CHAPTER IV

RESULTS

Species surveys and sample collections of the aculeate species in the north of Thailand (Table 4) were carried out during January 2006 to June 2007. Systematic random sampling was used for sample collections. We found 3 superfamilies of the infraorder Aculeata in northern Thailand. Those 3 superfamilies were Apoidea, Chrysidoidea and Vespoidea. From totally 120 specimens, the 88 specimens can be identified at the species level and 32 specimens were identified at the generic level. These species belonged to 64 genera, 23 subfamilies and 9 families. In Apoidea, there were 35 species in 5 families: Anthophoridae, Apidae, Halictidae, Megachilidae and Sphecidae. Five species were found in Chrysididae of the Chrysidoidea. In Vespoidea, There were 80 species in 3 families: Formicidae, Scoliidae and Vespidae. The summary of the aculeate bee species occurring in this thesis was provided in Table 1. The taxonomic list of insects in the infraorder Aculeata found in the north of Thailand and each species was numbered for references and kept at the Entomology Lab, the Department of Biology, Faculty of Science, Naresuan University, Phitsanulok (Table 5).

The species diversity index, Pielou's index (J') among the 8 habitats was slightly different, except grassland was mostly different. The index was the highest in hill evergreen forest (0.846) and was the lowest in grassland (0.369). The dominant index, Simpson's index differed from the species diversity index because grassland had the highest value (0.175) and hill evergreen forest had the lowest value (0.020). Moreover, the value of Pielou's index in natural forest (6 forest types combined) (0.880) was higher than that of cultivated area (0.663). The detail of species structure index from the 8 habitat types was shown in Table 2.

Table 1 The summary of insects in the infraorder Aculeata found in the north of Thailand.

Superfamilies/Families		Subfamilies	Tribes	Genera	Species
3	9	23	38	64	120
Apoidea					
	Anthophoridae	Anthophorinae	Anthophorini	*Amegilla*	*A. florea*
		Xylocopinae	Ceratinini	*Ceratina*	*Ceratina lieftincki*
				Pithilis	*P. smaragdula*
			Melectini	*Thyreus*	*Thyreus* sp.
			Xylocopini	*Xylocopa*	*X. confusa*
					X. latipes
		2	4	5	6
	Apidae	Apinae	Apini	*Apis*	*A. andreniformis*
					A. cerana
					A. dorsata
					A. florea
					A. mellifera
		Bombinae	Bombini	*Bombus*	*Bombus* sp.
		Meliponinae	Meliponini	*Hypotrigona*	*Hypotrigona* sp.
				Trigona	*T. apicalis*
					T. collina
					T. fimbriata
					T. fuscobalteata
					T. itama
					T. laeviceps
					T. melanoleuca
					T. minor
					T. nitidiventris
					T. peninsularis
					T. terminata
					T. thoracica
					T. ventalis
		3	3	4	20
	Halictidae	Halictinae	Halictini	*Halictus*	*Halictus* sp.
		1	1	1	1
	Megachilidae	Megachilinae	Megachihi	*Coelioxys*	*Coelioxys* sp.
				Megachile	*Megachile* sp.1
					Megachile sp.2
		1	1	2	3

Table 1 (Cont.).

Superfamilies/Families	Subfamilies	Tribes	Genera	Species
Sphecidae	Nyssoninae	Bembecini	*Bembix*	*Bembix* sp.
	Sceliphroninae	Sceliphronini	*Chalybion*	*Chalybion* sp.
			Sceliphron	*Sceliphron* sp.1
				Sceliphron sp.2
	Sphecinae	Sphecini	*Sphex*	*Sphex* sp.
	3	3	4	5
Total: 5	**10**	**12**	**16**	**35**
Chrysidoidea				
Chrysididae	Chrysidinae	Chrysidini	*Chrysis*	*Chrysis* sp.1
				Chrysis sp.2
				Chrysis sp.3
			Trichrysis	*Trichrysis* sp.
			Praestochrysis	*Praestochrysis* sp.
	1	1	3	5
Total: 1	**1**	**1**	**3**	**5**
Vespoidea				
Formicidae	Aenictinae	Aenictini	*Aenictus*	*A. binghami*
	Cerapachyinae	Cerapachyini	*Cerapachys*	*C. sulcinodis*
	Dolichoderina	Dolichoderin	*Dolichoderus*	*D. thoracicus*
				D. tuberifer
			Iridomyrmex	*I. anceps*
			Philidris	*Philidris* sp.
			Technomyrmex	*T. kraepelini*
				T. modiglianii
	Formicinae	Camponotini	*Camponotus*	*C. camelinus*
				C. leonadi
				C. rufoglaucus
				C. singularis
				Camponotus sp.1
				Camponotus sp.2
			Polyrhachis	*P. abdominalis*
				P. armata
				P. bihamata
				P. dives
				P. flavicornis
				P. furcata

Table 1 (Cont.).

Superfamilies/Families	Subfamilies	Tribes	Genera	Species
				P. hippomanes
				P. muelleri
				P. proxima
				P. tibialis
				Polyrhachis sp.1
				Polyrhachis sp.2
		Oecophyllini	*Oecophylla*	*O. smaragdina*
		Plagiolepidini	*Anoplolepis*	*A. gracilipes*
				Lepisiota sp.
			Paratrechina	*P. longicornis*
			Plagiolepis	*Plagiolepis* sp.
	Myrmicinae	Cataulacini	*Cataulacus*	*C. granulatus*
		Crematogastrini	*Crematogaster*	*C. coriaria*
				C. difformis
				C. rogenhoferi
		Formicoxenini	*Cardiocondyla*	*C. wroughtonii*
		Melissotarsini	*Rhopalomastix*	*R. janeti*
		Meranoplini	*Meranoplus*	*M. bicolor*
		Myrmecinini	*Pristomyrmex*	*P. punctatus*
		Pheidolini	*Pheidole*	*P. plagiaria*
		Pheidologetonini	*Pheidologeton*	*P. diversus*
		Solenopsidini	*Monomorium*	*M. destructor*
			Solenopsis	*S. geminata*
		Tetramoriini	*Rhoptromyrmex*	*R. wroughtoni*
			Tetramorium	*T. flavipes*
	Ponerinae	Ectatommini	*Gnamptogenys*	*bicolor*
		Leptogenyini	*Leptogenys*	*L. diminuta*
				L. kitteli
		Odontomachini	*Odontomachus*	*O. rixosus*
				O. simillimus
		Ponerini	*Diacamma*	*D. sculpturata*
				D. vargens
			Harpegnathos	*H. venator*
			Odontoponera	*O. denticulata*
			Pachycondyla	*P. astuta*
				P. chinensis
				P. luteipes
				P. rufipes

Table 1 (Cont.).

Superfamilies/Families	Subfamilies	Tribes	Genera	Species
	Pseudomyrmecinae	Pseudomyrmecini	*Tetraponera*	*T. allaborans*
				T. attenuata
				T. rufonigra
	7	21	33	61
Scoliidae	Scoliinae	Campsomerini	*Campsomeris*	*Campsomeris* sp.
		Scoliini.	*Scolia*	*Scolia* sp.
	1	2	2	2
Vespidae	Eumeninae	-	*Delta*	*D. pyriforme*
				Delta sp.
		-	*Phimenes*	*P. flavopictus*
		-	*Rhynchium*	*Rhynchium* sp.
	Polistinae	Polistini	*Polites*	*P. olivaceus*
				Polites sp.
		Ropalidiini	*Parapolybia*	*P. varia*
			Polybioides	*Polybioides* sp.
			Ropalidia	*Ropalidia* sp.1
				Ropalidia sp.2
	Stenogastrinae	Stenogastrini	*Parischnogaster*	*Parischnogaster* sp.
	Vespinae	-	*Provespa*	*P. anomala*
		-	*Vespa*	*V. affinis*
				V. mandarinia
				V. soror
				V. tropica
				V. velutina
	4	3	10	17
Total: 3	**12**	**26**	**45**	**80**

Table 2 Ecological indices of aculeate bee species structure in the 8 different habitats: deciduous with bamboo forest (BB/DF), deciduous dipterocarp forest (DDF), evergreen forest (EGF), hill evergreen forest (HEGF), mixed evergreen and deciduous forest (MXF), grassland (GL), forest area (FA) and cultivated area (CA).

Habitats	Ecological indices	
	Pielou's index (J')	Simpson's index (C)
BB/DF	0.843	0.028
DDF	0.668	0.048
EGF	0.603	0.063
HEGF	0.846	0.020
MXF	0.691	0.047
GL	0.369	0.175
FA	0.880	0.238
CA	0.663	0.036

The calculated Sorensen's similarity coefficient, which matches in species between a pair area, was shown in Table 2. The study of species structure indices compared among the 8 types of habitats (Table 6): deciduous with bamboo forest (BB/DF), deciduous dipterocarp forest (DDF), evergreen forest (EGF), hill evergreen forest (HEGF), mixed evergreen and deciduous forest (MXF), grassland (GL) and cultivated area (CA), including forest area (FA) indicated that the difference in habitat type influences species differentiation in the aculeates which occupy these habitats. The similarity measurement, BB/DF and HEGF (0.639), and FA and CA (0.621) showed the most similar aculeate species structure. Moreover, the lower index indicates the differences in the aculeate species structure between the habitats: BB/DF and GL (0.081), DDF and GL (0.000), EGF and GL (0.000), HEGF and GL (0.079), and MXF and GL (0.045) (Table 3).

Table 3 The Sorensen's similarity coefficient of insect species in 8 habitats: deciduous with bamboo forest (BB/DF), deciduous dipterocarp forest (DDF), evergreen forest (EGF), hill evergreen forest (HEGF), mixed evergreen and deciduous forest (MXF), grassland (GL), forest area (FA) and cultivated area (CA).

Comparison of areas	Sorensen's similarity coefficient (S_s)
BB/DF and DDF	0.416
BB/DF and EGF	0.274
BB/DF and HEGF	0.639
BB/DF and GL	0.081
BB/DF and MXF	0.433
DDF and EGF	0.480
DDF and HEGF	0.364
DDF and GL	0.194
DDF and MXF	0.418
EGF and HEGF	0.352
EGF and GL	0.000
EGF and MXF	0.441
HEGF and GL	0.079
HEGF and MXF	0.471
MXF and GL	0.045
FA and CA	0.621

In addition, 3 ecological indices: the similarity index, species diversity index and domidant index in all habitats of natural forests and cultivalted areas in each location (Table 4) were shown in Table 8 and Table 9 (Appendix).

The species richness (Table 7) and species diversity index (J') (Table 8) of each habitat in each location (Table 4) showed that deciduous with bamboo forests in Phitsanulok 1 (75 species, 0.859), deciduous dipterocarp forests in Phetchabun (21 species, 0.892), evergreen forests in Tak 3 (21 species, 0.955), hill evergreen forests at Mae Hong Son (41 species, 0.852), mixed evergreen and deciduous forests at Chiang Mai (25 species, 0.842), grassland in Phitsanulok 1 (5 species, 0.428) and cultivated areas in Chiang Mai (48 species, 0.876) are the highest value of each habitat in each location.

From the calculated dominant index (C) (Table 8) of each habitat in each location (Table 4), we found that the deciduous with bamboo forests in Nan (0.059), deciduous dipterocarp forests in Sukhothai (0.080), evergreen forests in Chiang Mai 2 (0.120), hill evergreen forests in Nan (0.046), mixed evergreen and deciduous forests in Chiang Rai (0.092), grassland in Phitsanulok 2 (0.253) and cultivated areas in Phichit (0.069) showed the highest value of dominant species.

From the comparison of areas using Sorensen's similarity coefficient (S_s) in all habitats in each location (Table 4) found that the deciduous with bamboo forests between Nan and Uttaradit (0.865), deciduous dipterocarp forests between Tak 2 and Phitsanulok 2 (0.872), evergreen forests between Mae Hong Son and Tak 3 (0.800), hill evergreen forests between Mae Hong Son and Nan (0.676), mixed evergreen and deciduous forests between Tak 2 and Nakhon Sawan (0.781), grassland between Phitsanulok 1 and Phitsanulok 2 (0.670), and Phitsanulok 1 and Chiang Mai 2 (0.670), and cultivated areas between Lampang and Lamphun (0.861) showed the highest similarity index (Table 9).

Table 4 Study areas of aculeate species in 7 habitat types: deciduous with bamboo forest (BB/DF), deciduous dipterocarp forest (DDF), evergreen forest (EGF), hill evergreen forest (HEGF), mixed evergreen and deciduous forest (MXF), grassland (GL) and cultivated area (CA).

Type of Habitats	Locations				Altitude (msl.)
	Provinces	Districts	Tambols	Abbreviations	
BB/DF	Chiang Mai 1	Mueang	Suthep	CM1	396
	Chiang Rai	Phan	Mae Chedi Mai	CR	538
	Kamphaeng Phet	Khlong Lan	Kosampi	KP	322
	Mae Hong Son	Pai	Mae Hee	MHS	690
	Nakhon Sawan	Mae Wong	Mae Le	NSW	325
	Nan	Pua	*Pua*	N	264
	Phayao	Muang	Maeka	PY	568
	Phetchabun	Nam Nao	Nam Nao	PB	178
	Phitsanulok 1	Wang Thong	Chomphu	PL1	240
	Phitsanulok 2	Nakhon Thai	Nakhon Thai	PL2	227
	Phitsanulok 3	Wang Thong	Wang Nok Aen	PL3	56
	Sukhothai	Khirimat	Muang Kao	ST	540
	Tak 1	Mueang	Mae Tah	T1	488
	Tak 2	Samngao	Samngao	T2	322
	Uttaradit	Thapla	Nam Khrai	UD	231
DDF	Phayao	Muang	Maeka	PY	573
	Phetchabun	Nam Nao	Nam Nao	PB	479
	Phitsanulok 1	Wang Thong	Chomphu	PL1	540
	Phitsanulok 2	Nakhon Thai	Nakhon Thai	PL2	627
	Phitsanulok 3	Wang Thong	Wang Nok Aen	PL3	658
	Sukhothai	Khirimat	Muang Kao	ST	600
	Tak 1	Mueang	Mae Tah	T1	468
	Tak 2	Samngao	Samngao	T2	916
	Uttaradit	Thapla	Nam Khrai	UD	614
EGF	Chiang Mai 2	Chomthong	Ban Pong	CM2	2,572
	Mae Hong Son	Pai	Mae Hee	MHS	2,051
	Tak 3	Tha *Song Yang*	Tha *Song Yang*	T3	1,817

Table 4 (Cont.).

Type of Habitats	Locations				Altitude (msl.)
	Provinces	Districts	Tambols	Abbreviations	
HEGF	Chiang Mai 1	Mueang	Suthep	CM1	1,059
	Mae Hong Son	Pai	Mae Hee	MHS	1,719
	Nan	Pua	*Pua*	N	1,567
	Phitsanulok 1	Wang Thong	Chomphu	PL1	1,493
	Tak 3	Tha *Song Yang*	Tha *Song Yang*	T3	516
HEGF	Chiang Mai 1	Mueang	Suthep	CM1	586
	Chiang Rai	Phan	Mae Chedi Mai	CR	440
	Nakhon Sawan	Mae Wong	Mae Le	NSW	751
	Phetchabun	Nam Nao	Nam Nao	PB	838
	Tak 2	Muang	Mae Tah	T2	923
GL	Chiang Mai 2	Chomthong	Ban Pong	CM2	664
	Phitsanulok 1	Wang Thong	Chomphu	PL1	746
	Phitsanulok 2	Nakhon Thai	Nakhon Thai	PL2	440
CA	Chiang Mai 2	Chomthong	Ban Pong	CM2	2,444
	Lampang	Thoen	Lom Raet	LPA	429
	Lamphun	Mueang	Nai Mueang	LPU	220
	Phichit	Wachirabarami	Ban na	PC	37
	Phrae	Mueang	Nai Viang	PR	95

Key to the superfamilies of Aculeata found in northern Thailand

Modified from Goulet and Huber, 1993.

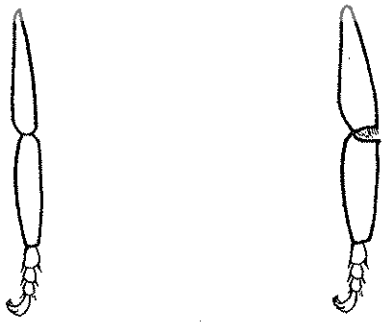
1.	a)	Wings absent; metasomal segment 1 and/or 2 node-like	Vespoidea (Formicidae)
	b)	Wings present	(2).
2(1b).	a)	Metasoma with 2-8 apical teeth	Chrysidoidea
	b)	Metasoma not apical teeth	(3).

2a) 2b)

3(2b).	a)	Pronotum adnate tegulae	most Vespoidea
	b)	Pronotum not adnate tegulae	(4).

3a) 3b)

4(3b).	a)	Hind leg without curbicula or pollen basket, or tarsomere 1 cylindrical as wide as other segments; body hairs with simples	Apoidea (Speciformes)
	b)	Hind leg with curbicula or tarsomere 1 wider than other segments; body hairs with branches	Apoidea (Apiformes)



4a) 4b)

Superfamily Apoidea

The Apoidea is dispersed worldwide. They are divided into 2 informal groups, the spheciformes (sphecid wasps) and the apiformes (bees) (Finnamore and Michener 1993). Both the spheciformes and apiformes were considered here. A total of 35 species in 16 genera were found in this study. These species belonged to 9 subfamilies in 5 families: Anthophoridae, Apidae, Halictidae, Megachilidae and Sphecidae.

Key to the families of Apoidea found in northern Thailand

Modified from Goulet and Huber, 1993; Yamane, Ikudome and Terayama, 1999.

