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GROUND ANT FAUNA IN A BORNEAN DIPTEROCARP FOREST

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ABSTRACT. - The ant fauna of the forest floor was studied in a Bornean lowland dipterocarp forest using honey baits. A total of 51 species belonging to 23 genera was collected from 90 (45 daytime + 45 night) baits set on the ground surface and 90 (45 daytime + 45 night) baits set on tree trunks at 0.5-1.0 m above the ground. Collected species represented only 22% of the total ant species so far known from this area using a combination of several collection techniques. Although some species (*Pheidole* spp., *Camponotus gigas*, *Lophomyrmex longicornis*, etc.) are more frequently attracted than others, the frequency occurrence in these species was much lower than in the dominant species in warm temperate evergreen forests in Japan. Baits put on the ground surface attracted more ant species than those on tree trunks (35 vs. 25 spp.), and only 9 species were common to both types of habitat. Daytime and night baits attracted nearly the same number of ant species (34 vs. 31), only 14 being common to both time zones. Various aspects of ant diet and activity pattern are discussed.

INTRODUCTION

Ants are among the most abundant animal groups in tropical rain forests (e. g. Wong, 1984; Stork, 1987, 1991). According to Wilson (1990), in an Amazonian rain forest, ants occupied approximately one-third of the total biomass of all the insects, and weighed four times as heavy as that of all the vertebrates. Biomass of ants is especially large in the canopy (Tobin, 1991, 1994). In species richness some insect groups (e. g. beetles) may surpass ants (Erwin, 1983), yet ants are much more diverse than the other social insects such as termites, bees and wasps (Wilson, 1990; Bolton, 1995).

Measuring the species diversity of ants in various types of tropical ecosystems has been an important task in recent ecological surveys (e. g. Wilson, 1986). In Southeast Asia several authors have attempted to clarify ant faunas of different forest layers in various types of vegetation, mainly using bait traps (Agosti et al., 1994; Chung, 1992; Chung & Maryati Mohamed, 1993b; Itino & Yamane, 1995; Maryati Mohamed, 1995; Wilson, 1959). The

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results suggest that different layers in a forest and different types of forest may harbor different numbers and sets of ant species. However, since ants nest and forage from in the soil to the canopy up to 70 m above the ground, it is generally difficult to characterize the whole ant fauna of a forest. In particular, studying the arboreal fauna has been extremely difficult owing to unavailability of device for attaining the canopy (but see Fatima Zaharah, 1992; Wilson, 1992; Yamakura et al., 1995).

In the present study in the Lambir Hills National Park, Sarawak, Borneo, we used honey baits to attract ants. Ninety daytime and 90 night baits attracted a total of 51 species on the ground surface and on the lower part of tree trunks. Our final goal is to reveal the whole ant fauna of this forest by means of combining several techniques covering from soil to the canopy. When the survey is completed, we will know what proportion of the whole ant fauna can be known by means of honey bait method at the ground level, which may be easiest way in short-term surveys.

MATERIALS AND METHODS

The present study was conducted in the Lambir Hills National Park, Sarawak, Borneo, from 12 to 31 January, 1993. This lowland forest (100-200 m alt.) includes dipterocarp trees taller than 70 m. In the daytime, 45 baits with 20-30 % honey solution (series GD) were set on the forest floor of the Tower Region along the pass from the entrance of the forest into the Canopy Biology Plot (in total ca. 300 m long). Another 45 baits (TD) were set on tree trunks at 0.5-1.0 m above the ground along the same route in the daytime. The same number of baits (GN, TN) were set on both the forest floor and tree trunks also in the night. In the daytime baits were set around 9:00 and ants were collected around 11:00; in the night around 18:00 and 20:00, respectively. At least one or a few individuals of each ant species attracted to the baits were picked up with forceps, and deposited in alcohol.

To assess the habitat and time preference of each ant species and genus, we performed x^2 tests on the frequency occurrences of the ant taxa on the baits, with habitat type (ground/ tree trunk) and time of day (day/night) as the preference factors. Among the 51 ant species, only seven were analyzed because of their sufficient sample sizes (total frequency occurrences>9). For the generic analyses, six common genera were selected.

