

# **Ant Species Diversity in the Bogor Botanic Garden, West Java, Indonesia, with Descriptions of Two New Species of the Genus *Leptanilla* (Hymenoptera, Formicidae)**

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**ABSTRACT** Ant fauna was investigated in the Bogor Botanic Garden (Kebun Raya Bogor), West Java, Indonesia, by the following sampling methods: (1) collection of ants on tree trunks, (2) collection of litter ants using a handy sifter, (3) pitfall traps, (4) sugar baits, (5) collection of ants on bamboo shoots, (6) searching for colonies, (7) collection of foraging workers. In all, 216 species representing all the subfamilies known from the Oriental region were collected in 1985 and between 1990 and 1998. After intensive collections in 1995 and 1997, the cumulative number of ant species was still increasing slowly in 1998. The ant fauna was compared with the results from other sites in Southeast Asia, and those of preliminary surveys made by us in four national parks in West Java, i.e., Ujung Kulon and Pangandaran (lowland forests), and Gunung Halimun and Gunung Gede (mountain forests). Species composition in the Bogor Botanic Garden was similar to that of lowland rainforests in West Java, but remarkably different from mountain forests.

**Key words:** ants / diversity / Indonesia / sampling method / fauna / *Leptanilla*

Ants are one of the most dominant terrestrial animal groups in the tropics (Wilson, 1990). Most ants are predators so that they may have an important function in tropical ecosystems. In spite of the importance of studying biology and ecology of tropical ants, our knowledge of them is still scanty and fragmental. Even their taxonomy, basic to the study of every aspect of biology, is desperately incomplete (Ogata, 1992). Especially in the Oriental tropics, myrmecofauna has been rarely investigated after the pioneer works by F. Smith, C. Emery, A. Forel, and W. M. Wheeler in the late 19th and early 20th century. Beside the importance of their function in ecosystem, ants are now regarded to be useful insects as an indicator of biodiversity (e.g., Andersen, 1990; Majer & Beeston, 1996; Abensperg-Traun *et al.*, 1996; Longino & Colwell, 1997; Lawton *et al.*, 1998). Recently,

intensive researches have been carried out in several national parks and forest reserves in West and East Malaysia (Rosciszewski, 1995; Yamane, 1997; Yamane *et al.*, 1996; Chung & Maryati, 1996; Brühl *et al.*, 1998), though solid information on the ant fauna has not yet been available for any place in Indonesia (but see Dammermann, 1948 for the Krakatau). We have collected ants from several sites in West Sumatra and West Java during our researches on population dynamics of phytophagous insects and social organization and ecology of several ant species (see other papers in this volume, and those cited in this paper). As a first report of our myrmecofaunal survey in Indonesia, we will give a list of ants collected in the Bogor Botanic Garden, West Java, discuss the relative efficiency of different sampling methods, and compare ant faunas of Asian tropical forests.

The Bogor Botanic Garden is a famous tropical botanic garden established in early 19th, being one of the most attractive places to tourists in West Java. Several ant researchers already visited the Bogor Zoological Museum which was situated in the botanic garden, and collected ants there for taxonomic studies (*e.g.*, Bolton, 1976). However, up to now the ant fauna of the botanic garden has never been investigated systematically, probably because it always suffers much human disturbance, making it unattractive to researchers of primary forest faunas. However, faunal survey of ants in this garden is still important because of the following three reasons: (1) not a few ant species were described as new to science from Bogor (probably from the botanic garden) in the late 19th and early 20th century (*e.g.*, Emery, 1896; Forel, 1905, 1913; Wheeler, 1928; Wheeler & Wheeler, 1930; Karavaiev, 1935), though their descriptions were often inadequate and the condition of type specimens is sometimes bad. Specimens currently collected from the type locality may have important information to taxonomists. (2) Large part of lowland rain forests has already been lost from West Java together with some animals and plants. The Bogor Botanic Garden possibly harbors a part of original ant fauna of such forests. (3) Much attention has generally been given to biodiversity in primary forests with the most species-rich communities in the world. For the better understanding of such communities, intensive surveys in artificial or disturbed areas are also necessary.

The sampling of ants was made by the following methods: (1) searching for ants on tree trunks, (2) sifting leaf litter with a handy sifter (3) trapping ants with pitfalls (4) trapping ants with sugar baits, (5) searching for ants on bamboo shoots (6) finding colonies, and (7) collection of foraging workers in all types of habitats. The result is compared among different sampling methods, and with those of preliminary surveys made by us in four national parks in West Java, namely, Ujung Kulon and Pangandaran (lowland forests), and Gunung Halimun and Gunung Gede (mountain forests). The lists of ants in these national parks will be reported in separate papers. Voucher specimens are deposited in the Bogor Zoological Museum (Cibinong), and part of specimens is tentatively kept in FI Collection (Takamatsu) and SKY Collection (Kagoshima).

## METHODS

The Bogor Botanic Garden is situated at 6°35'S, 106°47'E, and ca. 240 m alt. (Figs. 1, 2). We collected ants using the following seven methods.

(1) Searching for ants on tree trunks. In March and April of 1997, we chose 10 to 20 trees from each of 9 areas (127 trees in total) in the garden (see Fig. 2). Ants walking on tree trunks at ca. 1-1.5 m above the ground were collected using an aspirator for 5 min. When ants marched in procession,

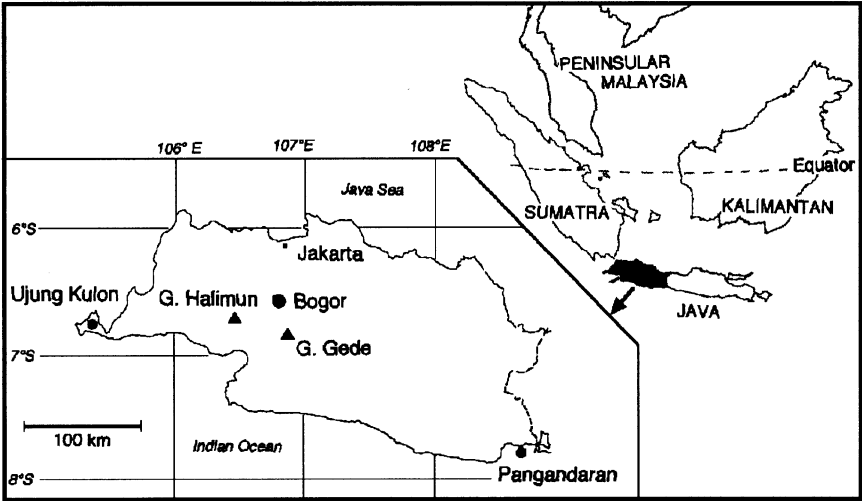


Fig. 1. Study sites in West Java.

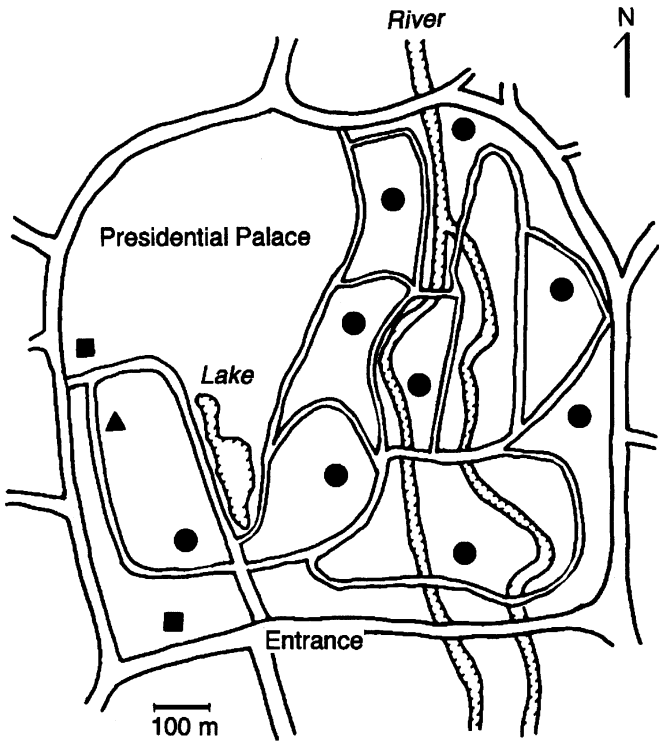


Fig. 2. Map of the study sites in the Bogor Botanic Garden. Circles: searching tree trunks and sifting leaf litter; Triangle: bamboo shoots; Squares: sugar bait traps. See Methods.

**Table 1.** Number of ant species collected by each collection method.

Subfamily	Total number of species collected	Collection methods					Colony collection
		Tree trunk	Litter sifting	Pitfall trap	Bait trap	Bamboo	
Aenictinae	3	0	0	0	0	0	3
Cerapachyinae	4	0	0	1	0	0	3
Dolichoderinae	10	4	4	3	4	0	10
Dorylinae	1	0	0	1	0	0	1
Formicinae	60	24	11	7	11	3	35
Leptanillinae	2	0	0	0	0	0	2
Myrmicinae	78	17	40	25	10	1	65
Ponerinae	54	7	27	19	3	0	48
Pseudomyrmecinae	4	1	2	0	0	0	0
Total	216	53	85	56	28	4	167

only 5 individuals were collected from it, then other parts of the trunk were searched.

(2) Sifting leaf litter and surface soil. In March and April of 1997, we set up 10 to 20 quadrates (30 cm x 30 cm) in each of 9 areas (118 quadrates). Leaf litter and soil (1-2 cm deep) were taken and sifted with a handy sifter (20 cm x 25 cm) with meshes of 8 mm x 8 mm on a plate which received dropping ants.

(3) Pitfall traps. In May to July of 1985, pitfall traps were set up in 16 sites. Fifteen traps (7 cm in diameter, 12 cm high) with 4% formalin were placed in each site and left for 3 days. Then, ants captured by the traps were collected. Because this is performed only to know the overview of ground level ants in the Bogor Botanic Garden, ants of 15 cups from the same site were all together put in a glass tube with 70% ethanol.

(4) Sugar baits. In the study of the effect of ants on phytophagous insect populations on *Ipomoea carnea*, one of us (WAN) collected ants on this plant and on the ground around it by bait traps. Cotton pieces with sugar solution were put on both the plants and ground. Ants attracted to the baits were collected after 30 min. Sampling was carried out in two *Ipomoea* communities from November of 1995 to May of 1996.

(5) Searching for ants on bamboo shoots. In January of 1991, TN and FI found some ants and hemipteran bugs on fresh bamboo buds. Twenty seven bamboo buds, 30-50 cm tall and with these insects, were covered with nylon bags and were cut at their bases. Ants and bugs were then collected from the buds. The detailed information about the interaction between ants and hemipteran bugs will be published in a separate paper.

(6) Finding colonies. From 1990 to 1998, we studied biology and ecology of several ant species by collecting whole colonies (Aoki *et al.*, 1994; Billen *et al.*, 1998, 1999; Ito, 1991, 1993abc, 1996, 1997, 1998, 1999; Ito & Billen, 1998; Ito *et al.*, 1996; Ito & Ohkawara, 1994, 2000; Ito & Takaku, 1994; Schoeters *et al.*, 1999; Wenseleers *et al.*, 1998). In the course of these studies, colonies of many other species were also collected.