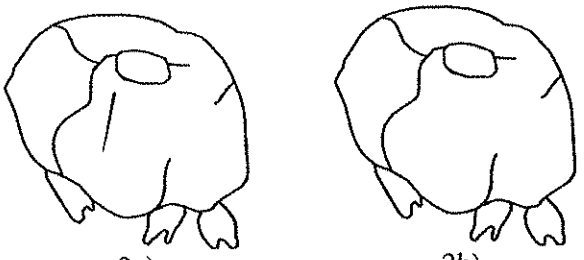
1. a) Hind leg without curbicula or tarsomere 1 as wide as other tarsomeres; body hairs with short to long simples or unbranched; petiole composed of sternum only ..... Sphecidae

   b) Hind leg with curbicula or tarsomere 1 wider than other tarsomeres; body hairs with short to long branches ..... (2).

1a) 2b)

2(1b). a) Episternal groove on mesopleuron present ..... Halictidae

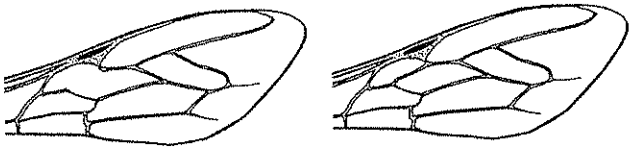
   b) Episternal groove on mesopleuron absent ..... (3).



2a) 2b)

3(2b). a) Labrum longer than wide; fore wing 2 submarginal cells ..... Megachilidae

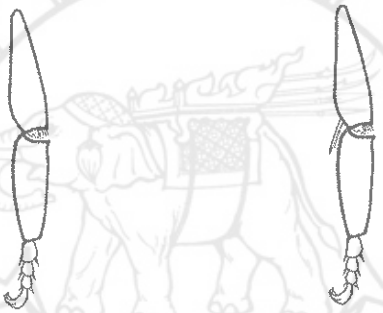
b) Labrum shorter than wide; fore wing 3 submarginal cells ..... (4).



3a) 3b)

4(3b). a) Hind leg with curbicula; hind tibia without apical spurs; hind wing without jugal lobe ..... Apidae

b) Hind leg without curbicula; hind tibia with apical spurs; hind wing with jugal lobe ..... Anthophoridae



4a) 4b)

Family Anthophoridae

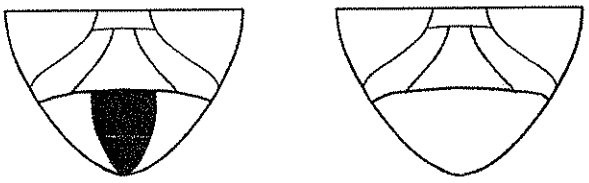
The family consists of 3 subfamilies, Nomadinae, Anthophorinae and Xylocopinae which are distributed around the world (Yamane, Ikudome and Terayama, 1999). Six species, in 4 tribes of 2 distinctive subfamilies: Anthophorinae (digger bees) and Xylocopinae (carpenter bees), were recognized in this study. We were able to identify the long-tongued bees. Pygidial plate and basitibial plate are present in almost all females. The pronotum is black, short and not extending back to the tegulae. The fore wing venation is well developed, and there are 3 submarginal cells and pterostigma in the fore wings. Hind femur lacks a well-defined trochantellus. Scopa is largely restricted to the hind tibia. The hind basitarsi is wider than the other segments.

Key to the species of Anthophoridae found in northern Thailand

Modifed from Goulet and Huber, 1993; Yamane, Ikudome and Terayama, 1999.

1. a) Pygidial plate present ..... Anthophorinae (2).

   b) Pygidial plate absent ..... Xylocopinae (3).



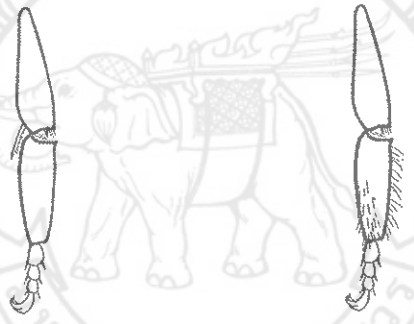
1a) 1b)

2(1a). a) Scopa absent ..... Melectictini

   - Body with patches of blue hairs ..... *Thyreus* sp.

   b) Scopa present ..... Anthophorini

   - Abdomen with blue bands on black ..... *Amegilla florea*

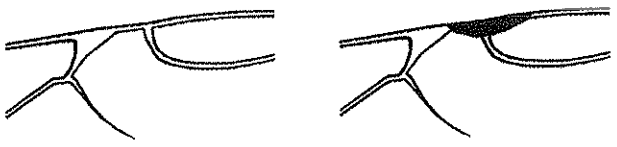


2a) 2b)

3(1b). a) Stigma absent ..... Xylocopini

   - Jugal lobe of hind wing shorter than vannal lobe ..... *Xylocopa* (4).

   b) Stigma present ..... Ceratinini (5).



3a) 3b)

4(3a). a) Yellow hair on thorax ..... *X. confusa*

   b) Body fully metallic black ..... *X. latipes*

5(3b). a) Body metallic green ..... *Pithitis smaragdula*

   b) Body not metallic green ..... *Ceratina lieftincki*

Subfamily Anthophorinae

The subfamily Anthophorinae is represented by a single species of genus *Amegilla* which are medium bees. They are distributed around the world (Michener, 2007). These insects have a strongly protuberant clypeus. Moreover, the marginal cell of the fore wing is shorter than the distance from its apex to wing tip. The apex of the marginal cell is rounded and separated from the wing margin. The fore wings have a small spot and stigma, whereas the hind wings have a jugal lobe.

Tribe Anthophorini

Genus *Amegilla* Friese, 1897

Amegilla is a genus of large bees in the tribe Anthophorini (Michener, 2007). They are widely distributed in Asia and Europe (Proshchalykin, 2004). Their body is medium-sized. The thorax is covered with brown hairs, but the metasomal terga lack have hair. The abdomen has a band with pale blue bands.

***Amegilla florea* (Smith, 1879)**

The length of body is 13-16 mm in the female. The head and mesosomal dorsum are densely covered by yellow-gray hairs. The compound eyes and ocelli are red-brown. The abdomens have 4 blue bands with black bases. The tibial scopa has yellowish hairs but the hairs in the anterior portion are black. Fore and hind wings are rather uniformly transparent. The fore wing has 3 submarginal cells without the stigma. The second submaginal cell is smaller than the first and second submaginal cells (Figure 3).

Subfamily Xylocopinae

The Xylocopinae occurs worldwide (Finnamore and Michener 1993). The total of 4 species in 4 genera form 3 tribes; Ceratinini, Melectini and Xylocopini were recorded in this study. All specimens were identified with characteristic of clypeus, which is not strongly protuberant and lateral parts as seen from underneath are bent backward, and not parallel to long-axis view with body.

Tribe Ceratinini

Genus *Ceratina* Latreille, 1802

Small carpenter bees are identified in the tribe Ceratinini (Daly, 1983; Warrit, 2007). *Ceratina* have black body. They have a weak scopa on the hind tibia. Most species have few yellow markings, most often restricted to the face, but often in other

parts of the body. The marginal cell is broad and longer than the distance from their apex to wing tip. In this study we found only one species, *Ceratina lieftincki*.

***Ceratina lieftincki* van der Vecht, 1952**

A body length of the female is about 4.5 mm. The head and thorax are mostly a black color but some parts of the gena, thorax, legs and abdomen (second to sixth metasomal terga) have whitish to yellow markings. The clypeus is like a thick inverted T. The abdomens have 5 yellow bands on a black background. The fore and hind wings are rather uniformly transparent (Figure 4).

Genus *Pithitis* Klug, 1807

Pithitis is a genus of the tribe Ceratinini. This genus is widely distributed from India through southeast Asia to Taiwan and Africa (Hirashima, 1969). Only one species, *Pithitis smaragdula* (Fabricius, 1787) was known from this study. Their body is brilliantly metallic green with a few pale markings on the head, thorax and legs, and is coarsely punctuated. Lower paraocular area is flat-bottomed punctures. The abdomen has a velvety black area on the terga and the sixth metasomal sternum has lateral teeth.

***Pithitis smaragdula* (Fabricius, 1787)**

This species is widely distributed in the Oriental region (Hirashima, 1969). The body of the female is about 8 mm in length with brilliantly metallic green in color. The middle of metasomal terga has a pair of longitudinal line while the fourth to sixth abdominal terga have a pair of velvety black section. The wings are rather uniformly transparent. This species is similar to the *Chrysis* species in the family Chrysididae but they lack apical teeth at the tip of their metasoma (Figure 5).

Tribe Melectini

Genus *Thyreus* Panzer, 1806

This genus is widely distributed worldwide except in the New World. *Thyreus* is a genus of the tribe Melectini (Michener, 2007). Their body has conspicuous patches of short blue to white hairs. The pattern of hair patches is easily recognized by having scutellum, posteriorly salient. The fore wing has 3 submarginal cells. The first submarginal cell is usually longer than the others. The jugal lobe of the hind wing is very small. The basitibial plates are absent. Only one species, *Thyreus* sp. was found from this study.

***Thyreus* sp.**

The total length of the female body is about 12 mm. The body is black with conspicuous patches of blue hairs. The first to sixth metasomal targa have 5 pair of blue hairs. The marginal cell of the fore wing is shorter than the distance from its apex to wing tip. The lateral of the mesothorax has obvious patches of blue hairs. The scutellum is posteriorly salient with black (Figure 6).

Tribe Xylocopini

Genus *Xylocopa* Latreille, 1802

This genus; carpenter bees are distributed worldwide. They are classified in the tribe Xylocopini which has a very large and robust body in genus *Xylocopa* (Finnamore and Michener 1993; Michener, 2007). Their colors are metallic black. Some species have yellowish areas on the face. They also lack a malar space, and the triangular second submarginal cell. The marginal cell is very slender and is longer than the distance from its apex to its wing tip. The jugal lobe of the hind wing is shorter than the vannal lobe. Two species were recorded in this study, *X. confusa* and *X. latipes*.

***Xylocopa confusa* Pérez, 1901**

This species is widely distributed across southeast Asia and Republic of Panama (Wcislo et al., 2004). They are large sizes bee, at about 2 cm. Their bodies are hairy. This species is characterized by yellow hair on the head and thorax. They have a black abdomen with black hairs. Their wings are uniformly dark brown (Figure 7).

***Xylocopa latipes* (Drury, 1773)**

This species is widely distributed across southeast Asia and India (Raju and Rao, 2006). They are very large bees. Their bodies are approximately 3-4 cm. Their body is fully metallic black and usually with black hairs. Their wings have metallic blue, green and purple colors under sunlight. The tibia of the fore legs is bright yellow (Figure 8).

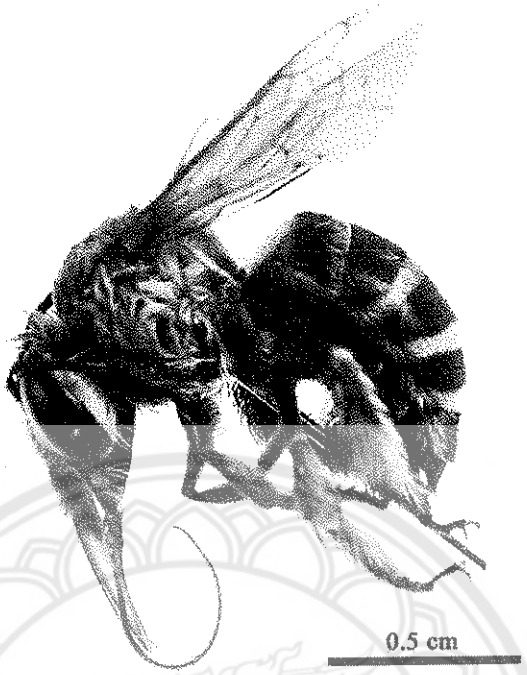


Figure 3 A female of *Amegilla florea* (Smith, 1879).

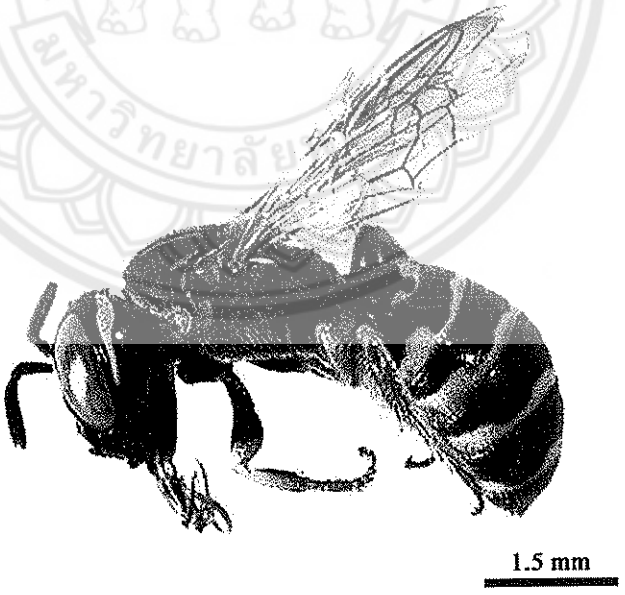


Figure 4 A female of *Ceratina lieftincki* van der Vecht, 1952.

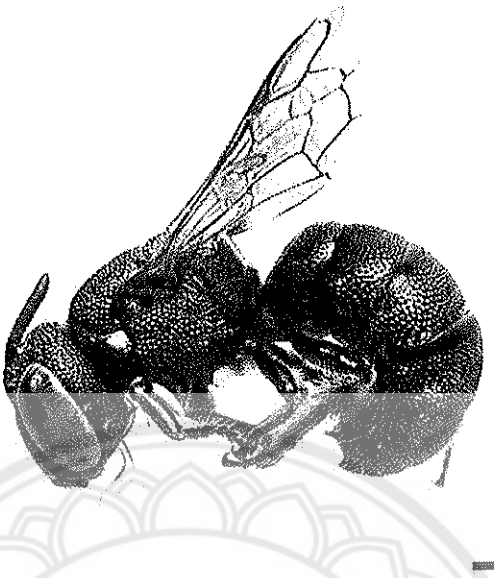


Figure 5 A female of *Pithitis smaragdula* (Fabricius, 1787).

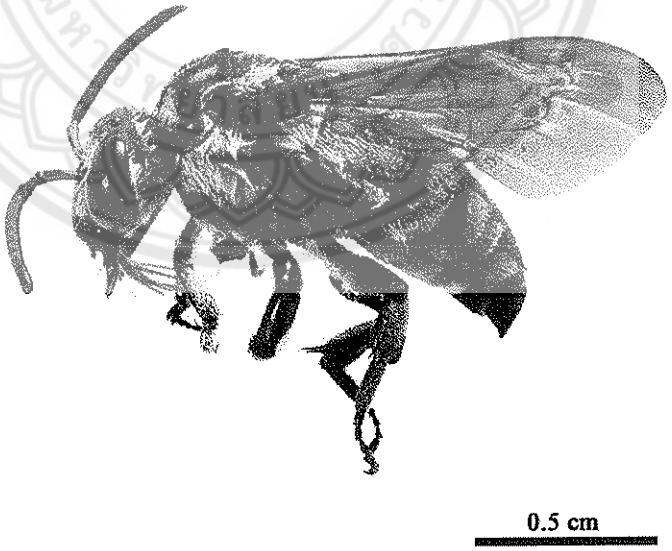


Figure 6 A female of *Thyreus* sp.

Figure 7 A worker of *Xylocopa confusa* Pérez, 1901.

Figure 8 A worker of *Xylocopa latipes* (Drury, 1773).

Family Apidae

This family is represented around the world and consists of honey bees, stingless bees and bumble bees (Michener, 2007). An Apidae is identified by having corbicula on the hind tibia. Moreover, their pronotum has a collar-like plate without projections that reach the tegulae. The labrum is wider than long. Body hairs are branched or plumose. The first segment of the metatarsus is often enlarged and flattened. The front wing has three submarginal cells and a stigma is present. The jugal lobe of the hind wing is shorter than the submedian cell.

A total of 20 specimens in 3 subfamilies were found in this study. They were identified as 18 species and 2 specimens were identified at the genus level.

Key to the species of Apidae found in northern Thailand

Modified from Sakagami, Inoue and Salmah, 1990; Michener, 2007.

1. a) Hind tibia with spurs ..... Bombinae
   - Hairy body with yellow color ..... *Bombus* sp.

   b) Hind tibia without spurs ..... (2).

1a) 1b)

2(1b). a) Sting present ..... Apinae, *Apis* (3).

   b) Sting absent ..... Meliponinae (7).

2a) 2b)

3(2a). a) Body length more than 1.5 cm ..... *A. dorsata*

   b) Body length less than 1.5 cm ..... (4).

4(3b). a) M vein of hind wing not extending apically beyond r-m vein ..... *A. mellifera*

b) Rs and M veins of hind wing extending apically beyond r-m vein ..... (5).

4a) 4b)

5(4b). a) Abdominal tergites without white band ..... *A. cerana*

b) Abdominal tergites with white band ..... (6).

6(5b). a) Abdominal tergites 1 and 2 with black band ..... *A. andreniformis*

b) Abdominal tergites 1 and 2 with orange band ..... *A. florea*

7(2b). a) Fore wing venation more reduced; pterostigma wider ..... *Hypotrigona*

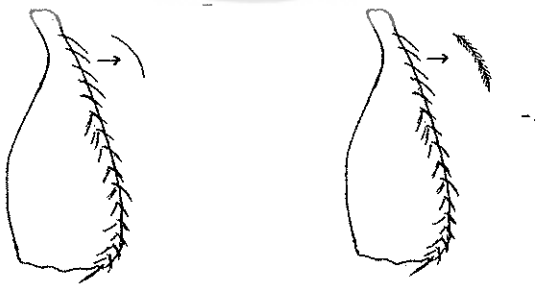
- Malar space shorter than flagella diameter; very small species, body length less than 3 mm ..... *Hypotrigona* sp.

b) Fore wing venation less reduced; pterostigma narrower; small to large species, body length bigger than large *Hypotrigona* ..... *Trigona* (8).

7a) 7b)

8(7b). a) Simple hairs on hind tibia ..... (9).

b) Plumose hairs on hind tibia ..... (11).



8a) 8b)

9(8a). a) Hind tibia apically not expanded ..... *T. ventralis*

b) Hind tibia apically more expanded ..... (10).