General collections of ants were made in the Tower Region combining several techniques to sample the whole ant fauna. However, until now the arboreal fauna has been quite insufficiently surveyed. All the specimens collected were identified in the laboratory. Genus level identification was made using the key by Bolton (1994), and collected specimens were directly compared with type material or specimens identified by authorities in the Forel Collection at Geneve and in the Collection of the Natural History Museum at London. Specimens examined in the present study are deposited in the Collections of the Forest Department of Sarawak (Kuching, Malaysia) and the Faculty of Science, Kagoshima University (Kagoshima, Japan).

RESULTS

1. Species number and composition

With the honey baits, a total of 51 species in 23 genera belonging to 4 subfamilies was collected (Appendix; Table 1). All the ponerine species collected were foragers on the ground. Three species, *Tetramorium laparum*, *Camponotus* sp. aff. *arrogans*, and *Camponotus* (*Tanaemyrmex*) sp. 15, were collected only from honey baits; all other species were represented also in the general collections. About 22% of the total species so far known in the Tower Region were represented by the species attracted to the baits. The highest ratio (30.8%) was obtained for Dolichoderinae (Table 1).

Table 1. Numbers of ant genera and species known so far from the study site compared with the faunal part as revealed by honey baits.

	Number of genera		Number of species	
Subfamily	Total*	With baits (%)	Total*	With baits (%)
Ponerinae	16	4(25.0)	46	4(8.7)
Cerapachyinae	1	0(0)	4	0(0)
Leptanillinae	1	0(0)	1	0(0)
Dorylinae	1	0(0)	1	0(0)
Aenictinae	1	0(0)	6	0(0)
Pseudomyrmicinae	1	0(0)	2	0(0)
Myrmicinae	24	12(50.0)	105	29(27.6)
Dolichoderinae	4	2(50.0)	13	4(30.8)
Formicinae	10	5(50.0)	57	14(24.6)
Total	59	23(39.0)	235	51(21.7)

"*Including several collecting techniques, and covering larger area."

Ants which were most frequently encountered were two species of *Pheidole* , *Ph. plagiaria* var. *giber* (22 baits/180) and *Ph.* sp. 1b (16), and *Camponotus gigas* (16). Other abundant species include *Lophomyrmex longicornis* (13), *Tetramorium palaense* (13), *T. curtulum* (12), and *Paratrechina* sp. 2 (11) (Appendix). Only 3 species of *Crematogaster* and 2 species of *Polyrhachis*, both being very large genera, were attracted to the baits.

The cumulative curve for the species number in each bait series (GD, GN, TG, TN), and that for four series combined indicate that more species are expected to be collected by this method (Figs. 1 & 2).

2. Richness and diversity: ground surface *vs.* tree trunks

Baits set on the ground surface attracted 35 species, while those on tree trunks attracted 25. Although species richness was higher on the former (Shannon diversity index: 2.740 for daytime, 2.852 for night) than on the latter (2.555, 2.142), the equitability indices for ground communities (Shannon equitability index: 0.886, 0.886) were slightly smaller than those for tree trunk communities (0.922, 0.930). This means that the higher diversity on the ground surface simply reflects the larger species number.

