- Short Communication -

The Vertical Distribution of Ants on Canopy Trees in a Bornean Lowland Rain Forest

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ABSTRACT The species composition of ants attracted to sugar baits was compared between four vertical levels of eleven canopy trees in a mixed dipterocarp forest in Sarawak, Malaysia. Fifteen, six and four species were collected at the subcanopy, understory, and forest floor levels, respectively, while no ants were attracted to the baits at the top layer (upper canopy) in the daytime. The ground ant fauna includes the predatory ponerine ants and carnivorous or omnivorous *Pheidole* ants. In contrast, many species of *Camponotus*, *Crematogaster*, and *Polyrhachis* were found in the subcanopy. The latter ants may be thought of as omnivorous or herbivorous ants which feed on plant nectar and/or arthropod exudates. The overlap in species composition between trees was relatively small.

Key Words: canopy / ant / Borneo / vertical distribution / *Dipterocarpus*

A large part of the biodiversity found on this planet exists in the canopy of tropical rain forests. Although the ant fauna is not particularly diverse compared to such other arthropod groups as beetles (e.g., Stork, 1987), ants have been found to be the most abundant insects and to constitute the largest proportion of the animal biomass in the canopy of tropical rain forests (Adis *et al.*, 1984; Tobin, 1991). It is still unclear, however, in what part of the canopy and at what time of the day ants are active, on what they forage in the canopy, and where they nest.

Tobin (1991, 1994) proposed that ants function as primary consumers in the canopy of tropical rain forests because their biomass is too large for them to function as secondary consumers (predators or scavengers). Although numerous studies in the temperate region have shown that in some species fluids are quite important (articles cited by Tobin, 1994; Yoshimoto & Yamane, 1990; Itino *et al.*, unpubl.), there has been no direct evidence showing that ants are primary consumers in tropical rain forest canopies. Our canopy-observation system in Borneo is suitable for testing Tobin's (1994) hypothesis. As a first step towards this goal, we conducted a short-term survey of the species composition of ants in the upper canopy, subcanopy, and understory (on the tree trunk) as well as on the forest floor.

MATERIALS AND METHODS

The data were collected in the Lambir Hills National Park, Miri, Sarawak, Malaysia (4°2'N, 113°50'E, 100-200 m in altitude). We established an eight ha (200 × 400 m) plot within an intact mixed dipterocarp forest and constructed two tree towers connected by several walkways (300 m in total length) (for details, see Inoue *et al.*, 1994). This canopy-observation system enabled us to reach the canopy layer and collect ant samples. Within the

Table 1. Vertical and between-tree distributions of the numbers of ant species trapped by sugar baits. —(1)— means that the two sampling areas had one ant species in common.

	Tree species	
	<i>Dipterocarpus pachyphyllus</i> (Site 1)	Others (Sites 2 & 3)
Upper canopy (45 - 48 m)	0	—
Subcanopy (25 - 35 m)	8	8
Understory (1 - 2 m)	3	3
Floor (0 m)	4	—

plot we established the following sites for trapping ants.

Site 1. A *Dipterocarpus pachyphyllus* (Dipterocarpaceae) tree (main tree; 48 m tall) was selected that was standing next to the tree tower 2. Upper canopy layer (45-48 m above the ground): 22 dispersed trapping points on the branches or leaves. Subcanopy layer (25-35 m): 17 points on the branches. Understory layer (1-2 m): 3 points on the trunk of the main tree, 4 points on the trunk of two subcanopy trees next to the main tree, and 2 points on the branches of several understory shrubs within 20 m from the main tree. Forest floor (0 m): 4 points on the fallen leaves within 20 m from the main tree.

Site 2. Traps were set on ten canopy trees (9 species) along the walkways (W1-W7), each 5-30 m apart (50-180 m from Site 1). Subcanopy layer (15-30 m): 2 points on the branches of each tree (20 points in total).

Site 3. Twelve understory trees (4-6 m tall) under the first walkway, each 5-10 m apart (180-200 m from Site 1, 0-150 m from Site 2) were used for trapping. Understory layer (1-2 m): 1 point on the branch of each tree (12 points in total).