9a)

9b)

10(9b). a) Hind tibia spoonlike ..... *T. terminate*

b) Hind tibia not spoonlike ..... *T. nitidiventris*

10a)

10b)

11(8b). a) Hind basitarsus without elliptical disc ..... *T. fimbriata*

b) Hind basitarsus with elliptical disc ..... (12).

11a)

11b)

12(11b). a) Mandible with only one tooth ..... (13).

b) Mandible with two teeth ..... (14).

12a)

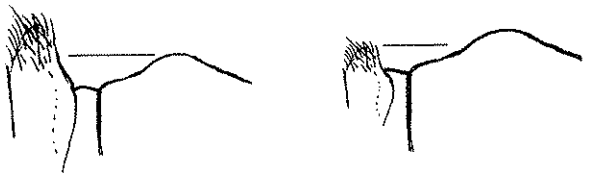
12b)

13(12a). a) Thorax extensively reddish ..... *T. thoracica*

b) Thorax extensively blackish ..... *T. itama*

14(12b). a) Propodeum covered by mesoscutellum ..... (15).

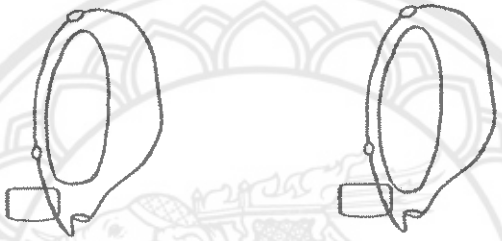
b) Propodeum not covered by mesoscutellum ..... (17).



14a) 14b)

15(14a). a) Malar space longer than 2nd flagellum width ..... *T. peninsularis*

b) Malar space as short as 2nd flagellum width ..... (16).



15a) 15b)

16(15b). a) Metasoma and hind tibia with reddish ..... *T. apicalis*

b) Body with blackish ..... *T. melanoleuca*

17(15b). a) Fore wing with bicolor; basally darker than apically ..... *T. collina*

b) Fore wing with unicolor and clean ..... (18).

18(17b). a) Line of mesoscutal hairs conspicuous ..... *T. fuscobalteata*

b) Line of mesoscutal hairs inconspicuous ..... (19).

18a) 18b)

19(18b). a) Body length 4 mm; mesoscutal hairs mixed with more dark hairs ..... *T. minor*

b) Body length 3 mm; mesoscutal hairs not mixed ..... *T. laeviceps*

Subfamily Apinae

The Apinae is in the subfamily that includes the majority of honey bees in the family Apidae (Michener, 2007). This subfamily consists of the corbiculate bees. The basitarsi lack scopal hairs and a pollen-carrying function. The tibial corbicula is a smooth, concave or sometimes flat area. They are surrounded by long hairs on the outer surface of the hind tibia. We found 5 species in the north of Thailand which were identified in the tribe Apini.

Tribe Apini

Genus *Apis* Linnaeus, 1758

These bees are the only living members of the tribe Apini (Oldroyd and Wongsiri, 2006). This genus consists of small to large size bees (1-2 cm). The eyes are covered with hair. The mandible of workers lack teeth and carinae. The claws of females are cleft. An arolia is present between claws but hind tibial spurs are absent. The wings are translucent and the prestigma is almost as long as or longer than the stigma. Both the jugal and vannal incisions of the hind wing are shallow. Pollen baskets are made of specialized hairs and are located on the outer surface of the tibiae of the hind legs. We found 5 species of honey bees in this study: *A. andreniformis* (small dwarf honey bee), *A. cerana* (indian honey bee), *A. dorsata* (giant honey bee), *A. florea* (dwarf honey bee) and *A. mellifera* (western honey bee).

***Apis andreniformis* Smith, 1858**

Apis andreniformis (small dwarf honey bee) is a very small honey bee from southern and southeastern Asia (Oldroyd and Wongsiri, 2006). Their bodies are about 1 cm long and about half the size of giant bees, *A. dorsata*. They are similar in size or slightly smaller than *Apis florea*. However, this species is identified with a uniformly black color of the first and second abdominal terga. The second abdominal tergum is deeply punctuated. The marginal setae on the hind tibiae are dark-brown to blackish (Figure 9).

***Apis cenara* Fabricius, 1793**

They are small honey bees (indian honey bee) of southern and southeastern Asia. *Apis cenara* is similar size or slightly smaller than *Apis mellifera*. The body length of a worker is around 12 mm. The head, thorax and first to fifth metasomal terga are covered by golden to orange hairs. The radius sector (Rs) and media (M)

veins of the hind wings are apically extended beyond the redius-media (R-M) vein (Figure 10).

***Apis dorsata* Fabricius, 1793**

The giant honey bee, *Apis dorsata*, is the world's largest honey bee (Oldroyd and Wongsiri, 2006). *Apis dorsata* workers are about 2 cm long. The giant honey bee is distributed over vast geographic areas in southeast Asia and is found throughout Thailand. The first and second abdominal terga are yellow to orange and other segments are black (Figure 11).

***Apis florea* Fabricius, 1787**

Apis florea is a very small honey bee from southern and southeastern Asia (Oldroyd and Wongsiri, 2006). The dwarf honey bees are 1 cm of body length. The first and second abdominal terga are reddish and other segments at least partially reddish. They are more reddish and the first abdomen is always red in an old worker. The second abdominal tergum is not deeply punctuated. The marginal setae on the hind tibiae are usually entirely white (Figure 12).

***Apis mellifera* Linnaeus, 1758**

The western honey bee, *Apis mellifera* is naturally distributed in central and western Asia, Africa and Europe (Pinto et al, 2007). The body length of workers is about 1.2 cm. Their body is golden brown and black with pale yellow to orange rings on the abdomen. The head, antennae, and legs are almost black. The redial sector (Rs) and media (M) veins of the hind wing are not apically extended beyond the redius-media (R-M) vein (Figure 13).

Subfamily Bombinae

Bombinae are distributed around the world (Cameron, Hines and Williams, 2007). Body length ranges from 1 to 2.5 cm (Michener, 2007). Their body is covered by yellow, black, orange or red hairs. Their females carry pollen and nectar on a corbicula on the hind leg which has long hairs on the upper part. The hind tibia has spurs. This subfamily is similar to Xylocopinae but Xylocopinae has a shiny body.

Tribe Bombini

Genus *Bombus* Latreille, 1802

These bees are members of the tribe Bombini. This genus is distributed around the world (Cameron, Hines and Williams, 2007; Michener 2007). They are

distinguished by the differentia of hair colors. The claws of the female are cleft. The arolia are present but small and the hind tibial spurs are present. The wings have complete strong venation. The hind wing lacks a jugal lobe.

***Bombus* sp.**

The body length in the female is 2 cm in average. Their head and thorax are covered by black hairs except the pronotum which is covered with yellow hairs. The first to second abdominal terga and the end of the abdomen are covered by yellow hairs with black hairs in the middle. The marginal cell is longer than the distance from its apex to the wing tip. The stigma is small but longer than the prestigma. This species is similar to carpenter bees, *Xylocopa* but can be distinguished by the difference of hair color on their body (Figure 14).

Subfamily Meliponinae

Meliponinae are abundant in subtropical and tropical regions of the world. Worldwide stingless bees are classified into 23 genera and 18 subgenera. Meliponinae is a subfamily of small bees in the family Apidae. They are similar to Apinae except they lack of sting. The stingless bee constitutes a diversified group, with many species building their nests in living or dead tree trunks (Sakagami, Inoue and Salmah, 1990; Camargo and Menezes-Pedro, 1992; Velthuis, 1997; Michener, 2007). They include certain characters: the wing venation is reduced, their body is covered with short to moderate hairs, the claws of the females are simple, hind legs have an arolia between the claws but without tibial spurs. The hind basitarsus, the base, is without an auricle. The space between the base of the eyes and the articulation of the jaws is the malar space, of taxonomic importance. A large numbers of species have been reported in tropical areas, of which 23 species have been reported in Thailand (Sakagami, Inoue and Salmah, 1990; Michener and Boongird, 2004). In this study, we found 14 species which are mostly distributed in deciduous with bamboo forests at an altitude of less than 400 meters above sea level. All species have been reported in Indo-Malayan areas (Sakagami, Inoue and Salmah, 1990; Klakasikorn et al., 2005).

Tribe Meliponini

Genus *Hypotrigona* Cockerell, 1934

Hypotrigona are the smallest Meliponinae known (about 2 mm). They are naturally distributed in Asia, Africa and Australia (Sakagami, Inoue and Salmah,

1990; Michener 2007). They have a long malar space. A nearly right-angled submarginal angle and bristles arranged in successive transversal rows on the inner surface of the hind basitarsus.

***Hypotrigona* sp.**

The body length of workers is about 2 mm. Their bodies are black and very shiny. Labrum, mandibles and tarsal joints are reddish-brown. The antennae are black with 12 segments; 2 segment of scape and pedicel, and 10 segments of flagella. The basal half of the clypeus is swollen and raised well above the sides of the face. The apical half of the clypeus has a downward slant. The wings are clear hyaline. The hind basitarsi have light golden bristles over their entire inner surface. The hairs on head, thorax, legs, and abdomen are less than on the basitarsi (Figure 15).

Genus *Trigona* Jurine, 1807

Trigona is the largest genus of the stingless bees and the most widely distributed genus of the Meliponinae. This genus is found in the Neotropics region from Mexico to Argentina and in the Indo-Australian region from India and Sri Lanka to Taiwan, including Thailand (Sakagami, Inoue and Salmah, 1990; Michener 2007). In this study, we found 13 species. Most of their characters differ from *Hypotrigona* because they have a short malar space and fore wing venation is less reduced, including a narrow pterostigma.

***Trigona apicalis* Smith, 1857**

The worker body length is about 6.5 mm. The head and thorax are black. Metasomal targa and hind tibia are brownish to reddish. The mandible, for the most part, is dark red. They have 2 usually large black teeth. The basal half of the fore wing is white but the apical half of the fore wing is deep brown to black. The malar space is as long as the width of the second flagella. The hind legs are covered with plumose hairs on posterior tibia and basitarsi has elliptical disc (Figure 16).

***Trigona collina* Smith, 1857**

The worker body length is about 6 mm. Their bodies and legs are black but tegula is black to blackish brown. The basal half of the fore wing is white but the apical half of the fore wing is dark brown to black. The hind leg has plumose hairs on rim of the tibia and has an elliptical disc on the basitarsi. This species is similar to *T.*

apicalis, however, the malar space width of *T. collina* is narrower than the width of the second flagella segment and less than the width of the scape (Figure 17).

***Trigona fimbriata* Smith, 1857**

They are the biggest bees in this genus. The worker body length is more than 8 mm. Their bodies are brownish to dark orange, including the wings. The malar space is moderately developed and the mandible has 2 usually large teeth. The distance between the rim of the compound eye and the base of the mandible is longer than the width of the second flagella. The clypeus is short but wide with dark hairs. The hind basitarsus do not have elliptical disc (Figure 18).

***Trigona fuscobalteata* Cameron, 1908**

The worker body is about 2.5 mm in length. The forewing, including tegula is about 3 mm in length. The wing has a rather uniform clarity throughout. The head and thorax are black, except the abdomen which varies from sepic brown to blackish. Anterior fringing of the hind tibiae is usually silvery-grey. The mesonotum is usually streaked with longitudinal hair bands. The hind leg has plumose hairs on the rim of the tibia and has an elliptical disc on the basitarsi. The width of the malar space is longer than the width of the second flagella (Figure 19).

***Trigona itama* Cockerell, 1918**

The worker body length is about 5.5 mm. The mandible, clypeus, scape (except at its extreme base) are black, including the erect hairs on the mesopleura. The distance between the base of the compound eye and the mandible is shorter than the width of the second flagella. The basal half of the fore wing is white but the apical half is brown. The hind legs are covered with plumose hairs on the posterior tibia and the basitarsi has elliptical disc. This species is similar to *T. collina* except only a single tooth of the mandible is present in *T. itama* (Figure 20).

***Trigona laeviceps* smith, 1857**

Trigona laeviceps is black body. The worker body length is about 3.5 mm. The mandible usually has 2 small teeth. The width of the malar space is shorter than width of the second flagella. The fore and hind wing are rather uniformly transparent. Posterior fringe of hind tibia consists of plumose hairs and hind basitarsus has elliptical disc. This species, *T. laeviceps*, is similar to *T. minor* because they lack G3

line on mesoscutal glabrous areas, but *T. laeviceps* is distinguished by its smaller size, and mesoscutum is covered by mixed dark hairs (Figure 21).

***Trigona melanoleuca* Cockerell, 1929**

The worker body is about 5.5 mm in length. The head, thorax and abdomen are black. They have 2 usually large and strong black teeth. The basal half of the fore wing is white but the apical half is dark brown to black. The hind legs are covered with plumose hairs on the rim of the tibia and the basitarsi has an elliptical disc. This species is similar to *T. apicalis* but the width of malar space of *T. melanoleuca* is shorter than that of their second flagella, and also their body is more metallic black (Figure 22).

***Trigona minor* Sakagami, 1978**

The length of the worker body is about 3.5 mm. The mandible has 2 small teeth. The width of the second flagella is longer than the distance between the rim of the compound eye and the base of the mandible. The wings are rather uniformly transparent. The posterior fringe of the hind tibia consists of plumose hairs and the hind basitarsus have an elliptical disc. The mesoscutal glabrous area is covered with hairs. G3 line is absent. *T. minor* is similar to *T. laeviceps* but is distinguished by its larger size, and mesoscutum is covered by dark hairs (Figure 23).

***Trigona nitidiventris* Smith, 1857**

The worker body is about 6 mm long with a black body. The mandibles are black except on the apical tips. The second to sixth metasoma segments are black but the first metasoma tergum is yellowish. The legs are partly brownish and the posterior fringed of tibia is covered with simple black hairs. The mesoscutal tomentum is well developed and extends to the mesoscutellum. The fore and hind wings are rather uniformly transparent (Figure 24).

***Trigona peninsularis* Cockerell, 1927**

The total length of the worker body is about 5 mm. Head, thorax and abdomen are black but most of the mandible is dark black. They have 2 large, black teeth with simple hairs. The fore wings are bicolors, basally brown with dark brown veins and apically white with orange veins, but the hind wings are rather uniformly transparent. This species is similar to *T. apicalis* and *T. melanoleuca* but the malar space is longer than the width of the second flagella (Figure 25).

***Trigona terminata* Smith, 1878**

The worker body is about 5 mm in length with black body. The mandibles are black except for the apical tips. The second to sixth metasoma segments are black but the first metasoma tergum is yellowish. A hind tibia is not spoon-shaped and the posterior fringe of the tibia is covered with simple black hairs. Fore and hind wing are rather uniformly transparent. This species is similar to *T. nitidiventris* but their bodies, *T. terminata* are larger and the hind tibia is not spoon-shaped (Figure 26).

***Trigona thoracica* Smith, 1857**

The worker body length is about 8 mm. The clypeus, supraclypeus, and scape are bright brown to reddish, and the head is black. The wings are rather uniformly transparent while the stigma of the fore wing is bright brown. The mesoscutum is dark brown to red. The abdomen is usually black and partly reddish. The width of the malar space is as long as that of the mandible which has 2 teeth. This species is recognized by reddish on mesonotum (Figure 27).

***Trigona ventralis* Smith, 1857**

The length of the worker body is about 4.5 mm with black body. The second to sixth metasoma terga are black but first metasoma tergum is cream in color. The mesoscutal tomentum is usually whitish and does not extend to the mesoscutellum. The posterior tibia fringed is covered with pale hairs. The fore and hind wings are rather uniformly transparent. This species is similar to *T. terminata* but their bodies are larger and the hind tibia is slightly spoon-shaped (Figure 28).

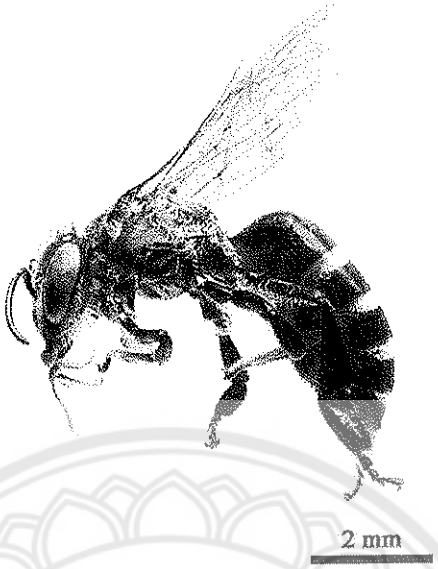


Figure 9 A worker of *Apis andreniformis* Smith, 1858.

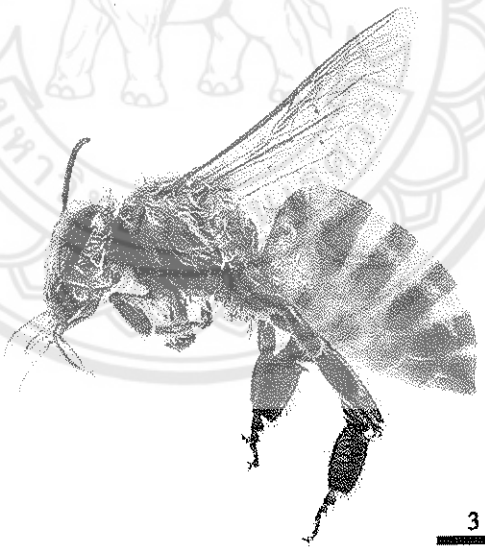


Figure 10 A worker of *Apis cerana* Fabricius, 1793.

Figure 11 A worker of *Apis dorsata* Fabricius, 1793.

