM44	
	NF5	PL5	NF27	PL27	NF44	PL44
<i>Myopias</i> sp1	1					
<i>Myrmecina</i> sp. 1	1					
<i>Myrmoteras</i> sp. 1	10	2				
<i>Myrmoteras</i> sp. 2	2					
<i>Odontomachus rixosus</i>			4			
<i>Odontoponera denticulata</i>		14	125	85	113	19
<i>Oligomyrmex</i> sp. 1	1					
<i>Oligomyrmex</i> sp. 2		1				
<i>Pachycondyla astuta</i>	13	1				1
<i>Pachycondyla leeuwenhoekei</i>	16	1	12	4	11	
<i>Pheidole capellinii</i>		4				
<i>Pheidole dugasi</i>						66
<i>Pheidole pieli</i>		1	6	5		
<i>Pheidole</i> sp. 1			2	4		6
<i>Pheidole</i> sp. 2				4		
<i>Pheidole</i> sp. 3		6	3			
<i>Pheidole</i> sp. 4	61	8		4	25	35
<i>Pheidole</i> sp. 5	53	248		8	31	1
<i>Pheidole</i> sp. 6	3	13	1	14	1	
<i>Pheidole</i> sp. 7	1					
<i>Pheidologeton affinis</i>	1200		22			
<i>Pheidologeton diversus</i>						3930
<i>Pheidologeton pygmeus</i>	1					
<i>Philidris</i> sp. 1			20			
<i>Plagiolepis</i> sp. 1		1	2	22	3	44
<i>Plagiolepis</i> sp. 2				1		4
<i>Platythyrea</i> sp. 1	1					
<i>Polyrhachis dives</i>	7	2				
<i>Polyrhachis halidayi</i>	1		1			
<i>Pristomyrmex sulcatus</i>						1
<i>Proceratium</i> sp. 2	5					
<i>Pseudolasius</i> sp. 1			2			
<i>Solenopsis</i> sp. 2			1			
<i>Strumigenys</i> sp. 1	2					
<i>Strumigenys</i> sp. 9		1				
<i>Strumigenys</i> sp. 10						3
<i>Strumigenys</i> sp. 11			1			
<i>Tapinoma melanocephalum</i>	3	1	4	21		26
<i>Tapinoma</i> sp. 2	1					
<i>Tetramorium eleates</i>	1		2			4
<i>Tetramorium</i> sp. 1	3					23
<i>Tetramorium</i> sp. 5				1		
<i>Tetramorium</i> sp. 7					1	
<i>Tetramorium</i> sp. 8	2					
<i>Tetramorium</i> sp. 9	1		1			
<i>Tetramorium</i> sp. 10	59					1
<i>Tetramorium</i> sp. 12			1			
<i>Tetraoponera allaborans</i>	2					
Total	1626	355	491	315	1752	5153

Total number of species found was 87 (39 in NF5, 30 in PL5, 30 in NF27, 24 in PL27, 19 in NF44 and 32 in PL44). See site abbreviation in Figure 1.

Table 4 Distribution of the dominant ant species in the forest area and disturbed pipe area along a natural gas pipeline.

Species	Plot%	Species	Plot%
	NF5		PL5
<i>Pheidologeton affinis</i>	73.80	<i>Pheidole</i> sp. 5	69.86
<i>Lophomyrmex birmanus</i>	7.81	<i>Odontoponera denticulata</i>	3.94
<i>Pheidole</i> sp. 4	3.75	<i>Pheidole</i> sp. 6	3.66
<i>Tetramorium</i> sp. 10	3.62	<i>Paratrechina</i> sp. 2	2.53
<i>Pheidole</i> sp. 5	3.26	<i>Pheidole</i> sp. 4	2.25
<i>Pachycondyla leeuwenhoekii</i>	0.98	<i>Cardiocondyla wroughtonii</i>	1.97
	NF27		PL27
<i>Anoplolepis gracilipes</i>	40.94	<i>Leptogenys diminuta</i>	27.62
<i>Odontoponera denticulata</i>	25.45	<i>Odontoponera denticulata</i>	26.98
<i>Pheidologeton affinis</i>	4.48	<i>Plagiolepis</i> sp. 1	6.98
<i>Philidris</i> sp. 1	4.07	<i>Tapinoma melanocephalum</i>	6.66
<i>Leptogenys diminuta</i>	3.87	<i>Monomorium pharaonis</i>	5.71
<i>Monomorium</i> sp. 1	3.36	<i>Pheidole</i> sp. 6	4.44
	NF44		PL44
<i>Crematogaster rogenhoferi</i>	77.23	<i>Pheidologeton diversus</i>	76.26
<i>Odontoponera denticulata</i>	6.45	<i>Crematogaster rogenhoferi</i>	16.92
<i>Camponotus</i> sp. 2	5.02	<i>Pheidole dugasi</i>	1.28
<i>Anoplolepis gracilipes</i>	3.48	<i>Plagiolepis</i> sp. 1	0.85
<i>Pheidole</i> sp. 5	1.77	<i>Pheidole</i> sp. 4	0.68
<i>Camponotus</i> sp. 4	1.71	<i>Monomorium pharaonis</i>	0.50

See site abbreviation in Figure 1.