We used sugar baits to attract ants. Absorbent cotton wads were soaked in 5 ml sugar solution (conc. 25 %). The sugar baits were put directly onto the setting points at 9:30-10:30 a. m. on August 30, 1993 at Site 1, and at 9:30-10:30 a. m. on August 25, 1993 at Sites 2 and 3. Two hours later, all the ants on each bait were collected.

RESULTS

Table 1 shows the number of ant species attracted at different layers. Several notable facts are worthy pointing out. First, there were no ants attracted to the baits in the upper canopy. The weather conditions there are inhospitable in the daytime (hot and dry), and the extrafloral nectaries on the leaves of *D. pachyphyllus* did not secrete any nectar. This pattern may explain this negative result. Second, although we collected 8 species in the subcanopy of the *D. pachyphyllus* tree and 8 species in the subcanopy of the other 10 canopy trees, there was only one species common to both kinds of site. But since the total number of ant species in the subcanopy seems to be much greater, the small species overlap between different trees could be at least partly due to small sampling size. Finally, the ant fauna at the ground level differs considerably from those at other levels (there is no overlap). However, this may again have been caused in part by the small sample size, because many of the species collected in the subcanopy were collected on the ground as well as in the understory during general collections. (For the species composition of ground ants, see Yamane & Itino, in prep.)

Figure 1 shows the cumulative number of ant species collected in the subcanopy of Site 1

Fig. 1 Cumulative number of ant species collected in the subcanopy of a *Dipterocarpus pachyphyllus* tree and 10 other trees.

(*D. pachyphyllus*) and Site 2 (other 10 canopy trees). At both sites, the number of ant species was still increasing just before the end of sampling, which suggests that additional species are present. The curve for the ten trees was steeper than that for the *D. Pachyphyllus* tree, suggesting that the variation in species composition among trees may be important.

The vertical distribution of individual ant species is shown in Table 2. The ground ant fauna includes the predatory ponerine ants and the carnivorous or omnivorous *Pheidole* ants. In contrast, many species of *Camponotus*, *Crematogaster*, and *Polyrhachis* were found in the upper part of the trees. Almost nothing is known of their food habits. However, they could be regarded as omnivorous or herbivorous ants which feed on plant nectar and/or arthropod exudates (Tobin, 1994; pers. comm.).

Table 2. Distribution of ant species across three vertical levels (Sites 1-3).

Subcanopy (25 - 35 m)	Understory (1 - 2 m)	Floor (0 m)
<i>Camponotus saundersi</i>	<i>Camponotus gigas</i>	<i>Odontoponera transversa</i>
<i>C. cylindricus</i>	<i>C. gilviceps</i>	<i>Diacamma intricatum</i>
<i>C. leonardi</i>	<i>C. saundersi</i>	<i>Pheidole</i> sp. 1(b)
<i>C. arrogans</i>	<i>Crematogaster</i> sp. 4	<i>Pheidole</i> sp. 14
<i>C. vitrea</i>	<i>Cr.</i> sp. 6	
<i>C.</i> sp. 22	<i>Polyrhachis armata</i>	
<i>Crematogaster</i> sp. 6		
<i>Cr. biroi</i> var. <i>bandarensis</i>		
<i>Cr.</i> sp. 30		
<i>Polyrhachis abdominalis</i>		
<i>P. bellicosa</i>		
<i>P.</i> sp. 10		
<i>Tetraponera attenuata</i>		
<i>Tetramorium laparum</i>		
<i>Meranoplus castaneus</i>		

DISCUSSION

Although the present results were derived solely from sugar bait-trapped ants, they show a difference in ant species composition between the forest floor and the subcanopy. Wilson (1987) reported that the arboreal ant fauna of Peruvian Amazon was diverse and numerically dominated by *Crematogaster* and *Camponotus*. The present results are consistent with Wilson's observation in two ways. First, the arboreal ant fauna seems very diverse in Sarawak, judging from the accumulation curves for ant species (if ants living under bark, in dead twigs, or on epiphytes are counted, the species number would drastically increase). In the Amazon, Wilson (1987) found a maximum of 43 ant species on a single tree. Stork (1987) collected between 10-32 ant species on a single canopy tree in Borneo treated with insecticide.