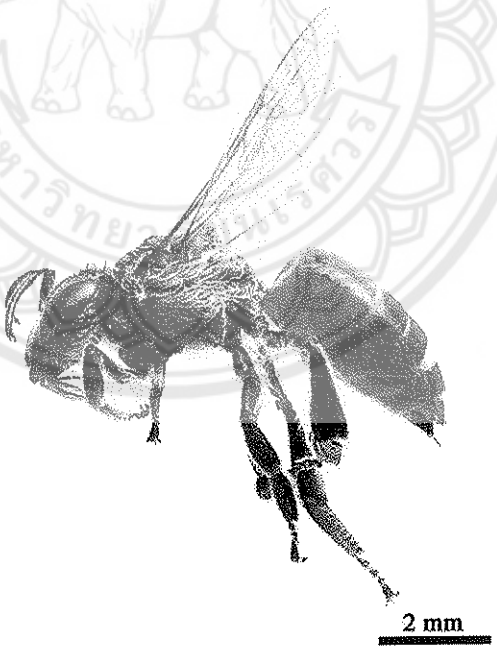


Figure 12 A worker of *Apis florea* Fabricius, 1787.

Figure 13 A worker of *Apis mellifera* Linnaeus, 1758.

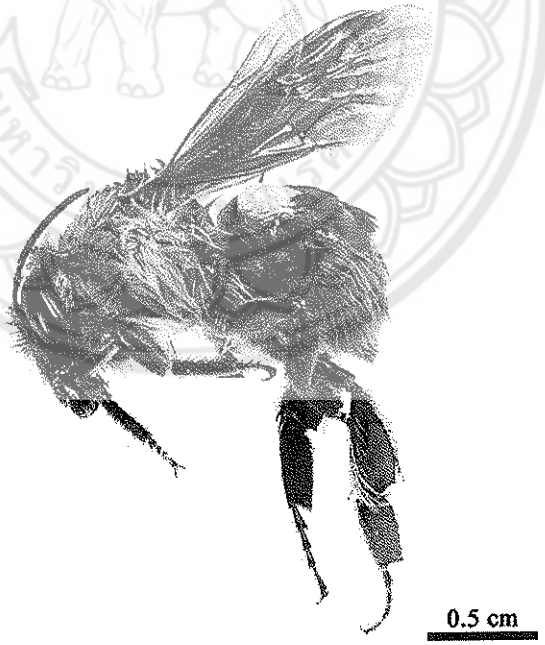


Figure 14 A female of *Bombus* sp.

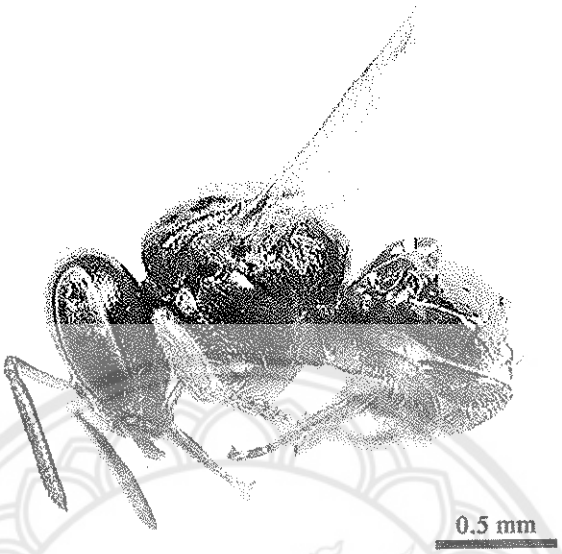


Figure 15 A worker of *Hypotrigona* sp.

Figure 16 A worker of *Trigona apicalis* Smith, 1857.

Figure 17 A worker of *Trigona collina* Smith, 1857.

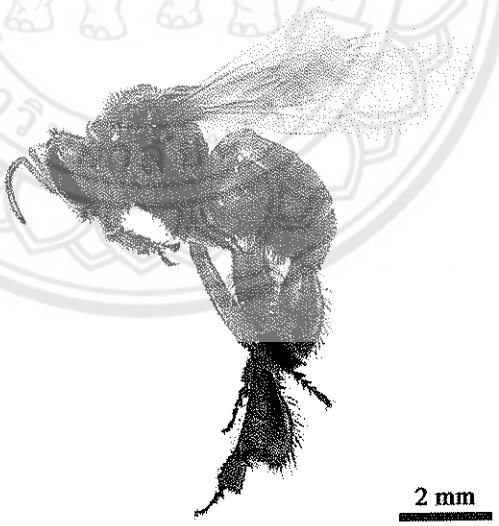


Figure 18 A worker of *Trigona fimbriata* Smith, 1857.

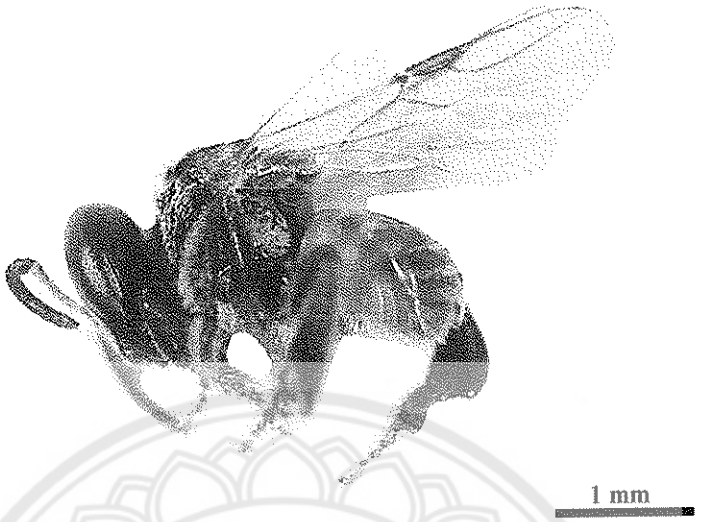


Figure 19 A worker of *Trigona fuscobalteata* Cameron, 1908.

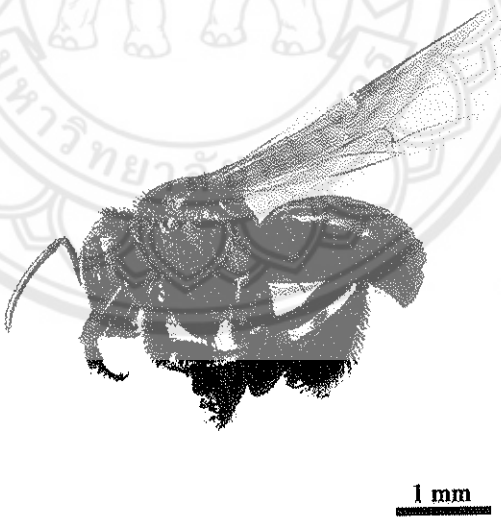


Figure 20 A worker of *Trigona itama* Cockerell, 1918.

Figure 21 A worker of *Trigona laeviceps* smith, 1857.

Figure 22 A worker of *Trigona melanoleuca* Cockerell, 1929.

Figure 23 A worker of *Trigona minor* Sakagami, 1978.

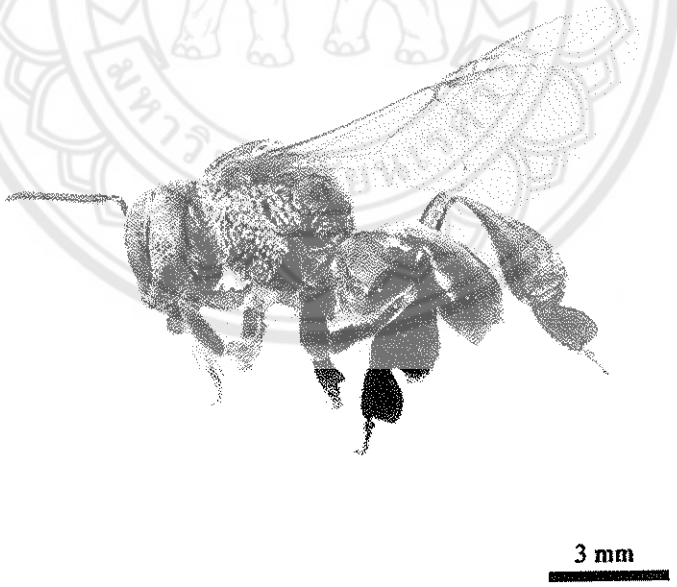


Figure 24 A worker of *Trigona nitidiventris* Smith, 1857.

Figure 25 A worker of *Trigona peninsularis* Cockerell, 1927.

Figure 26 A worker of *Trigona terminata* Smith, 1878.

Figure 27 A worker of *Trigona thoracica* Smith, 1857.

Figure 28 A worker of *Trigona ventralis* Smith, 1857.

Family Halictidae

This family consists of 3 subfamilies; Haclictinae, Nomiinae and Rophitinae. The largest and most common subfamily, the Haclictinae, contains genera *Halictus* and *Lasioglossum* (Finnamore and Michener, 1993). The *Halictus* in subfamily Haclictinae was the only one found in this study. Halictid bees are usually dark in color. The length of glossa is variable, short to long. A basitibial plate is present. The first flagellum of the antenna is shorter than the scape. The stigma of the fore wing is well developed. The sixth metasomal tergum of the female is located beneath the fifth tergum. The scopa of the ventral abdomen and/or hind legs is on trochanter to the tibia and is usually used for carrying pollen.

Tribe Halictini

Genus *Halictus* Latreille, 1804

Genus *Halictus*, Halictini is widespread throughout the Neotropical zone, North America, the Oriental region, the European region and Asia (Niu, Wu and Huang, 2004). Most species are black or dark brown in color. The second of radius-media (R-M) and media-cubitus (M-Cu) veins of the female fore wing are obvious. Females have a basitibial plate and a coarsely serrate spur on the hind tibia. Only one species, *Halictus* sp., was present in this work.

***Halictus* sp.**

The body of this species is black and partially covered by branched or plumose hairs. The first segment of the mid tarsus are often enlarged and flattened. The basal vein of the fore wing is strongly arched. The jugal lobe of the hind wing is longer than the submedian cell. The thorax is black. They have special hairs called scopa on their hind legs and ventral abdomen (Figure 29).

Family Megachilidae

The family Megachilidae is long-tongued bees and is mostly distributed in America, Africa, Asia and Australia. The labrum is rectangular which is longer than wide and broadly articulated to the clypeus (Mitchell, 1980; King, 1984; King and Exley, 1985; Yamane, Ikudome and Terayama, 1999; Fernández, 2001; Michener, 2007). Their fore wings have 2 submarginal cells because the first radial-medial (R-M) is fused to the second submarginal cell. Moreover, the first submarginal cell is longer than the second submarginal cell. Females have a ventral abdominal brush for carrying

pollen and the metasomal sterna have scopa which is only found on the hind legs of this species. Two genera, *Coelioxys* and *Megachile* of subfamily Megachilinae were found in the north of Thailand.

Key to the species of Megachilidae found in northern Thailand

Modified from Yamane, Ikudome and Terayama, 1999.

1. a) Scopa present on metasomal sterna ..... *Coelioxys* sp.
   b) Scopa absent on metasomal sterna ..... *Megachile* (2)

1a) 1b)

2(1b). a) Black body; white hairs on mesoscutellum, propodeum and 1st metasomal segment ..... *Megachile* sp.1
   b) Black body; brownish to reddish hairs on body ..... *Megachile* sp.2

Subfamily Megachilinae

The family Megachilidae is commonly divided into 2 subfamilies; Megachilinae and Lithurginae (Genaro, 1998; Yamane, Ikudome and Terayama, 1999). In this study, we found only one subfamily, the Megachilinae in the tribe of Megachihi, which was identified into 2 genera: *Megachile* and *Coelioyxs*. The body is nonmetallic color. The length of the stigma is as long as broad but the length of prestigma is more than twice as broad. Moreover, the length of the inner margin to the radial (R) vein is longer than their width. The claws of female are usually simple. The outer surfaces of the hind tibiae are covered with plumose hairs, but not bristle. Arolia is absent, at least on hind legs.

Tribe Megachihi

Genus *Coelioxys* Latreille, 1809

Coelioyxs is similar to the large leaf-cutter bee; *Megachile*. This genus in tribe Megachihi is distributed in America, Asia and Australia (Mitchell, 1980). We found only one species in this study, *Coelioyxs* sp. This genus can be distinguished by the hairs on the eyes and their bodies are not hairy like *Megachile*. *Coelioyxs* are black in color and have a coarsely punctuated body. They have a more tapered abdomen and the axilla has several

spine-like protuberances posteriorly. Metasoma is conical and the first metasomal segment is the widest and the scopa is absent in females.

***Coelioxys* sp.**

The length of the female body is about 1.4 cm. Their body is black and mostly covered with whitish plumose hairs. The distance between the lateral ocellar is wider than the distance between lateral ocelli and compound eyes. Antenna is filiform with 12 segments; 1 segment of scape, 1 segment of pedicel and 10 segments of flagellum. Each apex of the metasomal tergum is covered by white hairs. The fore and hind wings are rather uniformly transparent (Figure 30).

Genus *Megachile* Latreille, 1802

This genus is mostly distributed in America, Asia and Australia, and often called leafcutter bees (Mitchell, 1980). In this study, we found 2 species of tribe Megachihi. Their black bodies are covered with plumose hairs. The arolia is absent at least on hind legs. A scopa is present on second to fifth metasomal sterna. The anterior mesepisternum is not separated from the lateral part by a carina.

***Megachile* sp.1**

The head, thorax and abdomen are black with hairs. The compound eyes and ocelli are brown. The body length of a female is about 1.5 cm. The antenna is filiform with 12 segments: 1 segment of scape, 1 segment of pedicel and 10 segments of flagellum. Their bodies are covered with short black hairs but the mesoscutellum and first to second metasomal terga are covered with white plumose hairs. The maxillae and labium are prominent on head. Scopa pale on the second to fourth metasomal sterna is black hairs. The basal half of the fore wing is white but the apical half of the fore wing is brown (Figure 31).

***Megachile* sp.2**

The total length of female body is about 1.5 cm and the body color is black. The antenna is filiform with 12 segments: 1 segment of scape, 1 segment of pedicel and 10 segments of flagellum. The head, rim of thorax, pronotum, mesoscutum, mesopleuron and first to third metasomal terga are covered with brown hairs. The maxillae and labium are prominent on the head. The scopa pale on the second to fourth metasomal sterna are covered by brownish hairs. More than half of the basal fore wing is white but the apex of the fore wing is brown to black (Figure 32).

Figure 29 A female of *Halictus* sp.

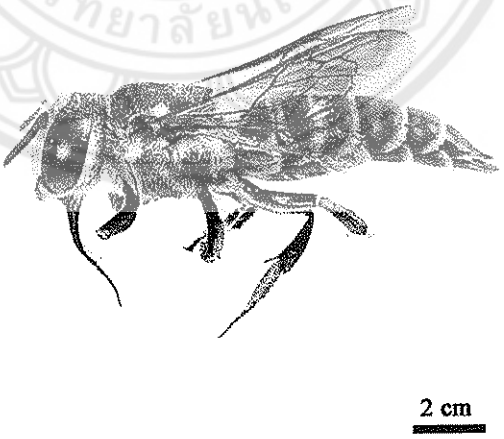


Figure 30 A female of *Coelioxys* sp.

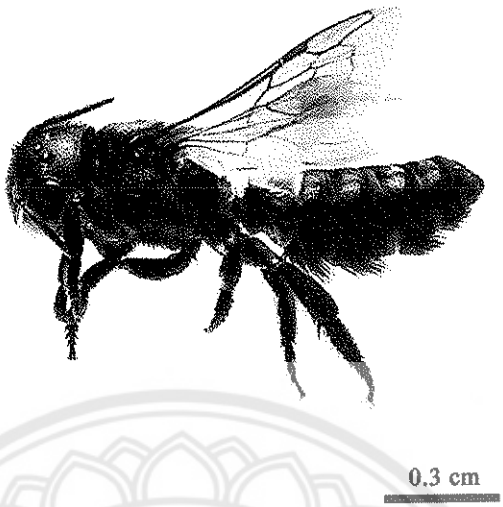


Figure 31 A female of *Megachile* sp.1.

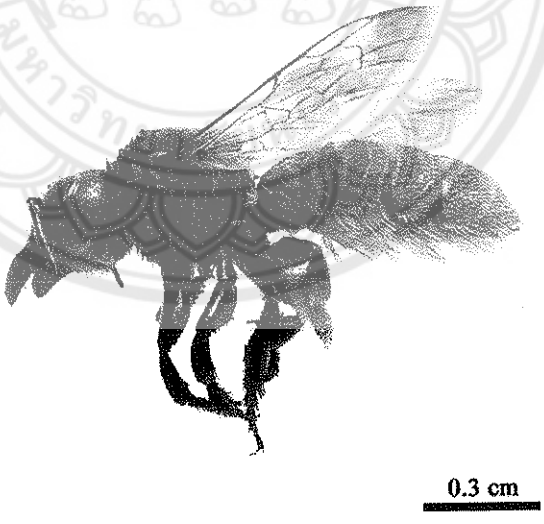


Figure 32 A female of *Megachile* sp.2.

Family Sphecidae

Most of this species are distributed around the world: the Oriental region and the Palearctic region (Budrys, 2000; Giovanettin, 2005). This family Sphecidae is spheciformes of superfamily Apoidea. In this study, we found 3 subfamilies: Nyssoninae, Sceliphroninae and Sphecinae. They are distinguished from vespids by having a short pronotum. The fore wings have 3 submarginal cells and the jugal lobe of the hind wings is wider than half the length of the anal area. The mid tibia has 2 apical spurs, 1 small and 1 large. Small rounded lobes extend towards but do not reach the tegulae. Their body hairs are simple rather than branched. The shape of the first metasomal sternum is cylindrical.

Key to the species of Sphecidae found in northern Thailand

Modified from Yamane, Ikudome and Terayama, 1999.

1. a) Petiole present ..... (2).
   b) Petiole absent ..... Nyssoninae
   - Medium ocelli parallel ..... *Bembix* sp.

1a) 2a)

2(1a). a) Tarsal claws of fore leg and mid leg with 2 or more teeth ..... Sphecinae
   - Thorax with reddish hairs ..... *Sphex* sp.
   b) Tarsal claws of fore leg and mid leg with single teeth ..... Sceliphroninae (3).

1a) 2b)

3(2b). a) Petiole shorter than the width of abdomen ..... *Chalybion* sp.
   b) Petiole longer than the width of abdomen ..... (4).