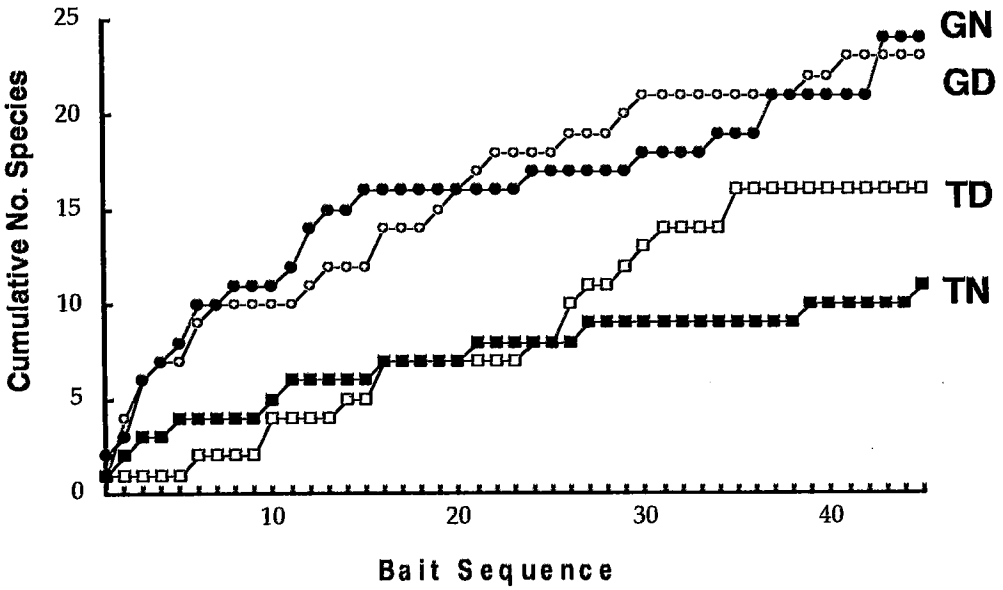

Fig. 1. Cumulative numbers of species collected from the four bait series. GD, ground, day; GN, ground, night; TD, tree trunk, day; TN, tree trunk, night.

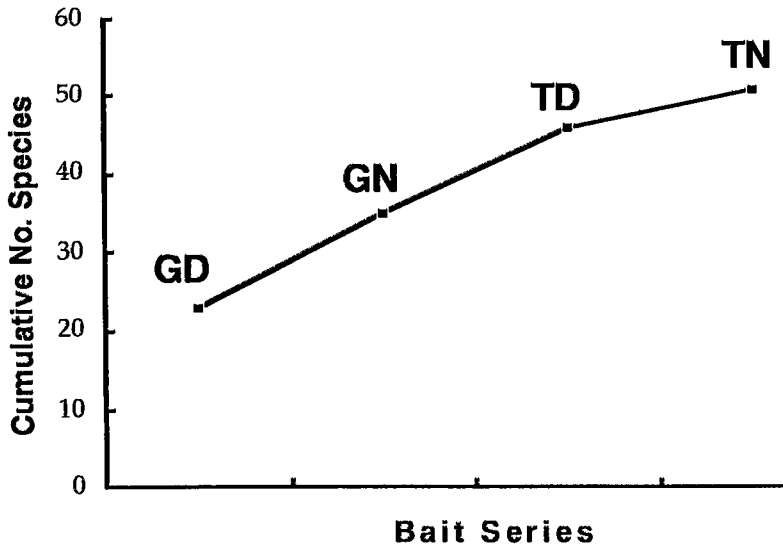

Fig. 2. Cumulative number of species collected from the four bait series. Symbols as in Fig. 1.

Of the 51 species, only nine were common to both types of habitat. Twenty six species were collected from the ground surface alone, and 16 were from tree trunks alone. Among the seven species, which had sufficiently large sample sizes for statistically testing the habitat preferences, five proved to be 'ground' species, which were significantly more often attracted to the ground baits than to the tree-trunk baits, and the other two species had no significant preferences (Table 2). Among the six common genera, five genera excluding *Camponotus* proved to be 'ground' genera (Table 3). We should, however, note that there are 16 ant species which occurred only on tree trunks (Appendix).

The number of attracted ant species per bait was larger for forest floor than for tree trunks (Fig. 3). On the ground surface, baits attracting no ant numbered only two (2.2%), while 46 (51.1%) on tree trunks. Moreover, some baits on the ground surface attracted four or five species, but on tree trunks even baits attracting three species were quite scarce.

3. Richness and diversity: daytime *vs.* night

Thirty four species were attracted to the baits in the daytime, and 31 in the night. Of the 51 species, only 14 were common to both zones of time; 20 species were collected only in the daytime, and 17 only in the night. The result seems to strongly suggest that night collection is indispensable for a faunal survey. However, x^2 tests revealed that only one species (*Tetramorium palaense*) is 'diurnal' and only one (*Camponotus gigas*) is 'nocturnal' among the seven species analysed (Table 2).