(7) Collection of foraging workers. On every occasion, we collected foraging ants in every type of habitat in order to add as many species as possible.

Preliminary researches on ant fauna were carried out in four national parks in West Java (Fig. 1). In these national parks, ants were collected mainly by searching for colonies. Main collection sites are as follows: near Cikaniki station (ca. 900-1200 m alt. ) in Gunung Halimun National Park; behind the

**Table 2.** Dominant species collected by each method.

Tree trunk	No. trees with ants found	Litter sifting	No. quadrates with ants found	Pitfall trap	No. individuals
<i>Dolichoderus thoracicus</i>	49	<i>Pheidole hortensis</i>	37	<i>Odontoponera denticulata</i>	245
<i>Pheidole plagiaria</i>	20	<i>Paratrechina</i> sp. 8	29	<i>Odontoponera transversa</i>	183
<i>Polyrhachis abdominalis</i>	19	<i>Hypoponera</i> sp. N1	21	<i>Lophomyrmex opaciceps</i>	193
<i>Oecophylla smaragdina</i>	17	<i>Pheidole</i> sp. 12	19	<i>Leptogenys mutabilis</i>	91
<i>Crematogaster difformis</i>	15	<i>Tetramorium meshena</i>	17	<i>Anoplolepis gracilipes</i>	79
<i>Anoplolepis gracilipes</i>	14	<i>Pachycondyla chinensis</i>	15	<i>Hypoponera</i> sp. N2	61
<i>Camponotus</i> sp. 4	13	<i>Monomorium</i> sp. 2	14	<i>Pheidole butteli</i>	43
<i>Tetramorium pacificum</i>	11	<i>Lophomyrmex opaciceps</i>	13	<i>Technomyrmex</i> sp. 3	28
<i>Diacamma rugosum</i>	10	<i>Strumigenys koningsbergeri</i>	12	<i>Pheidologeton affinis</i>	25
<i>Odontomachus simillimus</i>	8	<i>Strumigenys</i> sp. 8	12		

Bait trap on <i>Ipomoea</i>	No. individuals	Bait trap on ground	No. individuals	Colony collection*	No. colonies collected
<i>Dolichoderus thoracicus</i>	324	<i>Paratrechina</i> sp. 17	112	<i>Oligomyrmex</i> sp. 2	36
<i>Monomorium</i> sp. 3	84	<i>Anoplolepis gracilipes</i>	98	<i>Paratrechina</i> sp. 3	36
<i>Oecophylla smaragdina</i>	59	<i>Paratrechina</i> sp. 3	89	<i>Tetramorium pacificum</i>	32
<i>Paratrechina</i> sp. 17	28	<i>Monomorium</i> sp. 3	82	<i>Tetramorium kheperra</i>	31
<i>Polyrhachis abdominalis</i>	16	<i>Monomorium floricola</i>	73	<i>Dolichoderus thoracicus</i>	26
<i>Cardiocondyla wroughtonii</i>	14	<i>Paratrechina longicornis</i>	68	<i>Pheidole plagiaria</i>	25
		<i>Dolichoderus thoracicus</i>	55	<i>Pheidole hortensis</i>	25
		<i>Tapinoma indicum</i>	36	<i>Pheidologeton affinis</i>	22
		<i>Odontoponera denticulata</i>	26	<i>Hypoponera</i> sp. N2	21
		<i>Monomorium pharaonis</i>	25		
		<i>Tetramorium simillimum</i>	23		

\* Species collected for specific researches were excluded.

Cibodas Botanic Garden (ca. 1200-1400 m alt.) in Gunung Gede-Pangrango National Park; Peucang Island; near Cibon and Cidaon (ca. 10-30 m alt.) in Peninsular Ujung Kulon in Ujung Kulon National Park; and around the forest path in Pangandaran National Park (ca. 10-100 m alt.).

Sorting to species was made mainly based on morphological criteria, but we have always tried to adopt biological species concept using ecological and behavioral information as well. Most specimens were identified by comparing with specimens in the SKY Collection (Kagoshima) and Kubota Collection (Odawara) in which not a few specimens had been directly compared with type specimens. Some specimens were also directly compared with types in the Natural History Museum, London, and Nationaal Natuurhistorisch Museum, Leiden.

## RESULTS

### Ants on tree trunk

Ants were collected from 97 out of 127 trees. Average number of species per tree was  $2.2 \pm \text{SD}2.3$  (range: 0-10). In all 53 species were found (Table 1), of which 21 were collected only from single trees. Expected number of species to be collected by this method is  $71 \pm 8.3 \text{ SD}$  (Chao 2; see Colwell & Coddington, 1994). Formicinae, which constituted 44% (24 species) of the species collected on tree trunks, were the most dominant subfamily (formicine ants occupied 28% of ant species in the botanic

garden). 40% of the formicine species known in this garden was collected by this method. Especially *Camponotus* and *Polyrhachis* were dominant genera on tree trunks; 7 and 10 species were collected respectively. Top ten dominant species were shown in Table 2, of which four (*Dolichoderus thoracicus*, *Polyrhachis abdominalis*, *Oecophylla smaragdina*, and *Crematogaster difformis*) nested on trees. *D. thoracicus*, which constructs nests with live leaves on trees, was the most dominant, being found on 49 trees. *Vollenhovia* sp. 4 and *Paratrechina* sp. 6 were collected only by this method.

### Ants in litter and surface soil

One to 10 species of ant were collected from 115 out of 117 quadrates. Average number of species was  $3.8 \pm 1.9$  SD per quadrate. In all 85 species were found from litter and surface soil (Table 1), of which 23 were collected only from single quadrates, and 16 species were found in two quadrates. Expected number of species (Chao 2) for leaf litter and surface soil was  $101.5 \pm 7.5$  SD. In contrast to ant species composition on tree trunks, Formicinae were rare (only 11 species), while Myrmicinae (40 species) and Ponerinae (27 species) accounted for 47% and 33% of the total species from litter and surface soil, respectively. Dominant species were *Pheidole hortensis*, *Paratrechina* sp. 8, and *Hypoponera* sp. N1, all being collected from more than 20 quadrates (Table 2). *Cryptopone* sp. 2, *Myrmecina* sp. M, and *Pheidole aristotelis* were collected only by this method.

### Pitfall traps

56 species (1264 individuals) were collected from 16 sites by pitfall traps. Myrmicinae, which constituted 45% of the species collected by this methods, were a dominant subfamily, with dominant species shown in Table 2. Two species of *Odontoponera* were the most dominant; 183 individuals of *O. transversa* were obtained from 11 sites and 245 individuals of *O. denticulata* from 12 sites. Except for *Pheidologeton affinis* and *Anoplolepis gracilipes*, which were collected only from two sites but numerous in number, most of the species listed in the table were collected from 6 to 8 sites. *Crematogaster* sp. 8 and *Pheidole plinii* were collected only by the pitfall trap.

### Bait traps

In all 28 species (1336 individuals) were attracted to baits. Myrmicinae and Formicinae were dominant, while only three species of Ponerinae (two species of *Odontoponera*, and *Odontomachus simillimus*) were collected. We found 23 species on *Ipomoea* plants and 22 species on the ground; of which 17 species were common to *Ipomoea* and ground; species composition was similar between the two. *Dolichoderus thoracicus*, *Monomorium* sp. 3, *Paratrechina* sp. 3 and sp. 17, and *Anoplolepis gracilipes* were the most common. Species collected only by bait traps were *Monomorium pharaonis* and *M. destructor*, both being famous tramp species.

### Ants on bamboo buds

Ants were found on 25 out of 27 bamboo buds. Species composition was very poor, including only four species, *Pheidole plagiaria*, *Camponotus arrogans*, *Camponotus (Tanaemyrmex)* sp. 3 and *Paratrechina* sp. 3, all of which were common ants in Bogor. All buds were monopolized by one of the four species, among which *Pheidole plagiaria* was the most dominant (19 buds).

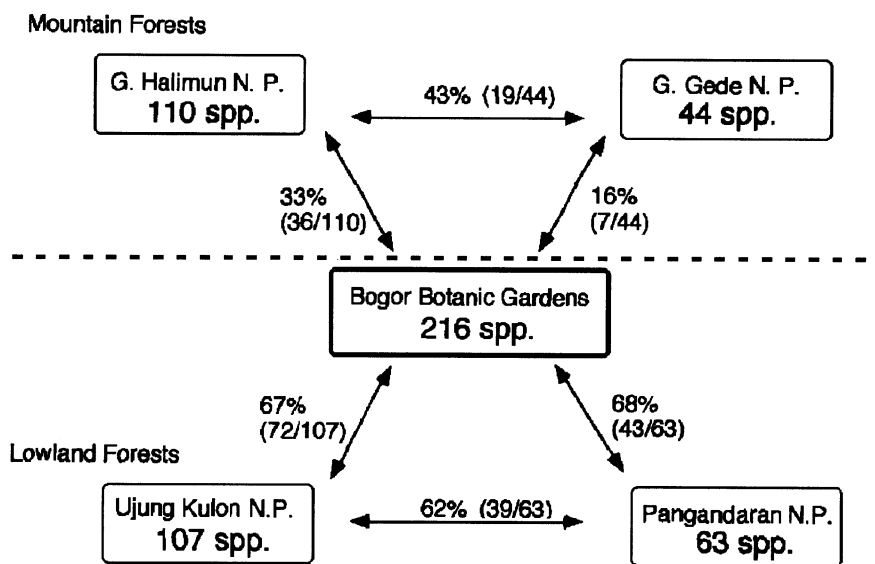


Fig. 3. Commonness of species composition of ants in the Bogor Botanic Garden to those in four national parks in West Java. Nomura-Simpson index of similarity (number of common species / smaller species number in a given pair) is shown as %. Bold figures mean total number of species collected by us until now.

### Colony collection

1114 colonies of 167 species were collected; among them 47 species were collected only once, and 24 species twice. Expected number of species collected by this method is  $213 \pm 14.3$  SD (Chao 2), the number being almost the same as that of total species in the Bogor Botanic Garden recorded in this paper. Except for the species which were collected for specific purposes such as behavioral and ecological studies (several ponerine ants and *Myrmecina* sp. A), dominant species were *Hypoponera* sp. N2, *Pheidologeton affinis*, *Tetramorium kheperra*, *T. pacificum*, *Pheidole plagiaria*, *P. hortensis*, *Oligomyrmex* sp. 2, *Dolichoderus thoracicus*, and *Paratrechina* sp. 3.

### Foraging workers

The following species were never collected by the sampling methods mentioned above: *Discothyrea* sp. 3, *Anochetus* sp. 4, *Harpegnathos* sp., *Ponera* sp. 3, *Cerapachys* sp. 2, two species of *Tetraoponera*, *Eurhopalothrix* sp., *Strumigenys* sp. 3, *Pristomyrmex brevispinosus*, *Gesomyrmex* sp. 1, 3 species of *Camponotus*, 10 species of *Polyrhachis*, and 3 species of *Paratrechina*. Except for the species of 3 arboreal genera (*Tetraoponera*, *Camponotus*, *Polyrhachis*), all the species are actually very rare on at least ground level; only 1 or 2 individuals have been collected until now.