4(3b). a) 1st metasomal segment yellow; leg yellow markings ..... *Sceliphron* sp.1

b) 1st metasomal segment black; femur of hind leg orange to red markings ..... *Sceliphron* sp.2

Subfamily Nyssoninae

This subfamily is found in most parts of the world (Calla, 1979), but in the north of Thailand was represented by a single species of the tribe Bembecini. These wasps have the mesonotum directed laterally and expand into the lamina that more or less overlies the base of the tegulae. The jugal lobe of the hind wing is shorter than the submedian cell. The petiole is absent.

Tribe Bembecini

Genus *Bembix* Fabricius, 1775

Bembix is identified in tribe Bembecini (Calla, 1979) which have 2 apical spurs on the middle tibiae. The fore wings have 3 submarginal cells. The shape of middle ocelli is nearly parallel.

***Bembix* sp.**

The length of body is about 2.2 cm in the female. Their body is black with yellow markings on the pronotum and metasoma, including the femur of the legs. This species differs from other species in family Sphecidae because the petiole is absent. Althought the shape of the *Bembix* species is similar to the *Vespa* species of family Vespidae, the middle ocelli of the *Bembix* species is nearly parallel. The propodeum is covered with white plumose hairs. The wings are uniformly transparent and do not have stigma (Figure 33).

Subfamily Sceliphroninae

Sceliphroninae are distributed around the world, but are abundant in the Old World (Yamane, Ikudome and Terayama, 1999). This subfamily is easily identified with the first metasomal segment (petiole) which is long. Two genera of subfamily Sceliphroninae; *Chalybion* and *Sceliphron* were found in the north of Thailand.

Tribe Sceliphronini

Genus *Chalybion* Dahibom, 1843

Chalybion is identified in tribe Sceliphronini and recorded in the Old World (Yamane, Ikudome and Terayama, 1999). Their body is metallic blue to bright blue-green and is covered with erect black hairs. The first metasomal segment is shorter than the width of the abdomen. The wings are nearly black. Only one species was collected from this area. Though this genus is similar to genus *Sceliphron* in shape and size, *Chalybion* is identified by their first metasomal segment which is shorter than the width of the gaster.

***Chalybion* sp.**

The length of the body is about 1.6 cm in female. Their body is metallic dark blue. The first metasomal segment is gently curved to straight, and is shorter than the width of the gaster. The pronotum and mesonotum are covered by coarse punctures with white hairs but the metanotum is longitudinally striated, except the propodeum which is covered with white hairs. Fore and hind wings are transparent with black color on the apex of the wings (Figure 34).

Genus *Sceliphron* Kiug, 1801

Many species of *Sceliphron* have yellowish markings on the body. The abdomen is long and the first metasomal segment is slender. The first metasomal segment is nearly linear line and is longer than the width of abdomen. The posterior of the first metasomal segment gradually widens toward the second metasomal segment. This genus is similar to genus *Chalybion* but the first metasomal segment of *Sceliphron* is longer than the width of abdomen.

***Sceliphron* sp.1**

The female body length is about 1.8 cm. The head, mesosoma and metasoma are black, except the first metasomal segment is marked with yellow color. Antennae have 12 segments; 1 segment of scape, 1 segment of pedicel and 10 segments of flagellum. The scape of the antenna is wider than other segments. The first metasomal segment is longer than the length of the abdomen. The legs are long with yellow markings on the femur. Fore and hind wing are uniformly transparent (Figure 35).

***Sceliphron* sp.2**

The body length of the female is about 2 cm. The head, mesosoma and metasoma are black, and the femur is red. The antennal number of *Sceliphron* sp.2 is similar to *Sceliphron* sp.1. The first metasomal segment is shorter than the length but they are longer than the width of the abdomen. The apically rim of mesoscutum and propodeum are yellow. The wings are bright brown and uniformly transparent (Figure 36).

Subfamily Sphecinae

They are distributed around the world (Yamane, Ikudome and Terayama, 1999). The subfamily Sphecinae is blue to black metallic or green with yellow stripes or markers. Most hairs on the body are plumose. The pronotum has a collar-like plate and does not reach the tegulae. The second medial-cubital (M-Cu) vein of the fore wing is contained the third submarginal cell (Sm). The tasal claws have 2 or more teeth. Planter lobes on the tarsus are absent. The first metasomal segment is very short and half as long as the width of the mesosoma. Genus *Sphex* was recorded in this study.

Tribe Sphecini

Genus *Sphex* Linnaeus, 1758

Genus *Sphex* is distributed around the world, but many species inhabit in Old World tropics (Yamane, Ikudome and Terayama, 1999). They are classified in tribe Sphecini. Only one species was recorded in this study. This genus is identified by their compound eyes which are straight for the most part, but curving in toward the ocelli. The lateral side of the propodeum has a deep furrow.

***Sphex* sp.**

The length of the female body is about 2.8 cm. Their body is black but the head and thorax are covered with red hairs. The metasoma is black in color. They have very short and slender petiole. All legs are red, except tarsus which are black. The fore and hind wings are transparent but the apex of the wings is black. This species is similar to the species *Vespa* (Vespidae) but *Sphex* sp. has a short petiole (Figure 37).

Figure 33 A female of *Bembix* sp.

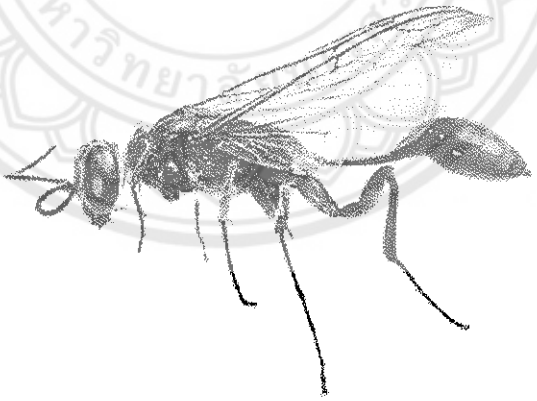


Figure 34 A female of *Chalybion* sp.

Figure 35 A female of *Sceliphron* sp.1.

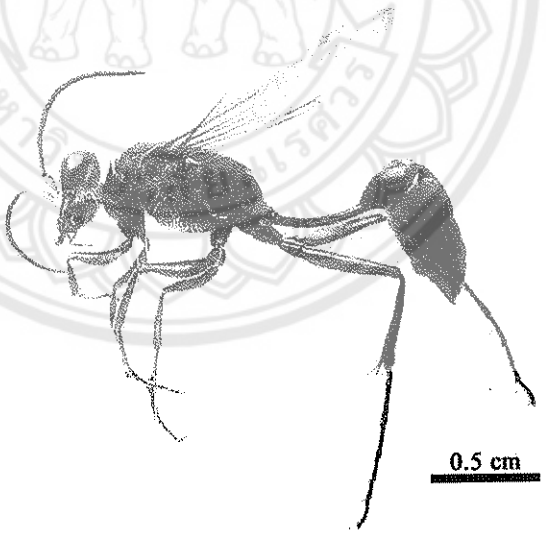


Figure 36 A female of *Sceliphron* sp.2.

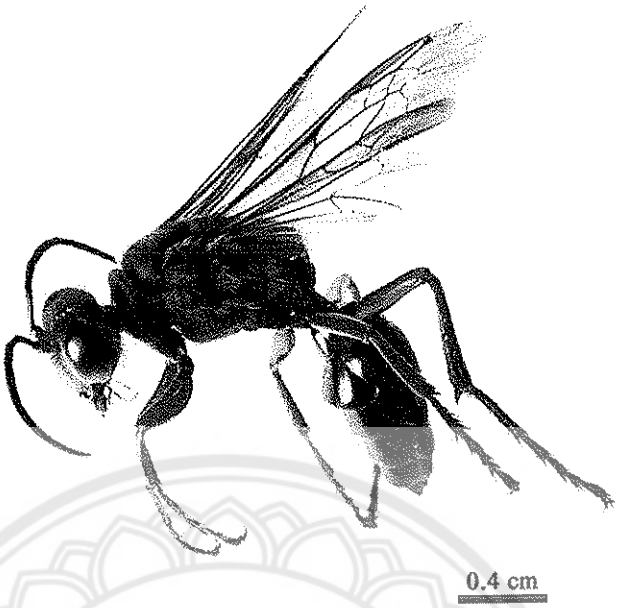


Figure 37 A female of *Sphex* sp.

Superfamily Chrysidoidea

The superfamily Chrysidoidea is primarily a tropical insect. They are divided into 7 families (Finnamore and Brothers 1993). This superfamily is identified by their fore wings which extend far beyond the posterior end of the mesosoma. The pronotum is twice as long as mesoscutum. In this study, superfamily Chrysidoidea was found in only one family, Chrysididae.

Family Chrysididae

The family is widely distributed and identified into 4 subfamilies (Danks and Downes, 1998). In the north of Thailand, we found 3 genera; *Chrysis*, *Trichrysis* and *Praestohhrysis*, in tribe Chrysidini. Most cuckoo wasps are small, seldom exceeding 1.2 cm in length. Usually they are a metallic green in color. The tip of the abdomen in many species has tooth-like projections. The hind wings lack closed cells. Most species are external parasites of other wasp larvae.

Key to the species of Chrysididae found in northern Thailand

Modified from Yamane, Ikudome and Terayama, 1999.

1. a) Three teeth at apical metasoma ..... *Trichrysis*
   - 2nd abdominal segment longer than other segments ..... *Trichrysis* sp.

   b) More 3 teeth at apical metasoma ..... (2).

1a) 1b)

2(1b). a) Four, six or eight teeth at apical metasoma ..... *Chrysis*
   - four teeth ..... *Chrysis* sp.1
   - Six teeth ..... *Chrysis* sp.2
   - Eight teeth ..... *Chrysis* sp.3

   b) Five teeth at apical metasoma ..... *Praestochrysis*
   - Reddish marking on 2nd abdominal tergum ..... *Praestochrysis* sp.

Tribe Chrysidini

Genus *Chrysis* Linnaeus, 1761

Genus *Chrysis* in tribe Chrysidini is distributed around the world except the Arctic region (Danks and Downes, 1998). The color of the body is usually metallic green or blue. Their bodies are covered with coarse punctures. The compound eyes and ocelli are present on the vertex. Antennae have 12 or 13 segments. The tip of metasoma has 4, 6 or 8 apical teeth. We found 3 species in this genus.

***Chrysis* sp.1**

The total length is about 1.3 cm and blue-green in color. Their body is covered with coarse punctures and gray plumose hairs. The antennae have 12 segments; 1 scape, 1 pedicel and 10 flagella. Their compound eyes are large and brown. The mesoscutellum is shorter than the mesoscutum and the metanotum are fused to the propodeum which has 2 lateral teeth. Their abdomen has 5 segments and the apical rim of metasoma has 4 acute teeth (Figure 38).

Chrysis sp.2

The length of the body is about 1 cm. Their body is greenish blue and covered with coarse punctures. The antennae have 12 segments; 1 scape, 1 pedicel and 10 flagella. The clypeus is short and wide. The metanotum are fused with the propodeum which has two lateral teeth. They have 4 abdominal segments. The second abdominal segment is the largest and the fourth abdominal segment is curved down. The apical metasoma has 6 acute teeth. Even though this species is similar to *Chrysis* sp.1 in body color, *Chrysis* sp.2 is distinguished by 6 acute teeth (Figure 39).

Chrysis sp.3

The body length is about 7 mm. Their body is greenish blue and covered with coarse punctures. The antennae have 12 segments; 1 scape, 1 pedicel and 10 flagella. The metanotum are fused with the propodeum which has 2 lateral teeth. They have 4 abdominal segments. The length of the second abdominal segment is shorter than the first abdominal segment. The apical metasoma has 8 acute teeth. Although this species is similar to *Chrysis* sp.1 and *Chrysis* sp.2 in body color, *Chrysis* sp.3 can be identified by having 8 acute teeth (Figure 40).

Genus *Trichrysis* Lichtenstein, 1876

Trichrysis is distributed from the Ethiopian to the Asia region (Finnamore, 1997; Yamane, Ikudome and Terayama, 1999). The body is usually metallic green or blue in color with many pits on the surface. The antennae have 12 or 13 segments. This genus is separated from other genera by the metasoma with 3 apical teeth. One species, *Trichrysis* sp. in tribe was found in the north of Thailand.

***Trichrysis* sp.**

Their body length is about 7 mm and greenish blue with coarse punctures. The compound eyes and ocelli are present. The antennae have 13 segments; 1 scape, 1 pedicel and 11 flagella. The metanotum are fused with the propodeum which has 2 lateral teeth. The second abdominal tergum is longer than the other segments. They have 4 abdominal segments and the anal edge has a pit row. The middle tooth is the sharpest but the same length as the other teeth. This species is similar to *Chrysis* sp.3 but *Trichrysis* sp. has 3 teeth on apical metasoma (Figure 41).

Genus *Praestochrysis* Linsenmaier, 1959

Praestochrysis is distributed in the Ethiopian, Oriental, Australian and Palaearctic regions (Yamane, Ikudome and Terayama, 1999). Only one species in tribe was present in this study. This genus is easily separated from the other genera with 5 teeth at apical metasoma and their forth to twelfth antennal segments are wider than long. The compound eyes and ocelli are present.

***Praestochrysis* sp.**

Their body is about 7 mm in total length and green-blue with blue marking on the mesonotum. The antennae have 12 segments: 1 scape, 1 pedicel and 11 flagella. The metanotum are fused with the propodeum which has 2 lateral teeth. The second abdominal tergum has considerable coppery or red markings. They have 4 abdominal segments and a pit area on the anal edge. The middle tooth is sharper and longer than the other teeth. This species is similar to *Trichrysis* sp. in their body color but *Praestochrysis* sp. has 5 teeth at the apical metasoma (Figure 42).

Figure 38 A female of *Chrysis* sp.1.

Figure 39 A female of *Chrysis* sp.2.

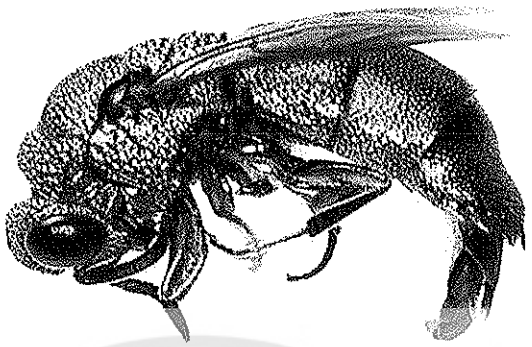


Figure 40 A female of *Chrysis* sp.3.

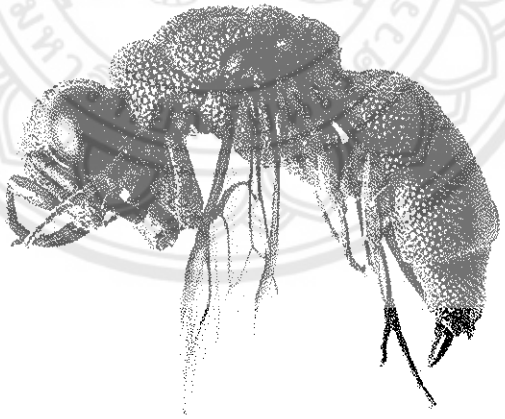
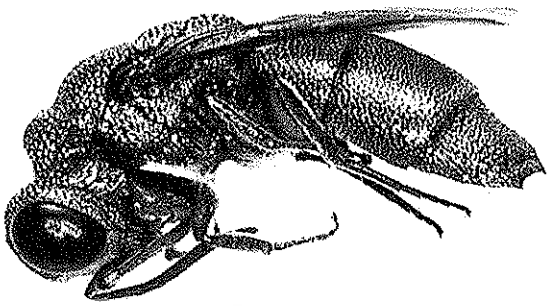


Figure 41 A female of *Trichrysis* sp.



2 mm

Figure 42 A female of *Praestochrysis* sp.

Superfamily Vespoidea

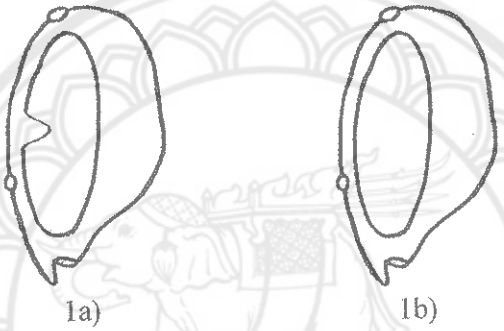
The Vespoidea is moderately large wasps. They are a mostly tropical group of 48,000 species in 10 families (Brothers and Finnamore, 1993). A total of 80 species in 45 genera were found in this study. These species belong to 12 subfamilies in 3 families, namely Formicidae, Scoliidae and Vespidae.

Key to the family of Vespoidea found in northern Thailand

Modified from Yamane, Ikudome and Terayama, 1999.

1. a) Wing presnt; inner margin of eye with notched …….. (2).

   b) Wing absent; inner margin of eye without notched; petiole (postiole) and/or petiolar node present …… Formicidae



1a) 1b)

2(1a). a) Two submarginal cells …….. Scoliidae

   b) Three submarginal cells …….. Vespidae

2a) 2b)

Family Formicidae

Formicidae is the family of ants which is distinguished from the other aculeate families by the presence of a metapleural gland at posteroventral portion of propodeal side and of 1 or 2 metasomal segments (pedicel) between the alitrunk and gaster (Bolton, 1997). Recently 247 known ant species were recorded in Thailand and are distributed among 55 genera in 10 subfamilies (Jaitrong and Nabhitabhata, 2005). In this study, 33 genera of ants were recorded in 7 subfamilies: Aenictinae, Cerapachyinae, Dolichoderinae, Formicinae, Myrmicinae, Ponerinae and Pseudomyrmecinae.

Key to the subfamily of Formicidae found in northern Thailand
Modified from Bolton, 1997; Shattuck, 1999.

1. a) Mesosoma attached to the gaster by a single petiolar segment ..... (2).

   b) Mesosoma attached to the gaster by 2 petiolate segments ..... (5).