Frequency of captures in some abundant genera was compared between daytime and night (Table 3). In three genera (*Pheidole*, *Lophomyrmex*, and *Patarechina*) no difference was found. In *Diacamma, Tetramorium*, and *Camponotus* notable biases were seen; the first two were more frequently trapped in the daytime and the last in the night.

Table 2. Habitat and time preferences of some selected ant species.

Species	Frequency occurrences				Frequency occurrences			
	Ground	Tree trunk	x^2	p	Daytime	Night	x^2	p
Pheidole plagiaria var. *giber*	13	9	1.26	NS	11	11	0	NS
Pheidole sp. 1b	16	0	15.4	<0.01	9	7	0.27	NS
Lophomyrmex longicornis	13	0	11.9	<0.01	6	7	0.08	NS
Tetramorium palaense	13	0	11.9	<0.01	11	2	5.31	<0.05
Tetramorium sp. 3	12	0	10.8	<0.01	7	5	0.09	NS
Paratrechina sp. 2	10	1	6.19	<0.05	4	7	0.39	NS
Camponotus gigas	10	6	1.1	NS	0	16	15.4	<0.01

"Among the 51 ant species collected, those with more than 10 total captures were analyzed."

Table 3. Habitat and time preferences of some common ant genera.

Genera	No. spp.	Frequency occurrences							
	included	Ground	Tree trunk	x^2	p	Daytime	Night	x^2	p
Diacamma	1	8	0	6.4	<0.05	7	1	3.27	NS
Pheidole	7	31	13	7.63	<0.01	25	20	0.58	NS
Lophomyrmex	1	13	0	11.9	<0.01	6	7	0.08	NS
Tetramorium	7	37	2	30.6	<0.01	27	12	5.95	<0.05
Paratrechina	4	14	4	4.62	<0.05	9	9	0	NS
Camponotus	6	18	13	0.83	NS	2	29	22.5	<0.01

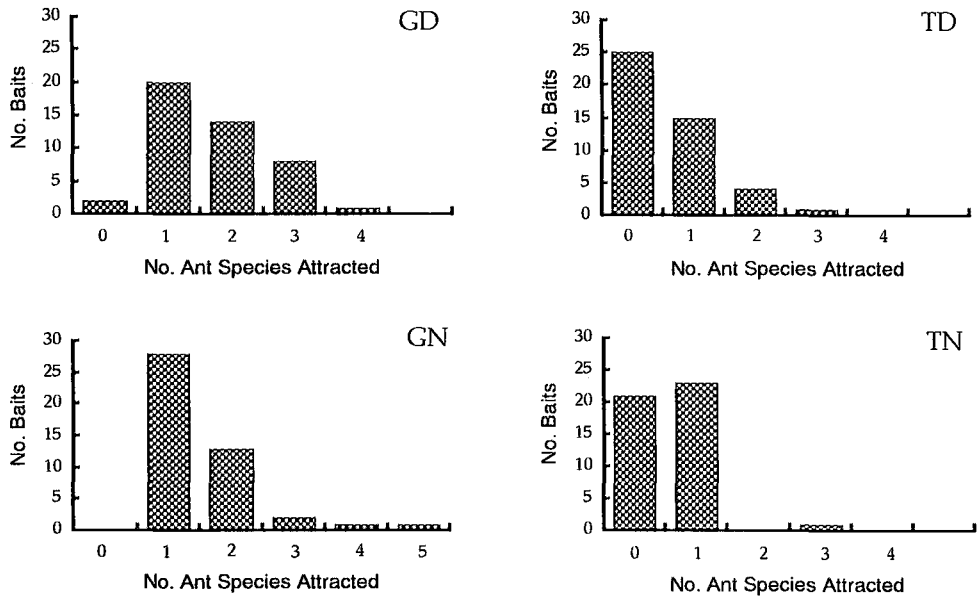

Fig. 3. Number of baits attracting various numbers of ant species in the four bait series. Symbols as in Fig. 2.