### The fauna

In total 216 species in 61 genera of all subfamilies distributed in Oriental tropics were collected by the methods mentioned above (see Appendix). Subfamilies Myrmicinae (78 spp.), Formicinae (60 spp.), and Ponerinae (54 spp.) accounted for 89% of total ant species. The most species rich genera were

**Table 3** Number of species common to two of the four collecting methods. Commonness (number of common species/smaller species number in a given pair) is shown in parentheses.

	Leaf litter	Bait trap	Tree trunk	Colony collection
Pitfall trap	41 (0.73)	12 (0.42)	16 (0.30)	52 (0.93)
Leaf litter		15 (0.54)	21 (0.40)	77 (0.91)
Bait trap			16 (0.57)	24 (0.86)
Tree trunk				40 (0.75)

*Polyrhachis* (25 spp.), *Pheidole* (14 spp.), *Camponotus* (13 spp.), *Paratrechina* (11 spp.), *Tetramorium* (10 spp.), *Hypoponera* (8 spp.), and *Strumigenys* (8 spp.). The notable feature of ant fauna in the Bogor Botanic Garden is the occurrence of the following very rare, so called "enigmatic" ants: two species of *Leptanilla*, two species of *Probolomyrmex*, and three species of *Discothyrea*.

Preliminary researches on the ant fauna in four national parks in West Java (Fig. 3) indicate that the ant fauna in the Bogor Botanic Garden is similar to those of lowland rain forests in Ujung Kulon (Nomura-Simpson index (NS) = 0.67) and Pangandaran (NS = 0.68), while it is remarkably different from that of Gunung Halimun (NS = 0.33) and Gunung Gede (NS = 0.16). This indicates that the Bogor Botanic Garden may harbor a native lowland rainforest ant fauna in West Java.

## DISCUSSION

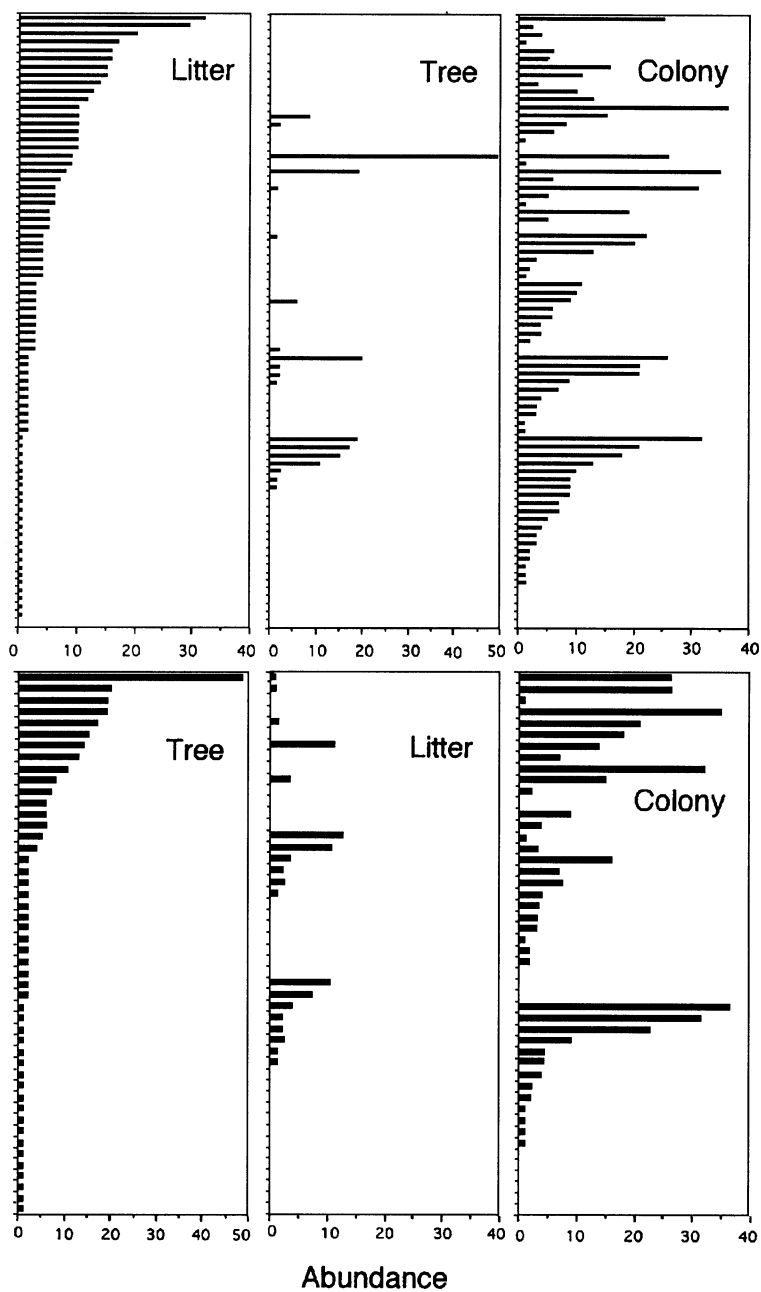
### Sampling methods

Ant species composition was remarkably different among sampling methods (Table 3, Fig. 4). Especially between ants on tree trunks and those on ground (pitfall trap and litter sifting), species commonness was as low as 0.3-0.4. Furthermore, abundance of each species is also remarkably different between sampling methods (Fig. 4). Several rare species in litter and surface soil are common on trees and *vice versa*. This suggests many of ground foraging ants rarely climb up trees, while many arboreal ants rarely forage on the ground as indicated by Yamane *et al.* (1996). Brühl *et al.* (1998) showed in Bornean rainforest ants that the stratification of ants is very strict with majority of species being confined to only one stratum. These results suggest several different sampling methods are necessary for ant faunal study in the tropics. In fact, systematic collection of ants by using three different methods in La Selva field station in Costa Rica (Longino & Colwell, 1997) showed that continuation of the same methods would not be efficient for capturing additional species.

Research efforts were considerably different among the methods used in this study. For example, only two weeks were spent to collect litter ants and ants on tree trunks, while we devoted more than one year for colony collection. Therefore, efficiency of collection methods can not be compared directly. However, the combination of searching litter and tree trunks, which yielded more than 50% (117 species) of the total ant species during approximately two weeks, was the easiest way to know the outline of ant fauna of this garden.

The problem with these methods is difficulty in classifying collected specimens into biological species because several ant species show remarkable morphological dimorphism or variation among workers. Especially assignment of small-sized specimens to relevant species is often difficult for di- or polymorphic species such as *Camponotus*, *Pheidole* and *Oligomyrmex* spp. Major workers, which have more specific morphological characters, are generally scarce, and majority of foraging workers





**Fig. 4.** Comparison of three collection methods (Tree: searching tree trunks; Litter: sifting leaf litter; Colony: colony collection) with matched abundance plot. In the left side of figure, the order of abundance for species is plotted with the most abundant species at the top. The middle and right side show the corresponding abundance for all the species shown in the left side. Abundance of ants is shown by the number of trees for *Tree*, number of quadrates for *Litter*, and number of colonies for *Colony*.

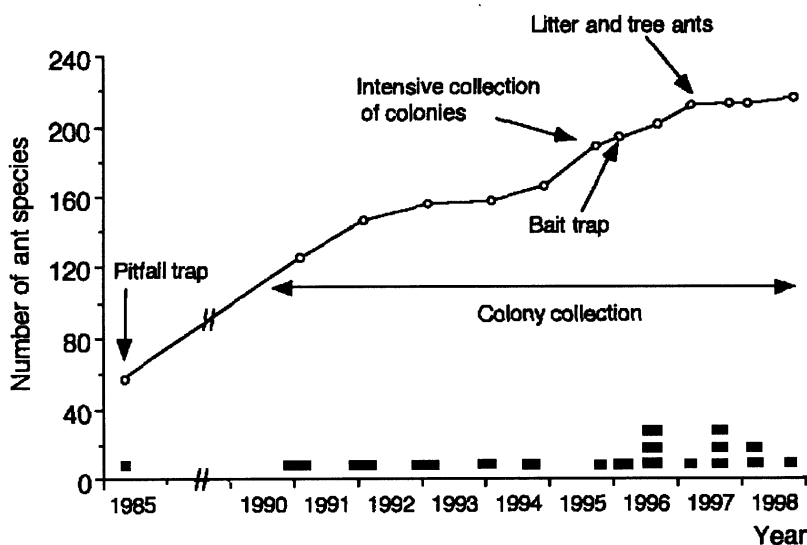


Fig. 5. Cumulative number of ant species collected in the Bogor Botanic Garden. Bars: research periods. Number of bars for a period indicates the number of researchers involved.

are minor workers. To identify such ants in terms of biological species, a reference collection based on colony series is necessary. In general, to reveal biodiversity of ants, researchers use Berlese funnels, Winkler bags, or pitfall traps for ground ants, and fogging (canopy knockdown) for arboreal ants. These methods are evidently very efficient for collection of many ant species, and special experiences are not necessary for people conducting samplings. However, with these methods ants derived from different colonies are mixed, and we are always not confident of combination of minors and majors. In our research, we made much effort to collect colony series, which is very helpful for correct classification, and will give much contribution to future taxonomic research.

The present results indicate remarkable differences in the relative abundance of species among the sampling methods (Fig. 4). For example, *Tetramorium meshena* was one of the dominant species in litter and surface soil sifting (found in 17 quadrates), while only one colony of this species has been found until now. *Strumigenys* sp. 4 and sp. 7, *Tetramorium pacificum*, *Monomorium* sp. 3, *Acropyga acutiventris*, and *Pseudolasius* sp. 3 were common in colony collection but rare in the other methods. Efficiency of colony collection largely depends on the accessibility of nest sites of the species concerned. For example, we can easily find colonies of species preferring sites such as 'under stones' or 'in dead wood', but rarely find underground and arboreal nests. Thus, among 39 Camponotini species which are largely arboreal nesters, colonies of only 19 species have been collected until now, while colonies of 46 out of 52 species of ground nesting ponerine ants have been collected.

Advantage of colony collection may apply to species with very small colony size. In general, ant colony size (number of workers/colony) tends to be much smaller in the tropics than in the temperate region (Kaspari & Vargo, 1995). For example, in the subfamily Ponerinae, the mode of colony size is less than 50 workers in Indonesia and Malaysia (Ito *et al.*, unpubl.). Several species have colonies with just a dozen workers. Collection of such species may not be easy without intentionally looking for nests, because very few workers can be seen foraging in such species.