1a) 1b)

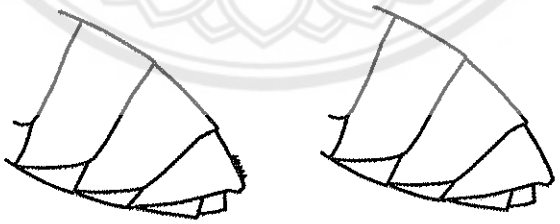
2(1a). a) Sting present at the tip of the gaster ..... (3).

   b) Sting absent at the tip of the gaster; compound eyes present ..... (4).

2a) 2b)

3(2a). a) Upper surface of 7th abdominal segment with a row of small spines ..... Cerapachyinae

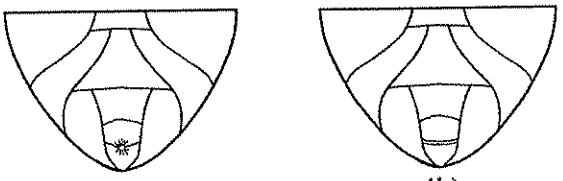
   b) Upper surface of 7th abdominal segment without a row of small spines ..... Ponerinae



3a) 3b)

4(2b). a) Tip of the gaster with a circular opening ..... Formicinae

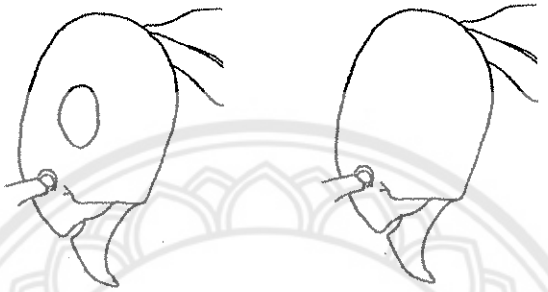
   b) Tip of the gaster with a slit-like opening ..... Dolichoderinae



4a) 4b)

5(1b). a) Compound eyes present ..... (6).

b) Compound eyes and frontal lobes absent; antenna with 10 segments ..... Aenictinae



5a) 5b)

Subfamily Aenictinae

The subfamily Aenictinae contains a single genus, *Aenictus* which is distributed around the world: tropical and subtropical zones of the Ethiopian, Oriental and Australian regions (Bolton, 1997). All known species are army ants in tribe Aenictini which are about 2.5 to 4.0 mm in length. The compound eyes and the frontal lobes are absent. The antennae have 10 segments and the antennal sockets are completely visible when viewed from the front. The mesosoma is attached to the gaster by 2 distinct segments; the petiole and the postpetiole.

Tribe Aenictini

***Aenictus* Shuckard, 1840**

The workers of *Aenictus* in tribe Aenictini are small in size (less than about 4 mm). They are similar to some myrmicines. They lack the frontal lobes and compound eyes but the antennal sockets are completely visible. We found only one species, *Aenictus binghami* in this study.

***Aenictus binghami* Forel, 1900**

The length of a worker body is about 2.5 mm and black in color. Moreover, the compound eyes are completely absent. The antennae have 10 segments, including a scape and pedicel. The mandible has 7 teeth. The subpetiolar process, which is a

spine at the lower surface of the petiole, is small but strong with an obtusely angulate anteroventral corner (Figure 43).

Subfamily Cerapachyinae

These species are known throughout the world in tropical and subtropical areas (Bolton, 1997). A single genus, *Cerapachys* in tribe Cerapachyini was recorded in this area. A row of small spines (pygidial teeth) on the upper surface of the gaster are present and can be used to separate this subfamily from all other subfamilies of ants. The frontal lobes are reduced and the antennal sockets are completely present. The petiole has 1 segment and the gaster has a distinct constriction between first and second segments.

Tribe Cerapachyini

Genus *Cerapachys* Smith, 1875

These ants are mainly distributed in tropical and subtropical areas (Yamane, Ikudome and Terayama, 1999). One species, *Cerapachys sulcinodis* in tribe Cerapachyini was discovered in the study area. Genus *Cerapachys* is most often confused with ponerines but they have frontal lobes which are very narrow. The antennal sockets and compound eyes are completely visible. The lower surfaces of the gaster are smoother than the upper.

***Cerapachys sulcinodis* Emery, 1889**

They are slender ants. The worker's length is about 2.5 mm. Their body is red- brown to black with white hairs. The second gastric segment is longer than the length of the petiole and the first gastric segment combined. The shape of the mesosoma is the box-like and the tibia of the middle leg has 1 spur. The pygidial margin has the denticulate (Figure 44).

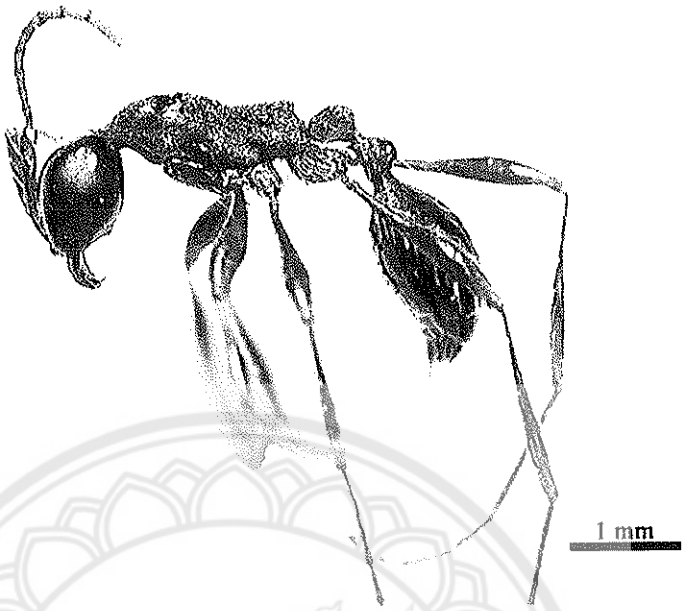


Figure 43 A worker of *Aenictus binghami* Forel, 1900.

Figure 44 A worker of *Cerapachys sulcinodis* Emery, 1889.

Subfamily Dolichoderinae

The species of Dolichoderinae can be found in most regions of the world (Yamane, Ikudome and Terayama, 1999). Four genera in tribe Dolichoderini were discovered in the study area, namely *Dolichoderus*, *Iridomyrmex*, *Philidris* and *Technomyrmex*. The compound eyes are usually present, but the ocelli are always absent. The antenna normally has 12 segments. The mesosoma is attached to the gaster by a single segmented petiole. The gaster is smooth without constrictions between the segments. The sting is absent and the tip of the gaster is slit-like opening without hairs. Members of subfamily Dolichoderinae is similar to those species of the subfamily Formicinae because both have a single segmented petiole and lack of sting. However, Dolichoderinae can be identified from Formicinae as the tip of the gaster has a slit-like opening while all formicines have a small circular opening.

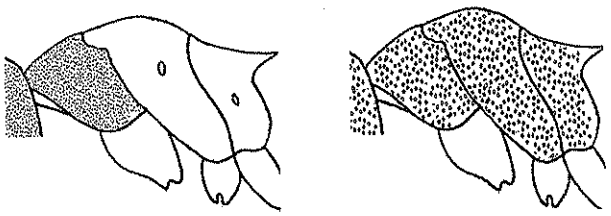
Key to the species of Dolichoderinae found in northern Thailand

Modified from Bolton, 1997; Shattuck, 1999.

1. a) Node of the petiole greatly reduced or absent; gaster with 5 plates on its upper surface ..... *Technomyrmex* (2).
   b) Node of the petiole present ..... 3.

1a) 1b)

2(1a). a) Head and thorax reddish brown, less finely punctuated ..... *T. kraepelini*
   b) Head and thorax black, more punctuated ..... *T. modiglianii*

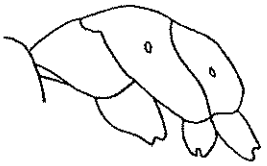


2a) 2b)

3(1b). a) Rear face of the propodeum generally concave ..... *Dolichoderus* (4).

b) Rear face of the propodeum usually rounded ..... 5.

3a)



3b)

4(3a). a) Head, alitrunk and petiole black ..... *D. thoracicus*

b) Head, alitrunk and petiole reddish brown ..... *D. tuberifer*

5(3b). a) Compound eyes placed relatively upward on the head, away from the clypeus and mandibles; rear margin of the head generally rounded as oval-shaped ..... *Iridomyrmex*

- Antenna without apical club; compound eyes small and less than half the size of the head; pronoturn and propodeum without spines ..... *I. anceps*

b) Compound eyes placed relatively downward on the head, closer to the clypeus and mandibles; rear margin of the head distinctly depressed or concave as heart-shape ..... *Philidris*

- Head, alitrunk, petiole and legs bright brown; mandibles with 10 brownish red teeth; gaster dark brown to black ..... *Philidris* sp.

5a)

5b)

Tribe Dolichoderini

Genus *Dolichoderus* Lund, 1831

The genus *Dolichoderus* contains the largest members of the subfamily Dolichoderinae. Two species in tribe Dolichoderini were found in this study site, namely *Dolichoderus thoracicus* and *Dolichoderus tuberifer*. The workers of them are less than about 5 mm. The body is often strongly sculptured and their antenna has 12 segments. Anterior hypostoma, which is underneath of the head near the base of the mandible, has slightly to well-developed rim. The pronoturn and/or propodeum have spines. If spines are absent, the rear face of the propodeum is often distinctly concave, but may be flat. The posterior margin of the propodeum varies from angulate to spine-shaped. The petiole is a distinct node which is not overhung by the gaster.

***Dolichoderus thoracicus* (F. Smith, 1860)**

This species is the common black ant. The total length of a worker's body is about 4 mm. Compound eyes are well developed and pronounced on the cranial surface. The head, alitrunk and petiole have coarse punctures. The mandible and legs are red-brown to black (Figure 45).

***Dolichoderus tuberifer* Emery, 1887**

The body length of a worker is about 2.5 mm. Compound eyes are present on the upper midline of the sides of the head. The head, alitrunk and petiole are red-brown with coarse punctures while the gaster is black, and oval-shaped. The legs are long and red (Figure 46).

Genus *Iridomyrmex* Mayr, 1862

Iridomyrmex in tribe Dolichoderini is distributed from India to China, Australia and New Caledonia (Shattuck, 1999). Their front margin of the clypeus is highly modified with convex areas while a central projection varies from strong to weak development. The compound eyes are located relatively high on the head and with a distance from the mandibles. Only one species, *Iridomyrmex anceps* was found in this study area.

***Iridomyrmex anceps* (Roger, 1863)**

The length of worker is about 3 mm with shiny black color. The head is large and rounded with large mandibles at the apex. The antenna has 12 segments and is longer than the head and prothorax combined. The geniculate does not have an apical

club. The compound eyes are small and less than half the size of the head. The pedicel has 1 segment and the node is an inverted-V-shaped crest. The pronoturn and propodeum do not have spines (Figure 47).

Genus *Philidris*, Shattuck 1992

This genus is separated from *Iridomyrmex* and is one of the smallest genus in this subfamily. *Philidris* in tribe Dolichoderini is distributed over the Oriental and Indo-Australian regions (Bolton, 1997). The front margin of the clypeus is highly modified with convex areas while a central projection has well developed. Occipital border of head is concave. The compound eyes are located relatively downward of the head, near the mandibles. Mandible has 10-12 teeth. Alitrunk is elongate in dorsal view and gaster is oval-shaped.

***Philidris* sp.**

The length of worker is about 1.5 mm. The shape of the head, including the mandible is heart-shaped. The head to petiole and legs are bright brown while the gaster is dark brown to black. Mandibles are brownish red with 10 teeth and the antennal scape is short. The compound eyes are black in color and less than half-length of the head. The pronoturn and propodeum do not have spines. A metanotal groove is present between the mesonotum and metanotum (Figure 48).

Genus *Technomyrmex*, Mayr 1872

Tribe Dolichoderini of *Technomyrmex* occur from Africa, to southern Asia and Australia (Bolton, 1997). The antenna has 12 segments. Anterior margin of clypeus is convex. The metanotum has a groove which is incised. The upper surface of the propodeum is shorter than the lower surface. The petiolar node is absent. The first segment of the gaster projects forward and partially or completely conceals the petiole. The petiole is flat and the gaster has 5 segments on its upper surface.

***Technomyrmex kraepelini* Forel, 1905**

The length of worker body is about 3 mm. Head and thorax are reddish brown and covered with fine punctuate. The head is longer than wide. The mesosoma and petiole are black and lack a dorsal spine. The gaster is brown to black. Compound eyes are small and positioned at midline of head (Figure 49).

***Technomyrmex modiglianii* Emery**

The worker body is about 2.5 mm in length. Their bodies are black with more punctuated on the head and thorax, and the head with mandibles is heart-shaped. The hair on the pronotum, mesonotum and gaster is short and white in color. The pronoturn and propodeum do not have spines and a metanotal groove is present. Compound eyes are larger than those in *Technomyrmex kraepelini* and positioned at the middle of the head (Figure 50).

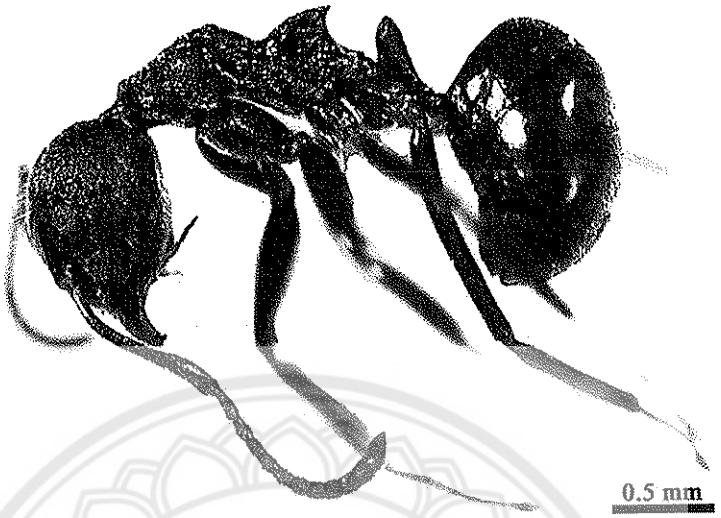


Figure 45 A worker of *Dolichoderus thoracicus* (F. Smith, 1860).

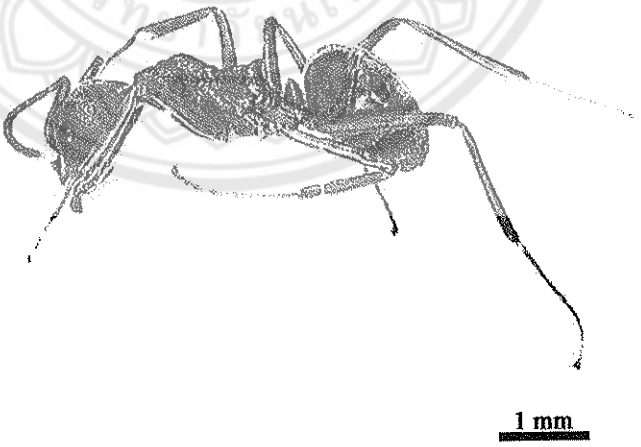


Figure 46 A worker of *Dolichoderus tuberifer* Emery, 1887.

Figure 47 A worker of *Iridomyrmex anceps* (Roger, 1863).

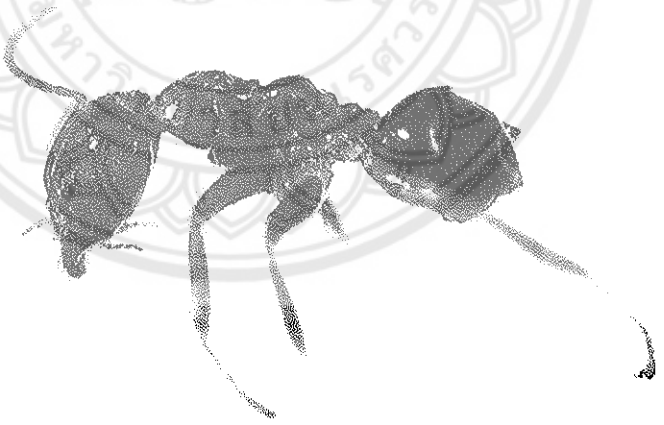


Figure 48 A worker of *Philidris* sp.

Figure 49 A worker of *Technomyrmex kraepelini* Forel, 1905.

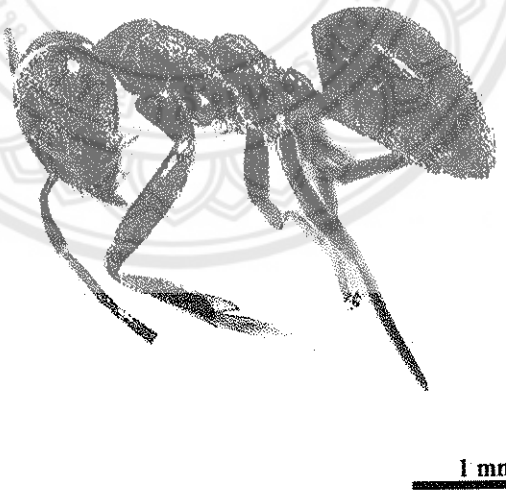


Figure 50 A worker of *Technomyrmex modiglianii* Emery, 1900.

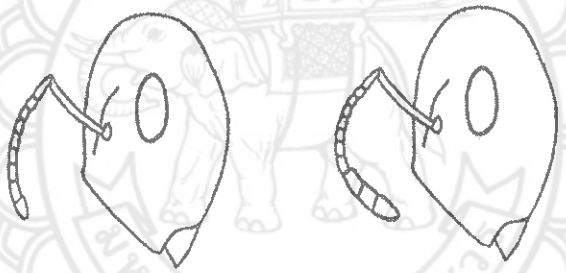
Subfamily Formicinae

This subfamily is very varied in size and shape. Species of formicines are found worldwide with about 3,700 species in 49 genera (Shattuck, 1999). Seven genera in 3 tribes: Camponotini, Oecophyllini and Plagiolepidini were recorded in this thesis. They are similar to those species of the subfamily Dolichoderinae as both subfamilies have a petiole and do not have a sting. However, formicines are distinguished from dolichoderines as the tip of the gaster has a circular opening whereas all dolichoderines have a slit-like opening. Ocelli and compound eyes of the worker are present. The mesosoma is attached to the gaster by a petiole. The gaster is smooth, without constrictions between the segments.