DISCUSSION

We have little information on ant fauna studied with honey baits in Southeast Asia. In the present study 35 species were collected from 45 daytime and 45 night honey baits set on the ground in a lowland primary forest in Sarawak. This represented approximately 16% of the ground-level ant fauna, and 15% of the whole known ant fauna there (Yamane and Abdul Rahman, unpubl., but arboreal ant fauna was insufficiently surveyed). A recovering fire-damaged forest in Kalimantan had a poorer ant fauna than the primary undisturbed forest in Sarawak (35 spp. from 90 daytime and 90 night honey baits set on the ground; Yamane, unpubl.), but the difference was rather slight. In a natural evergreen forest in southern Kyushu, Japan, 13, 10 and 8 species were collected from 33, 83 and 54 daytime sugar baits respectively. Only eight species were added by examining 10 soil samples from the same area (Yamane, et al., 1994). Thus, the specie diversity in temperate evergreen forests is much less than in tropical rain forests.

Although some species were more frequently encountered than others, the highest frequency was only 22 baits/180 in *Pheidole plagiaria* var. *giber*. This is quite in contrast to the results obtained in southern Japan by Yamane et al. (1994), where *Paratrechina flavipes* was collected from about half of the baits (78/170). It is not sure whether these frequently baited species are really dominant species there, because competitive ability of each species may be an important factor in determining the frequency of occurrence at baits. But in our experience, species with high competitive ability tend to have larger colonies, consequently larger biomasses.

Species composition of ants attracted to sugar (honey) baits is suggestive in discussing the diet in natural condition. Tobin (1994) argued that ground-dwelling ants have come to rely on carnivory because they are wingless and nectar sources are rare or non-existent at ground level in most forests. The ground-dwelling ants are classified into two major categories.

The first (ground ants) include those mainly foraging on the ground surface irrespective of their nesting habits, and the second (subterranean ants) include those of which almost all their activities except for nuptial flights are conducted underground (or under leaf litter) or within dead wood on the ground. Regarding most (but not all) of the subterranean ants (some ponerines, most species of the tribe Dacetini, etc.), Tobin's observation must be generally correct. However, our results show that some of the dominant ground species or genera including the ponerine *Diacamma intricatum* are strongly attracted to honey baits. *Pheidole* species, though foraging in the canopy at night (Fatimah Zaharah, 1992), may forage also on the ground for carbohydrates. The presence of many sugar-loving species suggests the common occurrence of nectar sources on the forest floor and in the lowest layer of vegetation. Among them would be fallen fruits, extrafloral nectaries and homopterans on shrubs and herbs, etc.

Bait-attracted ant fauna represented only part of the entire ground ant fauna. The curves for cumulative species number in the present study also indicate that there must exist more species that will be attracted to the baits (Figs. 1, 2). This might be partly explained by the patchy distribution pattern of tropical rain-forest ants (Levings, 1983). This also may have reflected the occurrence of frequent competitive interactions at the bait site. In at least southern Japan, honey baits are quickly occupied and monopolized by one or two dominant *Pheidole* species, but after their colonies are satisfied other species are allowed to take honey; sometimes two to five subordinate species can share a single bait (Wakashiba, pers. comm.). Chew (1977) and Chew & Chew (1980) discussed possible mechanisms permitting coexistence of many species in temperate ant communities (for the ant mosaic in the rain forest canopy, see Majer, 1993).

Bait-attracted ant fauna was richer on the ground surface than on tree trunks at 0.5-1.0 m above the ground. This is easily explained by the fact that baits put on the ground can be approached by ants from all the directions, while on tree trunks ants must come from restricted directions, usually from above or below. The present results support Fatimah Zaharah's (1992) observations that *Pheidole* species go up trees in the night. Although Wilson (1959) thought that few ground species in New Guinean rain forests forage on trees, in Borneo many species climb into tree canopies in the night. Among them are the giant forest ant *Camponotus gigas* (Chung & Maryati Mohamed, 1993a), *Pheidole* spp., *Pheidologeton* spp., etc. (Fatimah Zaharah, 1992).