### Have most species of ants been already collected?

Fig. 5 shows the curve for cumulative number of species collected by us in the Bogor Botanic Garden. After intensive collection of colonies in 1995 and of litter and tree ants in 1997, only a few species were added to the list in 1998. However, the cumulative species number will grow even from now onward, because of the following reasons: (1) we have not yet carried out sampling from canopy where diversity of ants is expected to be very large in primary forests (e.g., Wilson, 1987; Tobin, 1995; Brühl *et al.*, 1998). We occasionally collected supposed canopy ants such as *Gesomyrmex* sp. on the ground, which probably fell from canopy. There should be more canopy species which have escaped our scrutiny. (2) 34 species were collected only once during our research from 1990 to 1998, indicating that many species are very rare as already suggested for tropical biota. The reasons for rareness may be temporal immigration and extinction, low density, and/or cryptic habit (Longino & Colwell, 1997). Detection of fluctuation in species composition was difficult in this survey; however, at least one species, *Platythyrea quadridenta*, might have been established in the botanic garden during our 10-year research. This was collected in 1996 for the first time and occasionally found in 1997 and 1998. *P. quadridenta* is a relatively large-sized ponerine ant, and it is unlikely for it to have escaped our attention. A few ant species apparently disappeared; for example, *Meranoplus bicolor* was very often found in 1990, though recently we did not see this species at all. These observations indicate that species composition has actually changed. Further ant species will be established in the future. Among the 34 species, which were collected only once, at least 5 species, i.e., *Aenictus* sp.1, *A. dentatus*, *Leptanilla kebunraya* and *clypeata*, and *Cerapachys* sp. 5, are considered to reproduce by wingless females. In this case, temporal immigration is almost impossible, and their cryptic habit and/or low density may be responsible for their rareness.

### Comparison with other forests in the Oriental tropics

Recent studies on the ant fauna in lowland rainforests in West and East Malaysia indicate the occurrence of magnificent number of ant species. For example, Brühl *et al.* (1998) found 524 'morphospecies' in 73 genera in a lowland rainforest, Poring, Kinabalu Park, Sabah; Yamane (1998) listed 375 species in 66 genera from the Lambir Hills National Park in Sarawak; and Rosciszewski (1995) gave a list of 467 species in 75 genera from Pasoh forest in West Malaysia. The direct comparison of species number is not meaningful because of differences in sampling method, but the species number in the Bogor Botanic Garden (216 species in 61 genera) is apparently lower than those in primary forests mentioned above. However, this figure is still much larger than those obtained in the subtropics and temperate region. 267 species have been recorded from all over Japan (Terayama & Yamane, 1999); 138 species were found in a seasonal tropical rainforest in northern Kimberly of western Australia (Andersen & Yen, 1992), and 97 species from *Eucalyptus* forests in northwestern Victoria, Australia (Andersen, 1983, 1992). It is obvious that even in habitats with much human disturbance such as botanic gardens, tropical rainforest zone can harbor a richer species diversity of ants.

The number of species in each genus in the Bogor Botanic Garden is remarkably different from those in primary forests in Southeast Asia. Especially the numbers of species in dolichoderine and formicine genera are poor in Bogor (D: 10 spp., F: 60 spp.) and Lambir (D: 17 spp., F: 103 spp.) than in Poring (D: 44 spp., F: 175 spp.) and Pasoh (D: 29 spp., F: 136 spp.). The differences may have

resulted from different sampling methods (but at least partly also from the species concept adopted). Fogging conducted in Poring must have contributed to the greater species number of such arboreal ants as *Technomyrmex*, *Tapinoma* and *Dolichoderus* (Dolichoderinae), and *Camponotus* and *Polyrhachis* (Formicinae). Even considering the difference in sampling method, the remarkably poor species number in *Crematogaster* in Bogor (6 spp.) is notable. *Crematogaster* is one of the dominant ant genera in Pasoh (30 spp.), Poring (35 spp.), and Lambir (36 spp.). Several species of *Crematogaster* are well known as symbiotic partners of ant-plants *Macaranga* spp. (Itino, *et al.* in prep.). One of the reasons for the small species number in this genus in the Bogor Botanic Garden is that such mutualistic interactions are not observed. Fiala *et al.* (1999) recently reported that *Macaranga-Crematogaster* mutualism is not found in Java.

The low densities and species paucity of the ant hunter genera *Aenictus* and *Cerapachys* are among the notable characteristics of ant fauna in the Bogor Botanic Garden. Colonies of *Aenictus* ants have several thousands to millions of workers and perform mass raiding on other ant species (Roscsizewski & Maschwitz, 1994). In the present study, we collected three species of *Aenictus*, of which two were found only once and *A. javanus* was collected thrice over one-year stay. In the Ujung Kulon National Park, we collected two species during a four-day search, and also one species in the Pangandaran National Park during a one-week search. In some primary rainforests in West and East Malaysia, 8 to 11 species of *Aenictus* were collected (Roscsizewski & Maschwitz 1994; Yamane, 1997; Brühl *et al.*, 1998). *Cerapachys* colonies are generally with less than 100 workers (Wilson, 1959). They often nest in dead fallen wood on the ground, and under stones, making colony collection relatively easy. In the Bogor Botanic Garden, colonies of *Cerapachys* sp. 1, which reproduces by ergatoid queens, were collected five times, though the other three species were found only once. As in *Aenictus*, around 10 species of *Cerapachys* have been collected from each of lowland primary forests in West and East Malaysia (Roscsizewski & Maschwitz 1994; Brühl *et al.*, 1998; Yamane, 1997). In West Java, we have never collected *Cerapachys* from Ujung Kulon and Pangandaran, though at least five species were collected from Gunung Halimun and three species from Gunung Gede. Colony density is apparently higher in these mountain forests than in the Bogor Botanic Garden. For example in Gunung Halimun, four species were collected during a three-day search. These two genera almost completely depend on ants for prey. A clear resource partitioning, which is shown in preference of particular taxa, strata and prey size, is found among coexisting *Aenictus* species in West Malaysia (Roscsizewski & Maschwitz 1994). One of the reasons for the low density of ant-hunting specialists in the Bogor Botanic Garden may be the relatively poor species diversity of ants, but the small area is also responsible for it.

## Descriptions of Two New Species of the Genus *Leptanilla* (Hymenoptera, Formicidae) from Java, Indonesia

The world fauna of the Old World ant genus *Leptanilla* was revised by Baroni Urbani (1977), and up to now 36 nominal species have been recognized (Bolton, 1995). However, intraspecific variation has not been studied for most of the species, and approximately half the species were described from the male sex alone. We have collected two species of *Leptanilla* in Kebun Raya (Botanic Garden), Java,

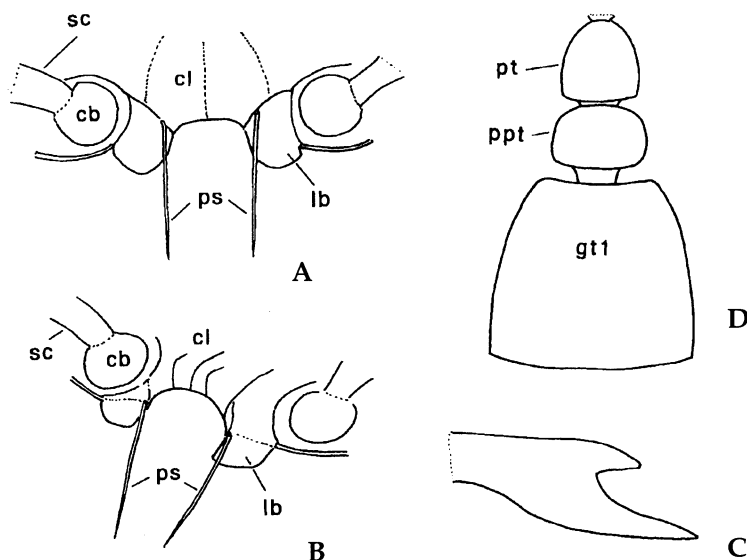


Fig. 6. *Leptanilla kebunraya* sp. nov. A, clypeus and antennal base in dorsal view. cb: condylar bulb; cl: clypeus; lb: anterolateral lobe of clypeus; ps: paired setae on clypeus; sc: antennal scape. B, same, seen obliquely in profile. C, apical two-thirds of right mandible. D, petiole (pt), postpetiole (ppt) and gastral tergite 1 (gt1) in dorsal view.

both being different from any described species in the worker morphology. These are described as new species below. The holotypes will be deposited in the Bogor Zoological Museum.

*Leptanilla kebunraya* Yamane et Ito, sp. nov.

Worker. Head in full-face view with almost parallel sides, slightly narrowed at its anteriormost and posteriormost portions, with almost straight posterior margin. Clypeus roundly raised between antennal insertions; the raised portion posteriorly ill defined, and anteriorly truncate; this truncated margin continuing at both sides as carinae sloping down to the level of antennal insertion where clypeus has a pair of lateral lobes. Mandible rather slender, with only two teeth including apical one; upper edge of mandible distinctly carinate and darkened. Scape moderately widened, widest at its mid-length, reaching only mid-length of head measured from posterior margin of antennal insertion to posterior margin of head; 2nd antennal segment longer than wide; 3rd segment with a distinct basal peduncle; 4th to 11th segments wider than long; apical segment approximately twice as long as wide. Pronotum in dorsal view narrower than head, roundly convex laterally, widest at its mid-length; the rest of alitrunk narrower than pronotum, demarcated therefrom by a narrow suture, with rather parallel sides. Alitrunk in profile with almost straight dorsal outline, but pronotum sometimes sloping anteriorly because it is movable at the junction with the rest of alitrunk; mesopleuron not defined posteriorly by any suture. Dorsal and lateral faces of posterior half of alitrunk meeting by a right