Key to the species of Formicinae found in northern Thailand

Modified from Bolton, 1997; Shattuck, 1999.

1. a) Antennae with 10 segments (including the scape) … (2).
   b) Antennae with 12 segments ..... (3).



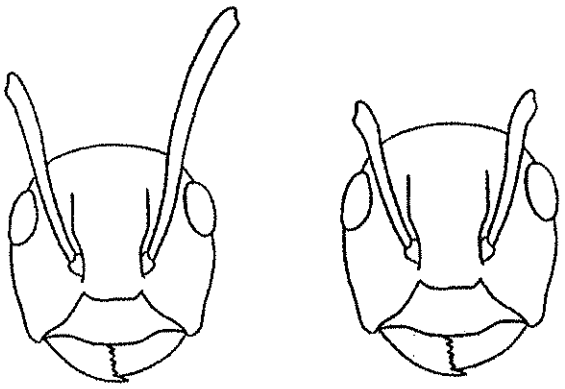
1a) 1b)

2(1a). a) Scapes longer than the rear margin of the head by more than two-thirds of their length or equal; pronotum longer than wide from dorsal view ..... *Anoplolepis*

- Gaster usually darker than head and thorax; erect hairs present on head and gaster but lacking on dorsum of mesosoma; propodeum and petiole without spines ..... *A. gracilipes*

b) Scapes longer than the rear margin of the head less than one-quarter of their length from dorsal view .... *Plagiolepis*

- Body with light brownish to black; petiole with an inverted-V-shaped crest ..... *Plagiolepis* sp.



1a) 2b)

3(1b). a) Metapleural gland opening absent; pronotum and mesonotum with randomly placed of soft hairs ..... (4).

b) Metapleural gland opening present; 3-5 pairs of large, stout, dark hairs present on pronotum and mesonotum ..... *Paratrechina*

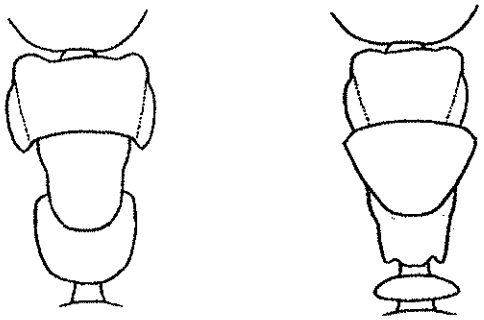
3a) 3b)

- Scapes and legs very long; whitish erect setae apparent; head, thorax, petiole, and gaster dark brown to blackish ..... *P. longicornis*

4(3a). a) Petiole long; node rounded or absent; mesonotum constricted and narrower than the pronotum and propodeum from top view ..... *Oecophylla*

- Body with light to dark brown to orange; petiole very slender; the mesosoma more domed ..... *O. smaragdina*in

b) Node of the petiole present; mesonotum wider than the pronotum and propodeum from top view ..... (5).



4a) 4b)

5(4b). a) Spines absent from the mesosoma and petiole ..... *Camponotus* (6).

b) Spines usually present on the mesosoma and/or petiole ..... *Polyrhachis* (11).

5a) 5b)

6(5a). a) Head brown to black ..... (7).

b) Head reddish ..... *C. singularis*

7(6a). a) Apically node of the petiole usually acute in lateral view ..... (8).

b) Apically node of the petiole usually round ..... *C. camelinus*

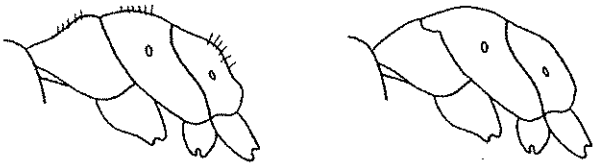
7a) 7b)

8(7a). a) Body is a single color ..... (9).

b) Body is bicolor ..... (10).

9(8a). a) More erect hairs on mesosoma and metasoma ..... *C. leonadi*

b) Less or absent erect hairs on mesosoma and metasoma ..... *C. rufoglaucus*



9a) 9b)

10(8b). a) Body is fat; compound eye is black; head of major with mandibles as heart-shaped ..... *Camponotus* sp.1

b) Body is long and slender; compound eye with red to reddish brown; head of major with mandibles as oval-shape ..... *Camponotus* sp.2

10a) 10b)

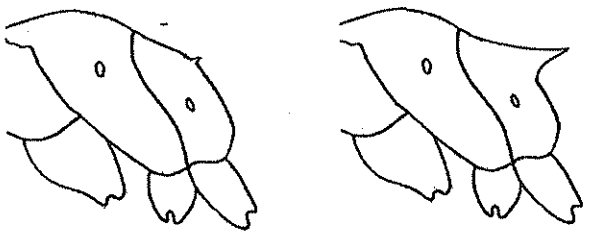
11(5b). a) Pronotal spines absent or node ..... (12).

b) Pronotal spines present ..... (13).

11a) 11b)

12(11a). a) Propodeal spines absent or node ..... *P. flavicornis*

b) Propodeal spines long ..... *P. hippomanes*



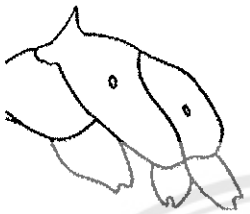
12a) 12b)

13(11b). a) Propodeal spines with laterally curved as hook ..... (14).

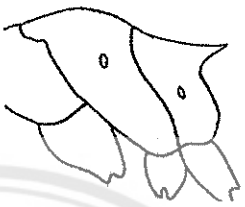
b) Propodeal spines without hook ..... (15).

14(13a). a) Mesonotum spines present; propodeal spines absent ..... *P. bihamata*

b) Mesonotum spines absent; propodeal spines present ..... *P. furcata*



14a)



14b)

15(13b). a) Propodeal spine absent, but if present, limited to near the propodeal angle ..... (16).

b) Propodeal spine long ..... (18).

15a)

15b)

16(15a.) a) Distance between each pair of petiolar spines wider ..... (17).

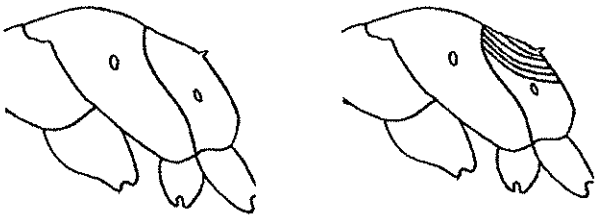
b) Distance between each pair of petiolar spines narrow or near ..... *Polyrhachis* sp.2

16a)

16b)

17(16a). a) Metasoma without longitudinal line ..... *P. proxima*

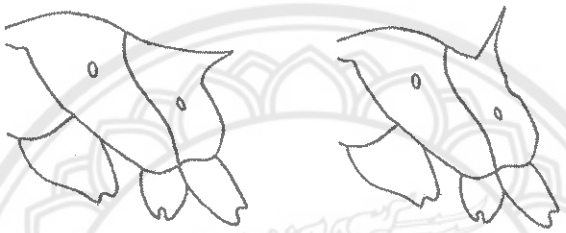
b) Metasoma with longitudinal line ..... *Polyrhachis* sp.1



17a) 17b)

18(15b). a) Propodeal spines directed backward ..... (19).

b) Propodeal spines directed straight ..... (21).



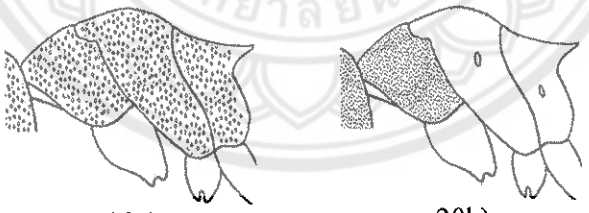
18a) 18b)

19(18b). a) Gaster black ..... (20).

b) Gaster red ..... *P. muelleri*

20(19a). a) Head to metasoma covered with coarse punctures ..... *P. armata*

b) Head to metasoma covered with fine punctures or smooth ..... *P. abdominalis*



20a) 20b)

21(18b). a) Gaster covered with golden hair ..... *P. dives*

b) Gaster not covered with hair ..... *P. tibialis*

Tribe Camponotini

Genus *Camponotus* Mayr, 1861

They are found world-wide (except polar region) (Shattuck, 1999). *Camponotus* is one of the largest ants in tribe Camponotini. Species vary greatly in size and shape, ranging from 5-14 mm in overall length. This genus is identified from other genera as the distinct gap between the rear margin of the clypeus and the antennal sockets is very long. Furthermore, hairs on the top of the mesosoma and gaster are golden-colored. The upper plate of the first gastral segment is less than one-half the total length of the gaster. Our study found 6 species within this genus, namely *Camponotus camelinus*, *C. leonadi*, *C. rufoglaucus*, *C. singularis*, *Camponotus* sp.1 and *Camponotus* sp.2.

***Camponotus camelinus* (F. Smith, 1857)**

Camponotus camelinus has black body. They are medium-sized ants which are about 8 mm in length and covered with punctuate. Workers have long legs and a slender body. Spines on thorax and petiole are absent while erect hairs are the present on petiole and gaster. Petiolar node is an inverted-U-shaped crest (Figure 51).

***Camponotus leonadi* Emery, 1889**

Camponotus leonadi has a medium-sized body about 8 mm. Their body is blackish. In major worker, the head is bigger than a minor worker, and the head of a major worker has heart-shaped mandibles. They have long slender body. Spines on the propodeum are absent while erect hairs are present on the mesosoma and metasoma. The petiole is an inverted-V-shaped crest. The fore legs are stronger than the other legs (Figure 52).

***Camponotus rufoglaucus* (Jerdon, 1851)**

They are medium-sized ants with about 8 mm in length. In a major worker, the head has heart-shaped mandibles and is bigger than a minor worker. A worker has long slender body. Spines on the propodeum are absent. The petiolar node is an inverted-V-shaped crest. Although *C. rufoglaucus* are similar to *C. leonadi* in body color, *C. rufoglaucus* can be distinguished by the mesosoma and metasoma which have less erect hairs or are absent (Figure 53).

***Camponotus singularis* (F. Smith, 1858)**

They are medium-sized ants and about 8 mm long. Workers have long legs and slender body. Spines on the thorax are absent while erect hairs are present on the petiole and gaster. The petiole is an inverted-U-shaped crest. Although *C. singularis* are similar to *C. camelinus* with black body, *C. singularis* is distinguished by the head color which is dark brown to red-brown (Figure 54).

***Camponotus* sp.1**

They are medium-sized ants and about 6 mm long. The head, mesosoma, legs and petiole are bright brown while the mandible and gaster are black. The head of major worker including mandible is heart-shaped. The mesosomal surface is smooth. The compound eyes are elongated on the upper midline of head. Spines on the propodeum are absent while erect hairs are present on the gaster. The petiole is an inverted-V-shaped crest (Figure 55).

***Camponotus* sp.2**

They are medium-sized ant and about 6 mm in length. Workers have long legs and more slender than *Camponotus* sp.1. The head, mesosoma, legs and petiole are reddish brown while the gaster is black in color. Mesosomal surface is smooth. The compound eyes are elongated on the upper midline of the head. Spines on the propodeum are absent while erect hairs are present on gaster. The petiole is an inverted-V-shaped crest (Figure 56).

Genus *Polyrhachis* F. Smith, 1857

Polyrhachis in tribe Camponotini are found throughout the Old World tropics (Shattuck, 1999). They were found 12 species which is one of the larger groups of ants in the north of Thailand. The major workers are black and about 5-10 mm in total length. Most species of genus *Polyrhachis* are easily recognized with spines on the mesosoma and the top of the petiole but sometimes the mesosoma is smooth. Their mandible have 7 teeth. The length of the first gasteral segment is one-half of the total length of the gaster. The area above the hind leg is smooth and lacks an opening.

***Polyrhachis abdominalis* F. Smith, 1858**

The length of worker body is about 8 mm. The body is red-black with fine pits. The anterior margin of the clypeus is black and rounded. The compound eyes are reddish black and located on the upper midline of the head. The prothorax has a pair of

spines, directed obliquely forwards. The prothorax, metathorax and petiole are slightly convex and both have a divergent spine at the apex (Figure 57).

***Polyrhachis armata* (Le Guillou, 1842)**

The length of a worker body is about 9 mm. Althougth *Polyrhachis armata* is similar to *P. abdominalis* in color and shape, *P. armata* can be distinguished by thier surface which is more punctured than *P. abdominalis*, and gaster are brown (Figure 58).

***Polyrhachis bihamata* (Drury, 1773)**

Total length of a worker is about 7 mm. The color of the head and second gaster to the last gaster are black while the thorax, the node of petiolar and the first gaster are red brown to black, including the coxa to the femur of the legs. The antennae are long slender with 12 segments. The compound eyes are moderately large. The petiole has 2 strong spines directed laterally as hooks while the pronotum and mesonotum have a pair of curved spines, shorter than the spines on the petiole (Figure 59).

***Polyrhachis dives* F. Smith, 1857**

Total length of a workers is about 5 mm. They are black in color. The mesosoma is covered with coarse punctures and the dorsal surface of the mesosoma is arched. The dorsolateral margins do not have a carina. The pronotum and propodeum have a pair of well-developed short spine directed laterally. The spine on the mesonotum is absent while the petiole has a pair of long lateral spines and a pair of small median cornicles (little horn). The petiolar spines are longer than those of a mesosoma. The gaster is covered with golden hairs (Figure 60).

***Polyrhachis flavicornis* F. Smith, 1857**

Workers are about 5 mm in body length and metallic dark brown to black in body color. The body of this species is not covered with hairs but the head and mesosoma are covered with coarse punctures. The mesosoma do not have a pair of spines while the petiole has a pair of short lateral spines (Figure 61).

***Polyrhachis furcata* F. Smith, 1858**

Total length of a worker is about 5 mm. Body color is red-black with white hairs. Mesosoma and petiole are covered with coarse punctures. Pronotum, propodeum and petiole has a pair of well-developed spine, directed laterally but petiolar spines are lateral hook, which are longer than those of mesosoma (Figure 62).

***Polyrhachis hippomanes* F. Smith, 1861**

The worker body is about 5 mm in lenght. Their body is metallic dark brown to black while the legs are reddish brown. This species lacks hairs on the body. The head and mesosoma are covered with coarse punctures. The pronotum do not have a pair of spines while the propodeum has a pair of well-developed spines, directed laterally. Furthermore, the petiole has a pair of short lateral spines, which are as long as those of mesosoma (Figure 63).

***Polyrhachis muelleri* Forel, 1893**

The length of body is about 7 mm in worker. The head to the petiole is red-black while the gaster is red-brown, including compound eyes. The head, thorax, and petiole have fine punctures. The anterior margin of the clypeus is rounded. The pronotum has 2 long straight spines, directed obliquely forwards. The mesosoma and petiole have a pair of well-developed spines, directed laterally. This species is similar to *Polyrhachis abdominalis* but they can be distinguished by color of their gaster which is red-brown (Figure 64).

***Polyrhachis proxima* Roger, 1863**

The worker body is about 8 mm long. Their body is ferruginous black while the compound eyes are red-black. Their body is not covered with coarse punctures but they are covered by golden hairs. Pronotum has 2 long straight spines, directed obliquely forwards. The pronotum does not have a pair of spines but they have a pair of small horns. The petiole has a pair of well-developed straight spines directed laterally (Figure 65).

***Polyrhachis tibialis* F. Smith, 1858**

The worker body is about 6 mm in length. Their bodies are red-brown while compound eyes are red-black. They are covered with coarse punctures and with a fine short golden pubescent pile. Mesosoma has a short stout spine at each of the anterior angles, and a much longer one at the posterior angles. The petiole has a long acute spine curving backwards and outward over the abdomen on each side (Figure 66).

***Polyrhachis* sp.1**

The length of worker body is about 6 mm. Their body is red-black while the compound eyes are red-brown. Mesosoma has two long straight spines on pronotum, directed obliquely forwards and 2 curve denticles on the propodeum. Petiolar spines

are present and straight spines. Their body is covered with white hairs. Even though this species is similar to *Polyrhachis proxima* in body color, *Polyrhachis* sp.1 differed from *P. proxima* by longitudinal lines on the propodeum (Figure 67).

***Polyrhachis* sp.2**

Worker body is about 5 mm in lenght. Their body is black while the compound eyes are reddish-black. The thorax has 2 long straight spines on the pronotum, directed obliquely forwards and 2 curved denticles on the propodeum. The petiole has a pair of well-developed straight spines. Their gaster is covered with white hairs. Though this species is similar to *Polyrhachis* sp.1 in body color, *Polyrhachis* sp.2 can be distinguished from *Polyrhachis* sp.1 by longitudinal lines on the protonotum and metanotum (Figure 68).

Tribe Oecophyllini

Genus *Oecophylla* F. Smith, 1860

Oecophylla are large arboreal ants from the Africa, Asian, and Australian tropics (Bolton, 1997). Only one species, *Oecophylla smaragdina* in tribe Oecophyllini was found in this study. The mandibles have 10 or more teeth. The fourth tooth (counting from the tip) is longer than the third and fifth teeth. The node of the petiole is rounded. The mesonotum is constricted and narrower than the pronotum and propodeum from a top view. The area above the hind leg is smooth and without a small opening. The scale of the petiole is low and rounded, without distinct front, top or rear faces.

***Oecophylla smaragdina* (Fabricius, 1775)**

Their body length is about 8 mm. The head to petiole is light to dark brown to orange while the gaster is darker than the other segments. The antenna is very long with 12 segments. The mandible and clypeus are very large, long and convex, but not distinctly carinated. Their alitrunk is more domed but the petiole is very slender and round. The compound eyes are large and positioned at middle line of the head (Figure 69).