Different sets of ant species are collected by different types of trap or technique (Chung & Maryati Mohamed, 1993b; Olson, 1991; Gadagkar et al., 1993). Moreover, the present study indicates the importance of night collection for some ant groups. The combination of several techniques and daytime and night collections will yield more species, though for rigorous comparison of ant fauna between habitat types or geographical regions a standardized method should be established.

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APPENDIX

Species	GD1	GD2	GD3	GDT	GN1	GN2	GN3	GNT	TD1	TD2	TD3	TDT	TN1	TN2	TN3	TNT	GT	TT	DT	NT
Diacamma intricatum	1	6		7	1			1									8		7	1
Pachycondyla astuta		2		2													2		2	
Odontoponera transversa						1		1									1			1
Brachyponera aff. *luteipes*	1			1													1		1	
Aphaenogaster sp. 2		1		1	1	1		2									3		1	2
Pheidole plagiaria	2	1	3	6	2	2	3	7	3	2		5	1	1	2	4	13	9	11	11
Pheidole sp. 1b	5	3	1	9	4	1	2	7									16		9	7
Pheidole sp. 11					1			1		1	1	2					1	2	2	1
Pheidole sp. 3			1	1													1		1	
Pheidole sp. 4									1			1						1	1	
Pheidole aff. *aristotelis*										1		1						1	1	
Pheidole sp. 6						1		1									1			1
Lophomyrmex longicornis	1	5		6	2	3	2	7									13		6	7
Acanthomyrmex ferox	1		1	2						1		1					2	1	3	
Acanthomyrmex dusun ?		1		1													1		1	
Acanthomyrmex concavus	1			1													1		1	
Tetramorium palaense	4	1	6	11	1		1	2									13		11	2
Tetramirium bicarinatum															1	1		1		1
Tetramorium sp. 1a	2	4		6	1	2		3									9		6	3
Tetramorium curtulum			7	7			5	5									12		7	5
Tetramorium laparum									1			1						1	1	
Tetramorium chepocha			2	2													2		2	
Tetramorium aptum						1		1									1			1
Meranoplus castaneus											1	1						1	1	
Meranoplus sp. 1					1			1									1			1
Pristomyrmex sp. 2											1	1						1	1	
Myrmicaria lutea															1	1		1		1
Solenopsis sp. 4					1			1									1			1
Monomorium sp. 1											1	1						1	1	
Crematogaster deformis							1	1									1			1
Crematogaster vacca									1			1						1	1	
Crematogaster sp. 3									1			1						1	1	
Smithistruma sp. 2						1		1									1			1
Tapinoma sp. 1									1	1	2	4						4	4	
Technomyrmex sp. 5															2	2		2		2
Technomyrmex modigliani					1			1					1			1	1	1		2
Technomyrmex butteri	1			1					1			1			1	1	1	1	1	1
Anoplolepis longipes	4			4	1			1									5		4	1
Oecophyla smaragdina	1			1													1		1	
Paratrechina sp. 1	1			1													1		1	
Paratrechina sp. 2	1	1	2	4	2	1	3	6							1	1	10	1	4	7
Paratrechina sp. 3		1		1	1			1		2	1	3					2	3	4	1
Paratrechina sp. 4						1		1									1			1
Camponotus gigas					2	3	5	10						3	3	6	10	7		16
Camponotus arrogans		1		1		2	1	3					2	3		5	4	5	1	8
Camponotus aff. *arrogans*						1		1									1			1
Camponotus sp. 72													1			1		1		1
Camponotus aff. *vitrea* (sp. 9)									1			1						1	1	
Camponotus sp. 15					2	1		3									3			3
Polyrhachis tyrannica										1		1						1	1	
Polyrhachis nigropilosa															3	3		3		3
Total (species) 51	14	12	8	22	16	15	9	25	8	7	6	16	4	3	8	10	35	25	34	31
Total (frequency)	26	27	23	76	24	22	23	69	10	9	7	26	5	7	14	26	145	52	102	95