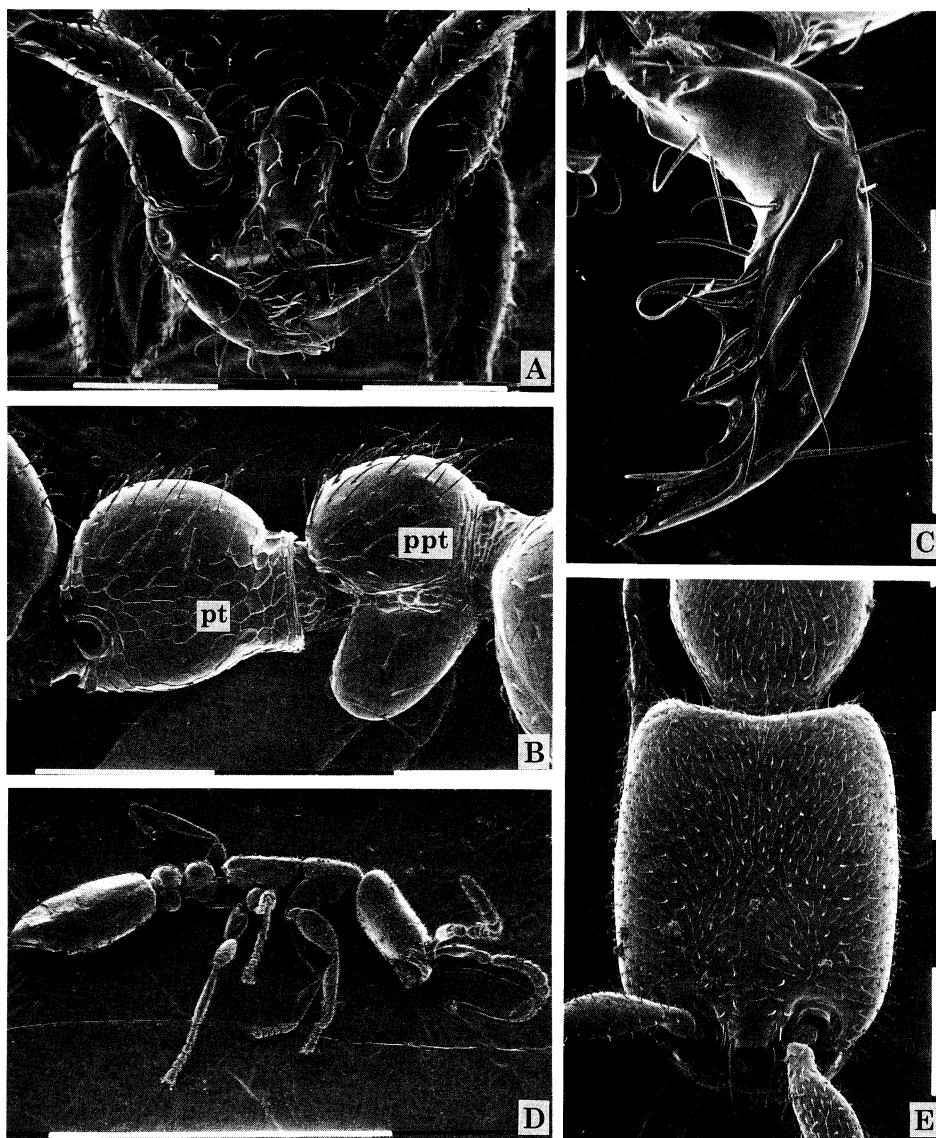


Fig. 7. A-C, *Leptanilla clypeata* sp. nov.; D, E, *L. kebunraya* sp. nov. A, anterior portion of head seen from above. B, petiole (pt) and postpetiole (ppt) in profile. C, left mandible. D, body in profile. E, head in full-face view (anterolateral lobes of clypeus are obscure because they are situated at a lower level near mandibular base). Scale bar: 1 mm.

angle, but the edge not sharply defined by a carina; posterior face of propodeum rather steeply sloping. Petiolar node in dorsal view almost as long as wide, slightly widened posteriorly; postpetiolar node shorter than petiolar node, distinctly wider than long, anteriorly distinctly narrowed. Petiolar node in profile with rather steep anterior and posterior slopes; anteroventral portion of petiole with a low and thin plate; postpetiole slightly smaller than petiole, ventrally with a medium-sized process. First gastral segment with weakly angulated anterolateral corners.

Body uniformly yellowish brown, smooth and somewhat shining, with small and superficial punctures, and densely covered with suberect and erect hairs.

Measurements (holotype). Total length 1.26 mm. Head length measured along sagittal plane 0.27 mm. Head width 0.22 mm. Scape length excluding condylar bulb 0.13 mm. Petiolar node length 0.08 mm; its width 0.08 mm. Postpetiolar node length 0.06 mm; its width 0.10 mm.

Holotype: worker, Kebun Raya, Bogor, Java, Indonesia, 11 iv 1997, F. Ito leg. (colony code: FI97-581). Paratypes: 7 workers from the same colony.

This species is similar to *L. butteli* Forel from Selangor, Malacca in having only two mandibular teeth. It is, however, easily distinguished from the latter by the presence of anterolateral lobes of clypeus, nearly parallel sides of head, distinctly pedunculate 3rd antennal segment, very narrow suture separating pronotum from the rest of alitrunk, larger postpetiole, etc.

The structure and function of the mandibular gland of the worker was studied by Billen *et al.* (1998).

*Leptanilla clypeata* Yamane et Ito, sp. nov.

Worker. Head in full-face view weakly convex laterally, rather strongly narrowed anteriorly, with posterior margin almost straight. Clypeus strongly convex dorsally, forming a raised platform between antennal insertions, anteriorly strongly produced and apically distinctly bilobed; the lobes divergent apically. Mandible elongate-triangular, strongly bowed inwardly, with three teeth including apical one which tapers sharply; other two teeth located close to each other near basal angle of mandible, small and apically not sharply pointed. Scape gradually widened toward its 2/3 length, then slightly narrowed toward apex, reaching about 1/2 length of head as measured from posterior margin of antennal insertion to posterior margin of head. Second antennal segment 1.5 times as long as wide; 3rd, 4th and 8th to 11th segments approximately as long as wide; 5th and 7th segments slightly wider than long; apical segment almost twice as long as wide. Pronotum in dorsal view roughly round, narrower than head; pro-mesonotal suture wide and deep; the rest of alitrunk distinctly narrower than pronotum, wider in posterior 2/3 than in anterior 1/3. In profile alitrunk with almost straight dorsal outline, with a distinct interruption at pro-mesonotal suture; suture between mesopleuron and metapleuron weak but discernible; dorsal face of propodeum smoothly merged into posterior face; metapleural gland elongate and very large, almost as long as petiolar node. Petiolar node in dorsal view longer than wide, very weakly convex laterally; its anterior margin almost straight; postpetiole wider than petiole; its node wider than long, with rounded sides. In profile petiolar node with relatively steep anterior slope, round dorsal outline and weakly convex ventral margin; postpetiolar node distinctly smaller than petiolar node, with evenly rounded dorsal outline in profile; ventral process of postpetiole well developed. Seen from above first gastral segment with antero-lateral corners not angulate.

Body almost smooth and somewhat shining, only with small and shallow punctures. Body hairs dense; most of them being suberect to erect on head, alitrunk and waist, but many being appressed on gaster; hairs around the tip of gaster nearly as long as those on other parts of gaster; short appressed pubescence absent.

Measurements (holotype). Total length 1.60 mm. Head length measured along sagittal plane 0.38 mm. Head width 0.31 mm. Scape length excluding condylar bulb 0.19 mm. Petiolar node length 0.11

mm; its width 0.09 mm. Postpetiolar node length 0.08 mm; its width 0.11 mm.

Holotype: worker, Kebun Raya, Bogor, Java, Indonesia, 7 iv 1997, F. Ito leg. (colony code: FI97-556). Paratypes: 11 workers from the same colony.

This species is closely related to *L. thai* Baroni Urbani from Khao Chong, Thailand, but distinguished therefrom by the following details: clypeus more strongly produced anteriorly, having a distinctly raised platform which is defined posteriorly; in profile dorsal and posterior faces of propodeum not forming a blunt angle; anterior portion of head lacking a pair of whitish markings. It also differs from another close relative, *L. havilandi* Forel from Singapore, in the following details: median lobes of clypeus much more strongly divergent apically; seen from above anterolateral corners of petiole distinctly angulate; in profile postpetiole more distinctly smaller than petiole; ventral process of postpetiole narrower in profile; most of the body hairs suberect or erect.

**ACKNOWLEDGEMENTS** We would like to thank all persons who have contributed to keeping the Bogor Botanic Garden in the present status; H. Katakura, S. Wirjoatmodjo, A. Budiman, and the staff of the Bogor Zoological Museum for their help and arrangement in this study; C. Baroni Urbani, M. Kubota, J. Lattke, and M. Terayama, for their help in identification of ants; LIPI (Indonesian Institute of Science) for research permission. FI thanks U. Maschwitz and C. Brühl for their kind advice and giving him important information, and C. van Achterberg for his hospitality in Leiden. This work was supported by Grants-in-Aid for International Scientific Research (leader: K. Nakamura, Nos. 02041033, 05041086, 08041141; leader: F. Ito, No. 11691130), and a Grant-in-aid for Creative Basic Research (leader: H. Kawanabe, No. 09NP1501) from the Ministry of Education, Science Sports and Culture of Japan.

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Received Dec. 15, 1999

Accepted Dec. 5, 2000

伊藤文紀, 山根正気, 江口克之, W. A. NOERDJITO, Sih KAHONO, 辻和希, 大河原恭祐, 山内克典, 西田隆義, 中村浩二      インドネシア西ジャワ州ボゴール植物園におけるアリ類の種多様性, およびムカシアリ属 2 新種の記載

インドネシア西ジャワ州ボゴール植物園のアリ相を次の7つの方法で調査した。(1) 樹幹を歩行するアリの採集, (2) ふるいを用いたリター中のアリの採集, (3) ピットフォールトラップ, (4) 砂糖水ベイト, (5) タケ新芽上のアリ採集, (6) コロニー採集, 及び (7) 採餌アリの採集。1985 年と 1990 年から 1998 年までの調査で, 東南アジア熱帯に分布する全ての亜科を含む 216 種が採集された。1995 年と 1997 年に集中的な調査を実施したが, 1998 年にも未記録種が多少採集された。当地のアリ相を東南アジアのほかの地域の熱帯降雨林, ならびに西ジャワ州の低地林 (ウジュンクロン国立公園, パンガンダラン国立公園) および山地林 (ハリムン国立公園, ゲデ・パンゲラン国立公園) での調査結果と比較した。ボゴール植物園のアリ相は西ジャワ州の低地林のそれと似ていたが, 山地林とは著しく異なっていた。またボゴール植物園で採集されたムカシアリ属 2 種を新種として記載した。

**Appendix** List of Ants collected in Kebun Raya Bogor in 1985 and between 1990 and 1998. Abbreviations in methods mean as follow; *T*: collected on tree trunk [method (1)], *L*: collected by litter sifting [method (2)], *P*: collected by pitfall trap [method (3)], *S*: collected by sugar baits [method (4)], *B*: collected on Bamboo shoots [method (5)], *F*: taken by only collection of foraging workers [method (7)]. The details of methods were given in the text. Species with colony codes were collected by searching for colonies [method (6)]. Species codes with SKY and eg mean personal species codes of Seiki Yamane and Katsuyuki Eguchi, respectively. The other species codes are used by Fuminori Ito.