Ants in the species *Crematogaster rogenhoferi* and *Odontoponera denticulata* were common at KM27 and KM44, both in natural forest and disturbed forest along the pipeline (Table 4).

The most abundant species collected in this study was *Pheidologeton diversus* with 3,930 individuals (40% of total individuals for all plots, 76.26% of plot PL44) and found only in PL44. *Crematogaster rogenhoferi* with 2,240 individuals (23% of total individuals for all plots) was the second most abundant species at site KM44 (at both NF44 and PL44). At KM44, bamboo forests covered most parts of the sampling site and thus more canopy ants such as *Crematogaster* spp were captured at this site.

Species composition

The results showed that few species were shared between NF and PL at each sample site,

with 12, 12 and 13 in KM5, KM27 and KM44, respectively. The lowest value in the similarity index (Sørensen) between NF and PL was found at KM5 with 35%, and a value of 44% at KM27 (MDF site) and the highest value was found at KM44 (MDF site) with 51%.

DISCUSSION

The species richness and abundance of ground-dwelling ants in the disturbed areas along the pipeline transect following successful reforestation tended to be as high as in natural forest at sites KM27 and KM44 (Figure 4). In contrast, species richness and abundance of ground-dwelling ants had significantly decreased in the unsuccessfully-replanted plot, PL5 ($t = 50.36$, $p < 0.01$). Along the pipeline at KM5, microenvironmental parameters such as soil and litter surface temperature would have been affected

as a result of forest clearance and unsuccessful reforestation. The lower percentage of canopy cover and litter would result in fewer species and lower abundance in the disturbed area compared with natural forest (Figure 4 and Table 3). Although this experiment was conducted on a small scale along the pipeline (100 m length and 20 m width), the results may indicate the effects of changes to environmental variables in disturbed forest which have had a marked difference on the species richness of ground-dwelling ants. Even on a small scale, ants have proven responsive to habitat change, with many studies documenting changes in the ant fauna response to various types of disturbance which have resulted in a loss of microclimate in terms of soil and litter characteristics, downed wood and soil surface temperature (Lynch *et al.*, 1988; MacKay *et al.*, 1991)

The site KM27 which was located in small patches of forest had the lowest number of ant individuals both in disturbed and undisturbed forest. This may have been the result of resources being limited by forest fragments and its effect on the microenvironmental variables. Carvalho and Vasconcelos (1999) found that ant species richness and abundance were lower in fragmented forest than continuous forest in the Amazon region.

High numbers of *Pheidologeton diversus* and *Crematogaster rogenhoferi* in PL44 made these two species the most abundant in this study. The Asian myrmicine, *Pheidologeton diversus* ants are usually abundant and their colonies are huge and as great numbers of them travel together to raid prey (Hölldobler and Wilson, 1990), they would be expected to be collected in huge numbers. The second most-collected ant species overall was *Crematogaster* spp with this also being the most collected species at KM 44 in bamboo forest.

Ant species distributions in natural forest and disturbed forest were greater and more similar at the mixed deciduous forest sites (KM27 and KM44) than in hill evergreen forest (KM5). The

disturbed sites at both KM27 and KM44 were successfully replanted and the lower ecological differences between natural forests and disturbed forests at these sites might have played a role in supporting the higher distribution of ants. However, at PL5, because of failure of the reforestation in the disturbed areas, the resultant changes in microclimate in terms of soil and litter might have limited the distribution of some species.

Many reports on deforestation, resulting from clear-cutting, forest clearance and forest conversion to agricultural land uses, have reported a dramatic decrease in the total species number and overall abundance of ants (Watt *et al.*, 2002; Widodo *et al.*, 2004). However, reforestation could mitigate the impacts of fauna biodiversity loss for many taxa (Roth *et al.*, 1994; Watt *et al.*, 2002). Perfecto and Snelling (1995) supported the importance of forest resuscitation resulting in higher ant diversity during a later successional stage when habitat and vegetation have recovered.

CONCLUSION

Microenvironmental variables (canopy cover and litter) were important factors associated with species richness and the abundance of ants. Ant species and their abundance were significantly higher in undisturbed areas than in disturbed areas in the hill evergreen forest, but no significant difference was found between areas in the mixed deciduous forest due to the effects of forest recovery along the pipeline transect. The species richness and abundance of ants were more similar between natural and disturbed forest areas in the mixed deciduous forest than in hill evergreen forest. This study indicated that areas with successful reforestation may help to provide better environmental conditions which can have remarkable effects on ant diversity in disturbed areas along the pipeline transect in the Thong Pha Phum National Park.

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