Second, the pantropical dominance and diversity of arboreal *Crematogaster* and *Camponotus* indicate the degree of their adaptations in the canopy of rain forests and their radiation in this habitat. These two genera are also among the most important members of 'plant-ants'. In Sarawak, several *Crematogaster* species are symbiotic partners of *Macaranga* spp. and several *Camponotus* species are associated with *Korthalsia* spp. (Itino & Yamane, in prep.; also see Fiala *et al.*, 1994).

The relative scarcity of other arboreal arthropods (in biomass), and the large biomass of arboreal ants in neo- and palaeotropical habitats suggests they are possibly primary consumers, as was already proposed by Tobin (1991, 1994). Extrafloral nectar and arthropod exudates may be among the primary resources of arboreal ants. So far, however, almost nothing is known about the foraging ecology in forest canopies. For example, not a few species of *Camponotus*, especially those of the subgenus *Colobopsis*, frequently move between forest floor and trees. There is a possibility that some 'arboreal' species forage on the ground. Studies of nesting and foraging biology of 'arboreal' species will be needed to answer this question.

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REFERENCES

- Adis, J., Lubin, Y. D. & Montgomery, G. G. 1984. Arthropods from the canopy of inundated and terra firme forests near Manaus, Brazil, with critical considerations on the pyrethrum-fogging technique. *Studies on Neotropical Fauna and Environment* **19**: 223-236.
- Fiala, B., Linsenmair, K. E. & Maschwitz, U. 1994. Diversität von Interaktionen zwischen Ameisen und Pflanzen im südostasiatischen Regenwald. *andrias* **13**: 169-178.
- Inoue, T., Yumoto, T., Hamid, A. A., Ogino, K. & Lee, H. S. 1994. Construction of a canopy observation system in the tropical rainforest of Sarawak. In: Inoue, T. & Hamid, A. A. (ed.), *Plant Reproductive Systems and Animal Seasonal Dynamics—Long-term study of dipterocarp forests in Sarawak*, 4-18. Center for Ecological Research, Kyoto University (Otsu).

- Stork, N. E. 1987. Guild structure of arthropods from Bornean rain forest trees. *Ecol. Entomol.* **12**: 69-80.
- Tobin, J. E. 1991. A neotropical rain forest canopy ant community: some ecological considerations. In: Huxley, C. R. & Cutler, D. F. (eds.) *Ant-Plant Interactions*, 279-307. Oxford University Press, Oxford.
- Tobin, J. E. 1994. Ants as primary consumers: diet and abundance in the Formicidae. In: Hunt, J. H. and Nalepa, C. A., eds., *Nourishment and Evolution in Insect Societies*. Westview Press, Boulder.
- Wilson, E. O. 1987. The arboreal ant fauna of Peruvian Amazon forests: a first assessment. *Biotropica* **19**: 245-251.
- Yoshimoto, T. & Yamane, Sk. 1990. Food habits of some ant species inhabiting the Taisho lava of the Sakura-jima volcano, Japan (Hymenoptera, Formicidae). *Rep. Fac. Sci. Kagoshima Univ. (Earth Sci. Biol.)* **23**: 9-22. (In Japanese with English summary.)

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市野隆雄, 山根正気 ボルネオの低地降雨林における林冠木上でのアリの垂直分布

マレーシア国サラワク州ランビル国立公園にある混交フタバガキ林において、11本の林冠木上におけるアリ種構成の垂直分布を、日中ショ糖ベイトトラップを用いて調べた。亜林冠部（地上高25-35m）、下層部（1-2m）、および林床部ではそれぞれ、15、6および4種のアリが採集されたが、林冠の最上層部（45-48m）ではアリはまったく誘引されなかった。林床部では捕食性のハリアリ亜科および肉食性あるいは雑食性のオオズアリ属のアリが採集されたのに対し、樹上（亜林冠部および下層部）ではオオアリ属、シリアゲアリ属およびトゲアリ属などの、植物の花外蜜や同翅目昆虫のだす甘露などを主な餌源としている可能性のあるアリが多く採集された。林冠木ごとのアリの種構成の重なりは比較的小さかった。