Species	Methods	Colony codes
<b>Subfamily Aenictinae (3 spp.)</b>		
Tribe Aenictini (3 spp.)		
<i>Aenictus dentatus</i> Forel		FI93-83
<i>Aenictus javanus</i> Emery		FI95-536, KT96-250, FI97-6
<i>Aenictus</i> sp. 1 (= sp. 7 of SKY)		FI92-337
<b>Subfamily Cerapachyinae (4 spp.)</b>		
Tribe Cerapachyini (4 spp.)		
<i>Cerapachys</i> sp. 1	<i>P</i>	FI90-124, FI90-VIII-E5-3, FI92Jan, FI94-41, FI97-604
<i>Cerapachys</i> sp. 2 (nr. sp. 32 of SKY)	<i>F</i>	
<i>Cerapachys</i> sp. 5 aff. <i>biroi</i> Forel		FI95-723
<i>Cerapachys</i> sp. 10 (= sp. 27 of SKY)		FI98-237
<b>Subfamily Dolichoderinae (10 spp.)</b>		
Tribe Dolichoderini (10 spp.)		
<i>Dolichoderus semirugosus</i> (Mayr) (= sp. 1)		FI97-81
<i>Dolichoderus sulcaticeps</i> (Mayr)	<i>T</i>	FI90-(234, 277), KO970902-13
<i>Dolichoderus thoracicus</i> (F. Smith)	<i>P, L, S, T</i>	FI90-(229, 248, 253), FI95-(365, 366, 373, 377, 379, 394, 448, 460, 466, 481, 483, 514, 568-2, 752, 753, 778, 791), KT96-(88, 177, 195, 263), KO970829-19, KY97-17
<i>Dolichoderus</i> sp. 2 nr. <i>gibbifer</i> Emery (= sp. 13 of SKY)		FI90-232
<i>Tapinoma indicum</i> Forel (= sp. 1)	<i>L, S, T</i>	FI95-782
<i>Tapinoma melanocephalum</i> (Fabricius)	<i>P, S</i>	FI90-(154, 242), FI94-154, FI95-(437, 541, 574)
<i>Technomyrmex butteli</i> Forel (= sp. 2, 4, 7)	<i>T</i>	FI90-(227, 233), FI95-(378, 469, 493), KT96-(219, 241), FI97-10, KY97-(13, 35)
<i>Technomyrmex kraepelini</i> Forel (= sp. 1)	<i>L, S</i>	FI90-(223, 228, 251) FI95-454, KT96-181
<i>Technomyrmex</i> sp. 3 (= sp. 10 of SKY)	<i>P, L</i>	FI90-262, FI95-743, FI98-(295, 299)
<i>Technomyrmex</i> sp. 8 (= sp. 6 of SKY)		FI95-413
<b>Subfamily Dorylinae (1 sp.)</b>		
Tribe Dorylini (1 sp.)		
<i>Dorylus laevigatus</i> (Smith F.)	<i>P, L</i>	FI90-(244, 272), FI94-150, FI97-21
<b>Subfamily Formicinae (60 spp.)</b>		
Tribe Camponotini (39 spp.)		
<i>Camponotus (Colobopsis)</i> nr. <i>leonardi</i> Emery	<i>F</i>	
<i>Camponotus (Colobopsis)</i> <i>vitreus</i> var. <i>oebalis</i> Forel	<i>F</i>	
<i>Camponotus (Colobopsis)</i> sp. 4 ( <i>vitreus</i> gp) (= sp. 38 of SKY)	<i>P, S</i>	FI90-212, FI95-(367, 368, 369, 505, 506, 570)
<i>Camponotus (Colobopsis)</i> sp. 5 (= sp. 65 of SKY)	<i>F</i>	
<i>Camponotus (Myrmanblys)</i> <i>reticulatus bedoti</i> Emery (= sp. 7)	<i>T</i>	FI95-356
<i>Camponotus (Myrmanblys)</i> sp. 1 (= sp. 78 of SKY)	<i>S, T</i>	FI95-(467, 553)
<i>Camponotus (?Myrmanblys)</i> sp. 8 (= sp. 13)	<i>T</i>	FI95-764

<i>Camponotus</i> (? <i>Myrmanblys</i> ) sp. 12	<i>T</i>	
<i>Camponotus</i> ( <i>Myrmosaulus</i> ) <i>singularis</i> F. Smith	<i>L, S</i>	
<i>Camponotus</i> ( <i>Tanaemyrmex</i> ) <i>arrogans</i> F. Smith	<i>B, T</i>	FI90-264, FI91-21
<i>Camponotus</i> ( <i>Tanaemyrmex</i> ) sp. 2		FI90-258, FI95-(507, 508, 509)
<i>Camponotus</i> ( <i>Tanaemyrmex</i> ) sp. 3 (= sp. 47 of SKY)	<i>B</i>	FI90-(265, 276), FI95-(391, 480, 563, 762, 790, 812), KT96-98, KT96-224, FI98-(427, 428, 431)
<i>Camponotus</i> ( <i>Tanaemyrmex</i> ) sp. 6 (= sp. 72 of SKY)	<i>T</i>	FI90-278, FI95-(351, 352, 364, 402), KT96-215, FI97-9
<i>Echinopla lineata</i> Mayr	<i>T</i>	FI90-(179, 235), KT96-(167, 217)
<i>Polyrhachis</i> ( <i>Cyrtomyrma</i> ) <i>laevissima</i> F. Smith	<i>F</i>	
<i>Polyrhachis</i> ( <i>Cyrtomyrma</i> ) <i>rastellata</i> var. <i>pagana</i> Santschi	<i>T</i>	
<i>Polyrhachis</i> ( <i>Myrma</i> ) <i>inermis</i> F. Smith	<i>T</i>	
<i>Polyrhachis</i> ( <i>Myrma</i> ) <i>proxima</i> Roger	<i>T</i>	KT96-232
<i>Polyrhachis</i> ( <i>Myrma</i> ) <i>tillaudata</i> Walker (= <i>P. mayri</i> )	<i>S, T</i>	
<i>Polyrhachis</i> ( <i>Myrma</i> ) <i>striata</i> Mayr (= sp. 1, = sp. 32 of SKY)		FI90-153
<i>Polyrhachis</i> ( <i>Myrma</i> ) sp. 2 (nr. sp. 33 of SKY)	<i>F</i>	
<i>Polyrhachis</i> ( <i>Myrma</i> ) sp. 3	<i>F</i>	
<i>Polyrhachis</i> ( <i>Myrma</i> ) sp. 4 (= SNS-10 of SKY)	<i>T</i>	FI92-382
<i>Polyrhachis</i> ( <i>Myrma</i> ) sp. 5 (= sp. 29 of SKY)	<i>F</i>	
<i>Polyrhachis</i> ( <i>Myrma</i> ) sp. 14 (= sp. 35 of SKY)	<i>F</i>	
<i>Polyrhachis</i> ( <i>Myrma</i> ) sp. 15 (= sp. 110 of SKY)	<i>F</i>	
<i>Polyrhachis</i> ( <i>Myrma</i> ) sp. 16 (= sp. 29 of SKY)	<i>F</i>	
<i>Polyrhachis</i> ( <i>Myrmatopa</i> ) sp. 7 (= sp. 46 of SKY)		FI90- (119, 279), FI95-452
<i>Polyrhachis</i> ( <i>Myrmhopla</i> ) <i>abdominalis</i> F. Smith	<i>L, S, T</i>	FI95-(358, 408, 439)
<i>Polyrhachis</i> ( <i>Myrmhopla</i> ) <i>arachne</i> Emery		FI90-(121, 125)
<i>Polyrhachis</i> ( <i>Myrmhopla</i> ) <i>armata</i> Le Guillou	<i>T</i>	
<i>Polyrhachis</i> ( <i>Myrmhopla</i> ) <i>basirufa</i> Emery	<i>F</i>	
<i>Polyrhachis</i> ( <i>Myrmhopla</i> ) <i>bicolor</i> F. Smith	<i>T</i>	
<i>Polyrhachis</i> ( <i>Myrmhopla</i> ) <i>caligata</i> Emery	<i>F</i>	
<i>Polyrhachis</i> ( <i>Myrmhopla</i> ) <i>cryptoceroideus</i> Emery	<i>T</i>	FI95-(408, 486, 789)
<i>Polyrhachis</i> ( <i>Myrmhopla</i> ) <i>dives</i> F. Smith	<i>P</i>	FI90-118
<i>Polyrhachis</i> ( <i>Myrmhopla</i> ) <i>moesta</i> Emery	<i>F</i>	
<i>Polyrhachis</i> ( <i>Myrmhopla</i> ) <i>pressa</i> Mayr	<i>T</i>	FI95-376
<i>Polyrhachis</i> ( <i>Myrmhopla</i> ) sp. 6 (= sp. 21 of SKY)		KT96-261
Tribe Gesomyrmecini (1 sp.)		
<i>Gesomyrmex</i> sp. 1 (= sp. 1 of SKY)	<i>F</i>	
Tribe Lasiini (17 spp.)		
<i>Paratrechina longicornis</i> Latreille	<i>S, T</i>	FI92-359, FI95-(444, 525), FI98-298
<i>Paratrechina</i> sp. 3 (= sp. 7)	<i>B, P, L, S, T</i>	FI90-(133, 149, 169, 257, 271), FI92-391, FI95-(380, 410, 412, 418, 420, 438, 451, 458, 479, 502, 511, 519, 522, 531, 547, 568, 575, 595, 600, 760, 783), KT96-(79, 201, 222, 220, 228), FI97-17, FI98-429, KT98-(19, 24)
<i>Paratrechina</i> sp. 5		FI92-395
<i>Paratrechina</i> sp. 6	<i>T</i>	
<i>Paratrechina</i> sp. 8	<i>L</i>	FI92-389, FI97-5
<i>Paratrechina</i> sp. 9	<i>F</i>	
<i>Paratrechina</i> sp. 10	<i>F</i>	
<i>Paratrechina</i> sp. 11	<i>F</i>	
<i>Paratrechina</i> sp. 12	<i>S</i>	FI95-411, KY97-16
<i>Paratrechina</i> sp. 13	<i>L, T</i>	FI95-572

<i>Paratrechina</i> sp. 17	<i>S</i>	FI94-212
<i>Pseudolasius</i> sp. 2 (= sp. 4)	<i>L</i>	FI90-(247, 252, 263, 270, 274), FI95-(397-2, 495), FI98-297, KO980817-1
<i>Pseudolasius</i> sp. 3 (= sp. 9, 10, 11, 12)	<i>P</i>	FI90-273, FI95-(382, 484, 521, 523, 540, 554, 564, 599), KT96-224, KO970902-4, FI97-77, FI98-294
<i>Pseudolasius</i> sp. 5		FI90-(261, 267)
<i>Pseudolasius</i> sp. 8	<i>P, L</i>	FI92-350, FI95-(544, 768, 769), FI98-433
<i>Pseudolasius</i> sp. 13	<i>L</i>	FI98-233
<i>Pseudolasius</i> sp. 15		FI97-625
Tribe Oecophyllini (1 sp.)		
<i>Oecophylla smaragdina</i> Fabricius	<i>P, L, S, T</i>	KT96-(1, 2, 3, 4, 5, 6, 7, 9, 175, 205, 243, 258), KY97-9
Tribe Plagiolepidini (2 spp.)		
<i>Acropyga acutiventris</i> Roger (= sp. 2)	<i>L</i>	FI90-(266, 275, 278), FI95-(375, 400, 450, 453, 485, 487), KT96-82, KO970829-2, KY97-(3, 19)
<i>Anoplolepis gracilipes</i> (F. Smith)(= <i>longipes</i> Jerdon)	<i>P, L, S, T</i>	FI90-(132, 160, 230, 236, 246, 256), KT96-(81, 86, 170, 214, 216, 296, sept2-4), KO980807-2
<b>Subfamily Leptanillinae (2 spp.)</b>		
Tribe Leptanillini (2 spp.)		
<i>Leptanilla clypeata</i> Yamane et Ito (= sp. 1)		FI97-556
<i>Leptanilla kebunraya</i> Yamane et Ito (= sp. 2)		FI97-581, see Billen <i>et al.</i> (1998)
<b>Subfamily Myrmicinae (78 spp.)</b>		
Tribe Basicerotini (1 sp.)		
<i>Eurhopalothrix</i> sp.1 (= sp. 2 of SKY)	<i>F</i>	
Tribe Cataulacini (1 sp.)		
<i>Cataulacus granulatus</i> (Latreille)		FI90-200
Tribe Crematogastrini (6 spp.)		
<i>Crematogaster difformis</i> F. Smith	<i>L, T</i>	FI90-(178, 217), FI94-(63, 64, 406), FI95-(363, 365, 370, 371, 372, 406, 436, 445, 494, 567-2), KT96-(239, 245, 246)
<i>Crematogaster</i> sp. 2 (= sp. 51 of SKY)	<i>P, T</i>	FI90-213
<i>Crematogaster</i> sp. 3 (= sp. 52 of SKY)		FI90-(222, 239), FI92-(386, 333), FI95-734, KT96-(183, 186, 257, 260), FI97-83, KY97-7
<i>Crematogaster</i> sp. 4 (= sp. 21 of SKY)	<i>T</i>	FI95-488, KT96-(176, 200)
<i>Crematogaster</i> sp. 5 (= sp. 23 of SKY)	<i>T</i>	
<i>Crematogaster</i> sp. 8	<i>P</i>	
Tribe Dacetonini (10 spp.)		
<i>Pyramica</i> sp. 1 (= <i>Trichoscapa mitis</i> )	<i>L</i>	FI92-404, FI98-438, KO980806-3
<i>Pyramica mutica</i> (Brown)		FI92-(334, 339, 410), FI95-516, FI97-1, KT96-192
<i>Strumigenys bryanti</i> Wheeler (= sp. 1)		FI93-211
<i>Strumigenys koningsbergeri</i> Forel	<i>P, L</i>	FI92-358, FI93-105, FI94-5, FI95-(427, 597, 748, 780, 787), FI96-(70, 72), FI97-(617, 636), FI98-301
<i>Strumigenys rogeri</i> Emery (= sp. 35 of SKY)	<i>L</i>	FI92-377, FI93-(103, 128), FI94-4, FI95-432, FI97-589
<i>Strumigenys</i> sp. 3	<i>F</i>	
<i>Strumigenys</i> sp. 4, nr. <i>lyroessa</i> (Roger) (= <i>Labidogenys</i> sp.1 of SKY)		FI92-(335, 356, 371), FI93-125-2, FI94-3, FI95-(414, 417, 498, 726), FI97-(586, 626)
<i>Strumigenys</i> sp. 6 (= sp. 25 of SKY)	<i>P, L</i>	
<i>Strumigenys</i> sp. 7, ? <i>kraepelini</i> Forel (= sp. 9, 10, = sp.1 of SKY)		FI92-363, FI93-(101, 102, 125), FI95-(489, 538, 550, 754, 796, 819), FI96-245, KT96-204, KO970902-8, KO970926-1, FI98-(235, 245, 426, 434, 435, 439),

<i>Strumigenys</i> sp. 8, nr. <i>juliae</i> Forel	<i>P, L</i>	KO980808-4 FI90-187, FI92-(342, 347, 388), FI95-(524, 805)
Tribe Formicoxenini (5 spp.)		
<i>Cardiocondyla emeryi</i> Forel (= sp. 2)	<i>S, T</i>	KT96-206, KY97-26
<i>Cardiocondyla nuda</i> (Mayr) (= sp. 4)		FI97-20, KY97-25
<i>Cardiocondyla wroughtonii</i> (Forel) (= sp. 1)	<i>L, S, T</i>	FI94-210
<i>Cardiocondyla</i> sp. 3 (= sp. 5 of SKY)	<i>L</i>	FI95-490
<i>Cardiocondyla</i> sp. 5 (= sp. 4 of SKY)	<i>T</i>	KT96-197
Tribe Melissotarsini (1 sp.)		
<i>Rhopalomastix</i> sp. 1, ? <i>rothneyi</i> Forel (= sp. 2 of SKY)		FI94-211, FI95-462
Tribe Meranoplini (2 spp.)		
<i>Meranoplus bicolor</i> (Guréin-Méneville)	<i>P</i>	FI90-191
<i>Meranoplus malaysianus</i> Schödl (= sp. 1)	<i>L</i>	FI92-387 (including paratypes), FI95-426, KT96-(185, 188)
Tribe Metaponini (4 spp.)		
<i>Vollenhovia fridae</i> Forel		FI92-328
<i>Vollenhovia</i> sp. 1 (= sp. 3 of SKY)	<i>L</i>	FI95-735, KO960830
<i>Vollenhovia</i> sp. 3 (nr. sp. 20 of SKY)		FI95-435, FI98-(236, 432)
<i>Vollenhovia</i> sp. 4 (nr. sp. 21 of SKY)	<i>T</i>	
Tribe Myrmecini (4 spp.)		
<i>Myrmecina</i> sp. A	<i>L</i>	Many, see Ito (1996)
<i>Myrmecina</i> sp. F	<i>L</i>	FI95-(571, 715), FI97-(545, 616, 618, 635)
<i>Myrmecina</i> sp. M	<i>L</i>	
<i>Pristomyrmex brevispinosus</i> Emery	<i>F</i>	
Tribe Myrmicariini (1 sp.)		
<i>Myrmicaria brunnea</i> Saunders (= sp.1)	<i>P, L, T</i>	FI90-(185, 207), KT96-255
Tribe Pheidolini (14 spp.)		
<i>Lophomyrmex opaciceps</i> Viehmeyer	<i>P, L</i>	FI90-(181, 184, 190, 240, 214), FI95-(419, 423, 473, 785), KY97-11
<i>Pheidole aglae</i> Forel (= sp. 2, = sp. eg-9)	<i>L</i>	FI90-(176, 177, 180, 210, 238), FI92-(343, 367, 397) FI95-781, KT96-262, FI97-80, KO970913-2, KO970902-17
<i>Pheidole aristotelis</i> Forel	<i>L</i>	
<i>Pheidole butteli</i> Forel (= sp. 8, = sp. eg-22)	<i>P, L</i>	FI90-(182, 226), FI92-(368, 381), FI95-(524, 530, 546, 570, 596, 732, 810, 824), KT96-(5, 194), FI97-(530, 560)
<i>Pheidole elisae nenia</i> Forel (= sp. 16, 13)		FI92-(341, 353, 357), FI95-820, KT96-(81, 203, 256), FI97-(32, 572), KO970913-9, KT98-12
<i>Pheidole hortensis</i> Forel (= sp. 6)	<i>P, L</i>	FI90-(199, 203, 237), FI92-(348, 401), FI95-(353, 381, 392, 398, 471, 472, 499, 573, 751, 775, 827), FI96-(254, 259), KO960902, FI97-631, KO970902-20, KO970829-8, KO970913-9, FI98-(241, 442)
<i>Pheidole nodgii</i> Forel (= sp. 19)	<i>P, L</i>	FI96-253, FI97-551
<i>Pheidole plagiaria</i> F. Smith (= sp. 3)	<i>B, P, L, T</i>	FI90-(171, 172, 193), FI92-(360, 400), FI95-(383, 442, 443, 470, 491, 534, 594, 784, 794), KT96-(80, 97, 143, 189, 238, 251, 259), KO98087-1, KT98-(5, 7, 13)
<i>Pheidole plinii</i> Forel (= sp. 27)	<i>P</i>	
<i>Pheidole sauberi sarawakana</i> Forel (= sp. 10, = sp. eg-28)	<i>L</i>	FI90-208, FI92-380, FI95-601, KY97-2
<i>Pheidole tandjongensis</i> Forel (= sp. 9)	<i>P, L</i>	FI90-(219, 225), FI93-(213, 214, 215), FI95-(250, 401, 424, 728, 724), KT96-(211, 225, 229, 265),

		FI96-(74, 75, 246, 250), FI98-243
<i>Pheidole</i> sp.1 (= sp. eg-75 nr. <i>platifrons</i> Santschi)		FI90-211, FI95-736
<i>Pheidole</i> sp. 7 (= sp. eg-96)	<i>P, L, S</i>	FI90-(173, 402), FI92-402, FI95-(449, 499, 567, 581), FI96-(76, 77, 252)
<i>Pheidole</i> sp. 12 (= sp. eg-41)	<i>P, L</i>	FI92-396, FI95-(533, 561, 729, 770), FI98-436
<i>Pheidole</i> sp. 17		FI95-434
Tribe Pheidologetonini (8 spp.)		
<i>Oligomyrmex</i> sp. 1 (= sp. 16 of SKY)		FI90-(202, 231)
<i>Oligomyrmex</i> sp. 2 (= sp. 4, = sp. 5 of SKY)	<i>P, L</i>	FI90-(137, 409), FI92-(308, 331, 346, 376, 383, 384, 385, 390, 392, 398, 409), FI95-(384, 386, 387, 388, 395, 422, 430, 431, 478, 580, 718, 720, 747, 765, 766, 773, 786), KT96-(180, 234, 235), KY97-8, KO980808-5, FI98-441
<i>Oligomyrmex</i> sp. 3 (= sp. 4 of SKY)		FI95-(421, 587)
<i>Oligomyrmex</i> sp. 5 (= sp. 8 of SKY)	<i>T, L</i>	FI95-527, KT96-247, FI97-31, KO970929-1
<i>Oligomyrmex</i> sp. 7	<i>L</i>	FI90-245, KT96-21
<i>Pheidologeton affinis</i> (Jerdon)	<i>P, L, T</i>	FI90-(170, 183, 186, 189, 195, 204, 215, 216, 220, 224, 243, 259), FI95-497, FI96-247, KT96-(166, 178, 179, 187, 223), KO960902, KO960918, KO970913-13
<i>Recurvidris kemneri</i> (Wheeler & Wheeler)	<i>P, L,</i>	
Tribe Solenopsidini (8 spp.)		
<i>Epelysidris</i> sp. 1 (= sp. 2 of SKY)		FI90-221
<i>Monomorium destructor</i> (Jerdon) (= sp. 5)	<i>S</i>	
<i>Monomorium floricola</i> (Jerdon) (= sp. 2)	<i>P, L, S, T</i>	FI92-366, FI95-360, KY97-15
<i>Monomorium pharaonis</i> (Lin.) (= sp. 4)	<i>S</i>	
<i>Monomorium talpa</i> Emery (= sp. 1, sp. 6)	<i>P, L</i>	FI92-374, FI95-(529, 731, 771, 797, 804), KT96-236, FI98-239
<i>Monomorium</i> sp.3	<i>S, T,</i>	FI92-332, FI95-(579, 585, 719, 750, 761), FI96-71, KT96-140, KT96-(93, 171, 196, 202, 213), FI97-16, KO970829-4, FI98-(242, 430)
<i>Monomorium</i> sp.7 (nr. sp. 5 of SKY)		FI95-468
<i>Solenopsis</i> sp. 1 (nr. sp. 1 of SKY)	<i>P, L</i>	FI92-361, FI95-361
Tribe Stenammini (2 spp.)		
<i>Calyptomyrmex</i> sp. 1 (= sp. 4 of SKY)		
<i>Lordomyrma</i> sp. 1 (= sp. 7 of SKY)	<i>L</i>	FI95-(500, 714)
Tribe Tetramoriini (11 spp.)		
<i>Tetramorium curtulum</i> Emery (= sp. 4)	<i>P, L</i>	FI92-(352, 369, 403), FI95-(400, 520, 795), KT96-182
<i>Tetramorium insolens</i> (Fr. Smith) (= sp. 5)		FI94-153, FI95-(405, 446, 447), KO970913-2
<i>Tetramorium kheperra</i> (Bolton) (= sp. 1)	<i>P, L, T</i>	FI90-(174, 175, 205), FI92-(329, 330, 344, 351, 364, 365, 370, 372, 373, 379, 393, 399), FI93-(48, 49, 87, 88, 89), FI95-(416, 727, 755, 763), KO960910, KO960830, FI97-19, KO970830, FI98-293, KT98-(16, 28)
<i>Tetramorium kraepelini</i> Forel (= sp. 3)	<i>P, L, S</i>	FI93-127, FI95-(428, 429, 742, 757), KO960902, FI97-12
<i>Tetramorium lanuginosum</i> Mayr (= sp. 2)		FI92-365
<i>Tetramorium meshena</i> (Bolton)	<i>L</i>	FI98-425
<i>Tetramorium pacificum</i> Mayr (= sp. 8)	<i>L, S, T,</i>	FI90-(196, 201, 206, 218, 407), FI92-(236, 336, 338, 340, 349, 354, 355, 362, 407), FI93-(46, 47, 107, 108, 109), FI94-65, FI95-(350, 362, 440, 441,



		756, 821), KT96-(173, 203, 221) KO970829-20, FI98-(240, 296)
<i>Tetramorium simillimum</i> (F. Smith) (=sp. 9)	S,	KT96-227, KO980808-2
<i>Tetramorium smithi</i> Mayr (= sp. 10)	L	FI95-515
<i>Tetramorium</i> sp. 6 ( <i>eleates</i> gp., = sp. 39 of SKY)	L, T	FI92-(345, 408), FI95-(557, 744), FI97-(14, 18), FI98-446
<i>Rhoptromyrmex wroughtonii</i> Forel		FI95-403
<b>Subfamily Ponerinae (54 spp.)</b>		
Tribe Amblyoponini (4 spp.)		
<i>Amblyopone reclinata</i> Mayr (= sp. <i>reclinata</i> group)	P, L	18 colonies in Ito (1993a,b), FI92-320, KY97-20
<i>Amblyopone</i> sp. 2		FI92-394, FI93-143, FI97-578
<i>Mystrum camillae</i> Emery	L	FI90-99, FI94-1, FI97-573
<i>Prionopelta kraepelini</i> Forel	P	FI92-306, FI95-603, KT97-199, see Ito and Billen (1998)
Tribe Ectatommini (5 spp.)		
<i>Discothyrea</i> sp. 1	L	
<i>Discothyrea</i> sp. 2		FI93-210
<i>Discothyrea</i> sp. 3	F	
<i>Gnamptogenys binghamii</i> (Forel) (= sp. 3)		FI94-42, KY97-28
<i>Gnamptogenys dammermanni</i> (Wheeler) (= sp. 1)	P, L	FI90-(39, 73, 79) FI92-411, FI93-(71, 212), FI94-2, FI95-(725, 822), FI97-(583, 629)
Tribe Platythyreini (5 spp.)		
<i>Platythyrea parallela</i> (F. Smith) (= sp. 2)	T	FI94-(57, 88, 170), FI95-407
<i>Platythyrea quadridenta</i> Donisthorpe		FI96-248
<i>Platythyrea</i> sp. 3	T	FI94-(89, 90, 91, 92, 127, 152, 161), FI95-(461, 464, 503, 535), FI97-(7, 41, 611)
<i>Probolomyrmex dammermanni</i> Wheeler (= sp. 2)	L	FI95-(517, 588, 717, 749), FI97-45, see Ito (1998)
<i>Probolomyrmex</i> sp. 1 (= sp. 3 of SKY)		FI92-305, FI93-60
Tribe Ponerini (40 spp.)		
<i>Anochetus graeffei</i> Mayr (= sp. 3)	L	FI92-(301, 302, 303, 304, 373, 412, 413, 414), FI93-(99, 100, 117), FI94-17, FI95-(433, 455, 456, 518, 590, 746), KY97-(1, 24), KO980806-5
<i>Anochetus modicus</i> Brown (= sp. 1)		FI92-300
<i>Anochetus</i> sp. 2 (= sp. 16 of SKY)		FI96-249, KY97-4
<i>Anochetus</i> sp. 4 ( <i>A. myops</i> -gp.) (= sp. 1 of SKY)	F	
<i>Anochetus</i> sp. 10 (= sp. 9 of SKY)		KO980808-1
<i>Centromyrmex feae</i> Emery	L	FI90-40, FI92-323, KO960830, FI97-(3, 558), KT97-193, KO980807-4
<i>Cryptopone</i> sp. 2	L	
<i>Cryptopone</i> sp. 4		KY97-10
<i>Diacamma rugosum</i> (Le Guillou)	P, S, T	FI90-(103, 104, 107), FI93-138, KT96-(84, 230, 244), FI97-613
<i>Harpegnathos</i> sp. ? <i>ventator</i> (F. Smith)		BZM collection
<i>Hypoconera</i> sp. N1 (= sp. 17 of SKY)	L	FI90-(52, 69), FI92-308, FI95-399
<i>Hypoconera</i> sp. N2 (= sp. N4, N6, = sp. 40 of SKY)	P, L	FI90-(48, 54), FI92-(307, 310, 318, 322, 376), FI95-(532, 586, 584, 716, 792), KT96-168, KO960902-1, FI97-(13, 544, 550), KY97-(14, 22, 27, 37)
<i>Hypoconera</i> sp. N3 (= sp. 1 of SKY)	L	FI90-65, FI92-312, FI93-216, FI95-558, FI97-(577, 588)
<i>Hypoconera</i> sp. N5 (= sp. 19 of SKY)	L	FI90-(76, 86), FI92-315, FI95-(589, 788)
<i>Hypoconera</i> sp. N7 (= sp. N9, = sp. 5 of SKY)		FI90-56, FI92-(325, 327), FI95-457, FI97-54
<i>Hypoconera</i> sp. N8 (= sp. 28 of SKY)		FI90-(42, 46, 87, 92), FI92-(309, 321), FI93-118, FI95-(548, 823, 826), KY97-(18, 21, 36), FI98-234

<i>Hypoponera</i> sp. N10		FI90-88, FI95-501
<i>Hypoponera</i> sp. N11		FI92-313, KT96-253
<i>Leptogenys diminuta</i> (F. Smith)	<i>P</i>	FI90-(1130-1, 53), 92L1, FI93-168, FI95-(592, 737, 809), FI96-(73, 78, 381, 382, 383), FI97-639, KO980807-6, KO980817-2, KO980818, see Ito (1997) and Ito and Ohkawara (2000)
<i>Leptogenys mutabilis</i> (F. Smith)	<i>P, L</i>	FI90-(41, 45, 47, 50, 63, 66), KT96-(254, 89), KO980806-4
<i>Leptogenys myops</i> (Emery)	<i>P, L</i>	FI90-(38, 50, 57, 59, 74, 75, 77, 80, 85, 88, 93, 96, 97, 98, 108, 126), FI94-142, FI97-(85, 638), KO980806-2, see Ito (1997)
<i>Leptogenys peuqueti</i> (André)	<i>P, L</i>	FI90-(37, 61, 70, 71, 72, 84, 89, 90, 91), FI93-(50, 156), FI94-(6, 7, 8, 12, 13, 17, 171), FI95-(354, 449, 722), KT96-(95, 226), FI97-(6, 15, 16, 642, 645), see Ito (1997)
<i>Leptogenys</i> sp. 21 (= sp. 25 of SKY)		FI93-77, FI95-(492, 545, 624), see Ito (1997)
<i>Leptogenys</i> sp. 25, nr. <i>peuqueti</i>	<i>P</i>	FI93-136, FI95-(355, 528)
<i>Myopias emeryi</i> (Forel)		FI95-396
<i>Odontomachus rixosus</i> F. Smith	<i>P, L</i>	FI90-(22, 23, 49, 64), FI92-311, KT96-(78, 210), see Ito <i>et al</i> (1996)
<i>Odontomachus simillimus</i> F. Smith	<i>P, L, T</i>	FI90-(21, 27, 29, 30, 31, 32, 33, 35, 44, 83), KT96-207, KT96-231, KT96-237, KY97-6
<i>Odontoponera transversa</i> (F. Sm.) (= sp. 2 of SKY)	<i>P, L, S, T</i>	FI90-28
<i>Odontoponera denticulata</i> (F. Sm.) (= sp. 1 of SKY)	<i>P, L, S</i>	FI90-68, KT96-(70, 96)
<i>Pachycondyla</i> (= <i>Pseudoponera</i> ) <i>amblyops</i> (Emery)	<i>P, L</i>	FI90-(24, 26, 34, 36, 45, 59), FI92-44, KY97-12, KO980806-1
<i>Pachycondyla</i> (= <i>Brachyponera</i> ) <i>chinensis</i> (Emery)	<i>P, L, T</i>	FI90-(60, 62, 67, 81, 84, 94, 193), FI92-(316, 317, 324), FI95-539
<i>Pachycondyla</i> (= <i>Brachyponera</i> ) <i>luteipes</i> (Mayr)	<i>L</i>	FI94-169, FI95- (549, 565)
<i>Pachycondyla</i> (= <i>Trachymesops</i> ) <i>sharpi</i> (Forel)	<i>P</i>	FI90-55, FI92-314, FI94-(152, 167, 168), FI95-475, KT96-(94, 233)
<i>Pachycondyla</i> (= <i>Bothroponera</i> ) sp. 1, ? <i>insularis</i> (Emery)	<i>P</i>	see Ito (1993c, 1999)
<i>Pachycondyla</i> (= <i>Ectomonymex</i> ) sp. 3, ? <i>javana</i> (Mayr)	<i>P, L, T</i>	FI90-(25, 51, 249), FI92-319, FI93-80, FI95-578, KT96-208, FI97-570, KO980807-5, KO980807-7
<i>Pachycondyla</i> (= <i>Mesoponera</i> ) sp. 5,	<i>L</i>	FI90-(78, 95), FI92-(405, 406), FI93-115, FI94-16,
? <i>rubra</i> (F. Smith) (= sp. .9 of SKY)		FI95-825, FI97-(20, 21), KY97-23
<i>Ponera</i> sp. 1	<i>L</i>	FI97-549
<i>Ponera</i> sp. 2	<i>L</i>	FI90-82
<i>Ponera</i> sp. 3	<i>F</i>	
<i>Ponera</i> sp. 6	<i>L</i>	FI97-(29, 35, 36)

#### Subfamily Pseudomyrmecinae (4 spp.)

##### Tribe Pseudomyrmecini (4 spp.)

<i>Tetraponera</i> sp. 1	<i>F</i>
<i>Tetraponera</i> sp. 2 (nr. sp. 20 of SKY)	<i>L, T</i>
<i>Tetraponera</i> sp. 3	<i>L</i>
<i>Tetraponera pilosa</i> F. Smith	<i>F</i>