Tribe Plagiolepidini

Genus *Anoplolepis* Santschi, 1914

Genus *Anoplolepis* is widespread in southeast Asia and the Pacific (Shattuck, 1999). *Anoplolepis* is recognizable by its very long body, pale yellow legs, and 11-segmented antennae. The scapes are very long, surpassing the rear margin of the head

by two-thirds of their length or more. The position of the compound eyes is at the midline of the head, and ocelli are absent. The mandibles have 6-9 teeth. They are most similar to some species of *Camponotus* (subfamily Dolichoderinae) but they are easily distinguished from *Camponotus* by the number of antennal segments (*Camponotus* has 12 segments) and the circular opening at the tip of the gaster. One species, *Anoplolepis gracilipes* in tribe Plagiolepidini was found in this study.

***Anoplolepis gracilipes* (F. Smith, 1857)**

Anoplolepis gracilipes has a brownish body color, and is weakly sclerotized. They are small to medium-sized ants and about 3.5 mm in length. They are notable for its remarkably long legs and antennae. Workers have slender body with the gaster usually darker than the head and thorax. Spines on the propodeum are absent while the metanotal groove is present. One node (petiole), which is an inverted-U-shaped crest, is present. Erect hairs are present on the head and gaster, but lacking on the dorsum of the mesosoma. The tip of the gaster is often surrounded by a ring of short hairs (Figure 70).

Genus *Lepisiota* Santschi, 1926

The genus *Lepisiota* is found from Africa to Asia (Bolton, 1997). In this study, only one species in tribe Plagiolepidini was discovered. They are recognized by 11 segments of antennae. The compound eyes are well developed while ocelli are present but may be reduced. The apical margin of mandibles is oblique, dentate, and projected by clypeus. The alitrunk is constricted in the mesonotal region. The propodeum is swollen and has 2 toothlike processes. The petiole has 1 segment. The dorsal margin of the propodeum and petiole is bispinose or bidentate. The circular opening of the tip of the gaster is often surrounded by a fringe of hairs.

***Lepisiota* sp.**

The worker body is about 2 mm in length. Their head is dark brown to black. The thorax, legs and petiole are bright brown while the gaster is metallic black. The compound eyes are large and located at the middle line of the head. The antenna is longer than the alitrunk and petiole combined. The mesosoma is attached to the gaster by a single segment, the petiole. A sting is absent, and the tip of the gaster has a small circular opening that is usually surrounded by a ring of short hairs (Figure 71).

Genus *Paratrechina* Motschulsky, 1863

This genus in tribe Plagiolepidini occurs in North and South America, Europe, Africa, and the east through India, China and the south to Indonesia and Australia (Shattuck, 1999). Only one species, *Paratrechina longicornis* was found in this study area. They are identified by large and distinctive pairs of erect hairs on the upper surfaces of the pronotum and mesonotum.

***Paratrechina longicornis* (Latreille, 1802)**

This species is easily identified by a long antennal scape, long legs, and white erect setae. Their body size is small to medium between 2 - 3 mm. Their body is dark brown to black in color. The antenna has 12 segments without a club. They have only one petiole between the propodeum and the gaster, and a sting is absent. The compound eyes are elliptical, and located close to the posterior border of the head. The petiole is wedge-shaped with a broad base and inclined forward (Figure 72).

Genus *Plagiolepis* Mayr, 1861

Genus *Plagiolepis* occurs in southern Europe, Russia, Africa and in the east to India, Korea, and in the south to Asia and Australia (Shattuck, 1999). Only one species, *Plagiolepis* sp. in tribe Plagiolepidini is recorded from this study area. Members of the genus *Plagiolepis* are small ants with a stout body. The antennae have 11 segments and the scapes are shorter than one-quarter of head length. The propodeum is round and lacks teeth or protuberances.

***Plagiolepis* sp.**

Total length of workers is about 2.5 mm. The body color is light brown to black and the gaster is covered with erect hairs. This species has short antennal scapes which exceed the posterior margin of the head by less than the length of the second antennal segment. The compound eyes are elliptical shape on the upper midline of the head. The mesonotal groove is present while spines on body are absent. The petiole is an inverted-V-shaped crest (Figure 73).

Figure 51 A worker of *Camponotus camelinus* (F. Smith, 1857).

Figure 52 A worker of *Camponotus leonadi* Emery, 1889.

Figure 53 A worker of *Camponotus rufoglaucus* (Jerdon, 1851).

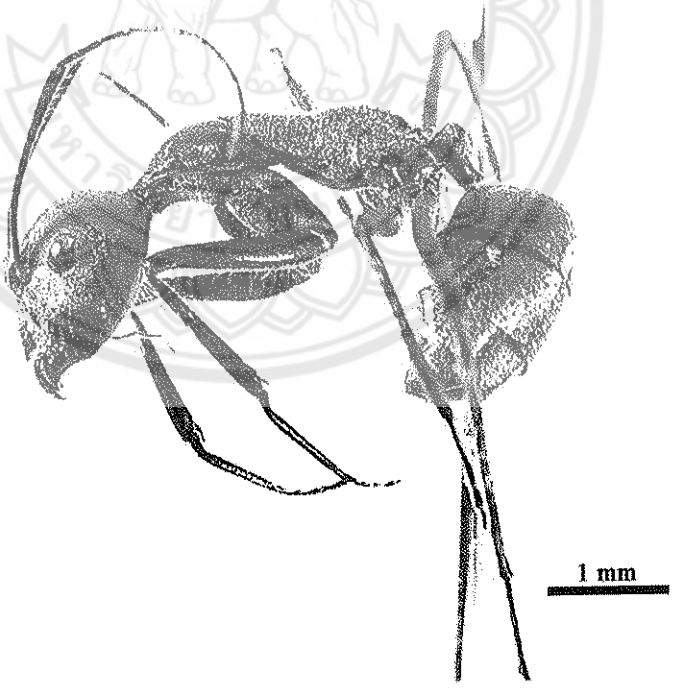


Figure 54 A worker of *Camponotus singularis* (F. Smith, 1858).

Figure 55 A worker of *Camponotus* sp.1.

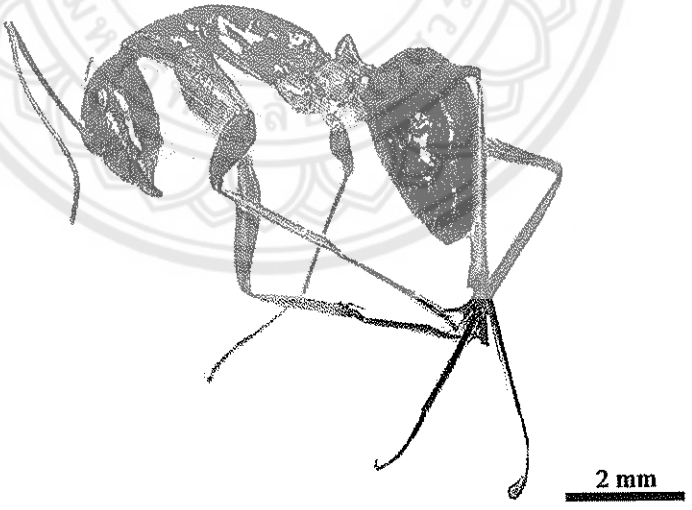


Figure 56 A worker of *Camponotus* sp.2.

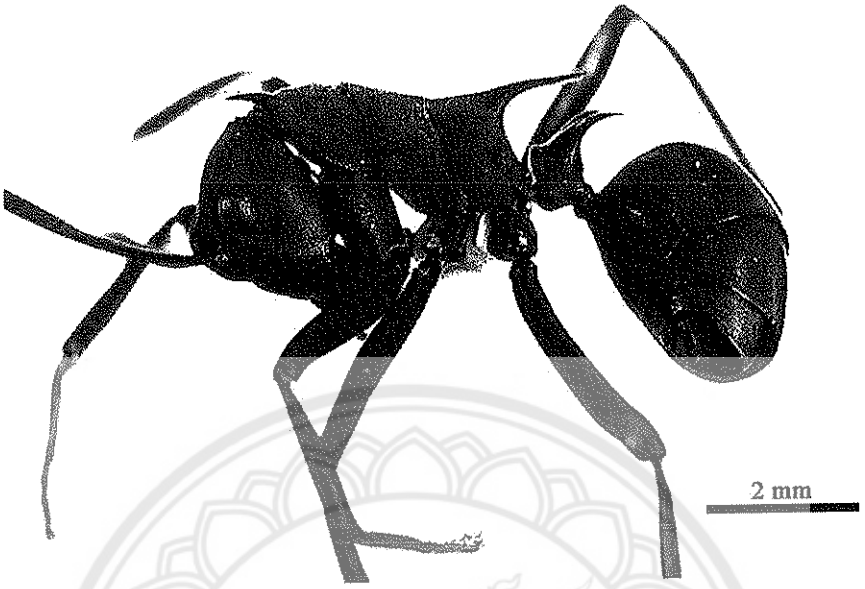


Figure 57 A worker of *Polyrhachis abdominalis* F. Smith, 1858.

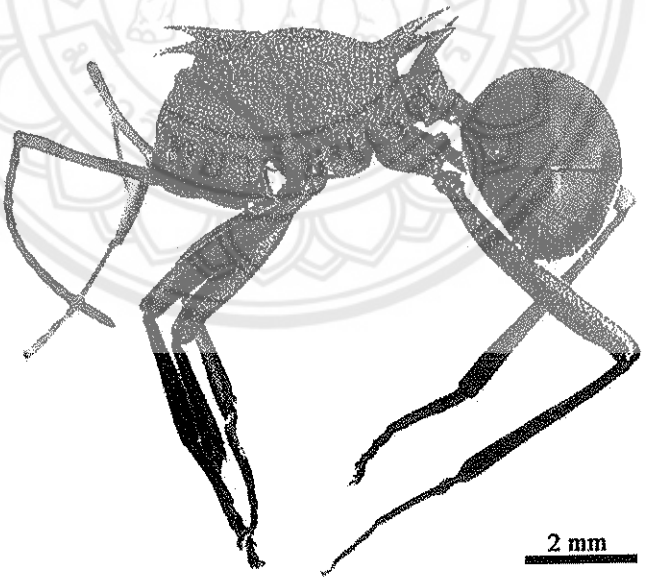


Figure 58 A worker of *Polyrhachis armata* (Le Guillou, 1842).

Figure 59 A worker of *Polyrhachis bihamata* (Drury, 1773).

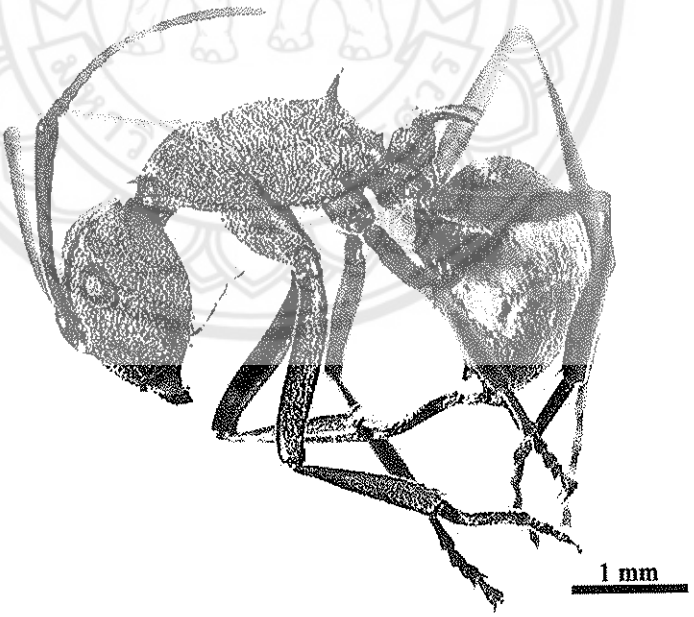


Figure 60 A worker of *Polyrhachis dives* F. Smith, 1857.

Figure 61 A worker of *Polyrhachis flavicornis* F. Smith, 1857.

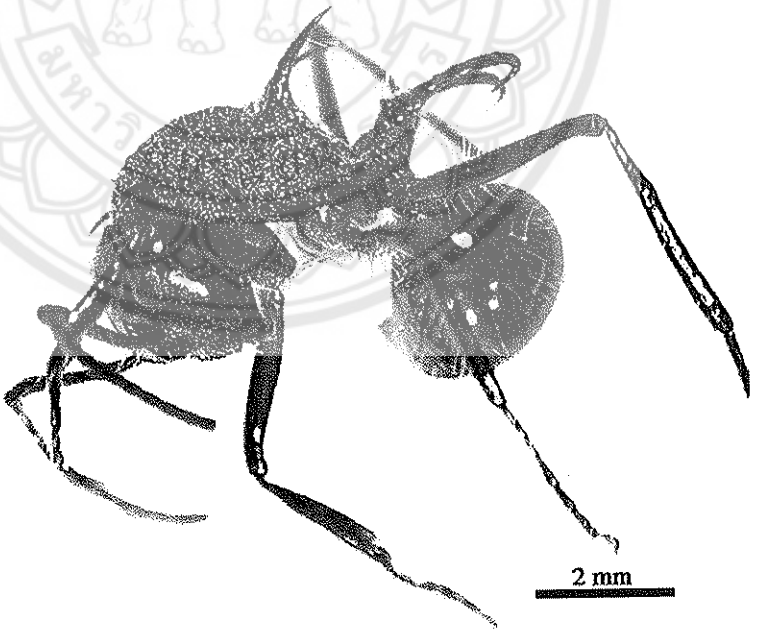


Figure 62 A worker of *Polyrhachis furcata* F. Smith, 1858.

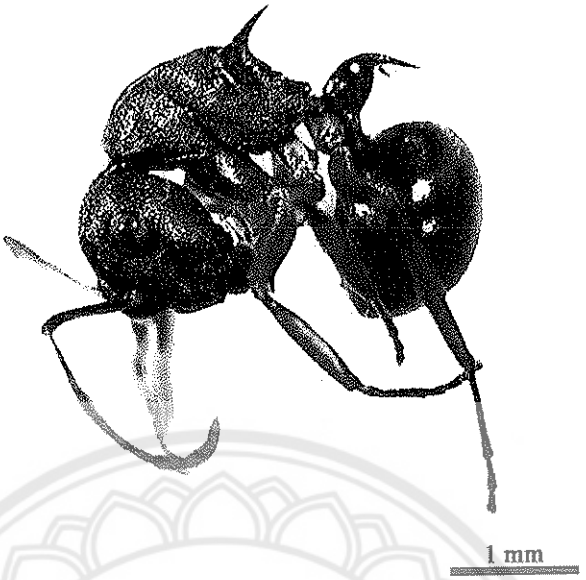


Figure 63 A worker of *Polyrhachis hippomanes* F. Smith, 1861.

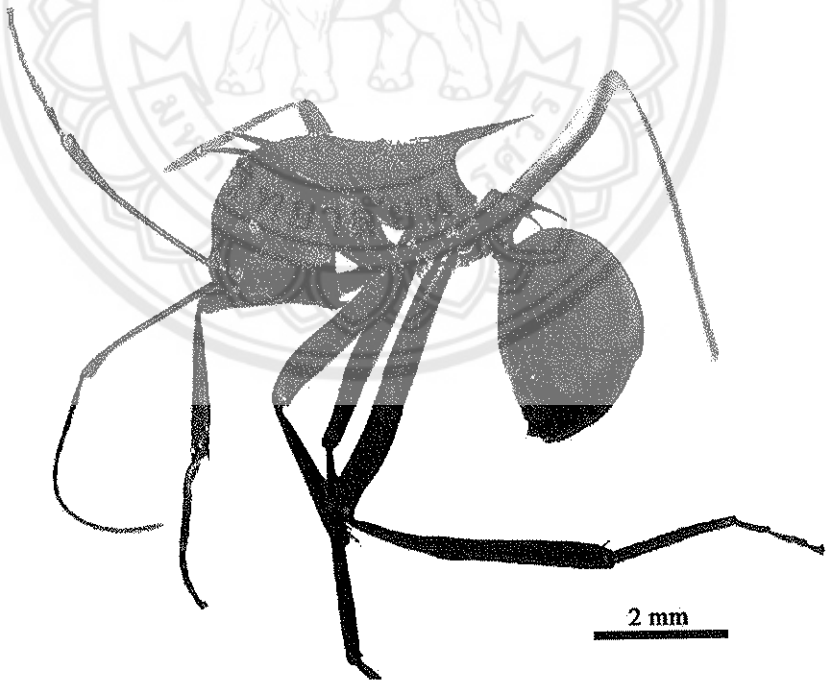


Figure 64 A worker of *Polyrhachis muelleri* Forel, 1893.

Figure 65 A worker of *Polyrhachis proxima* Roger, 1863.

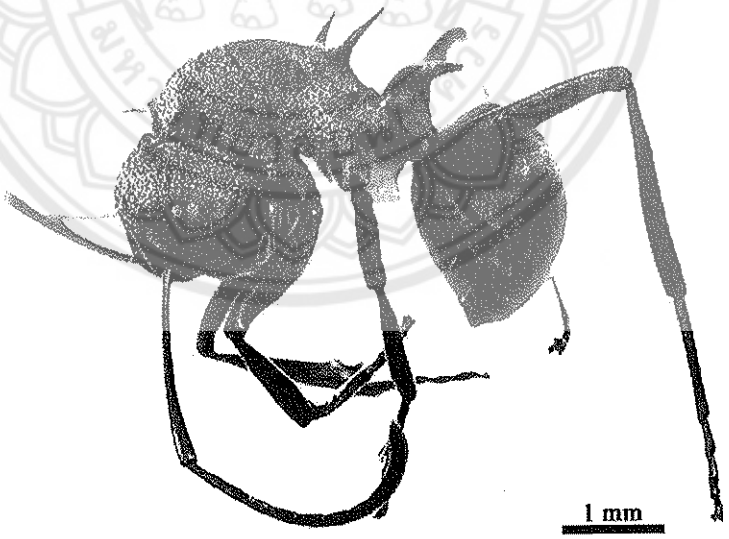


Figure 66 A worker of *Polyrhachis tibialis* F. Smith, 1858.

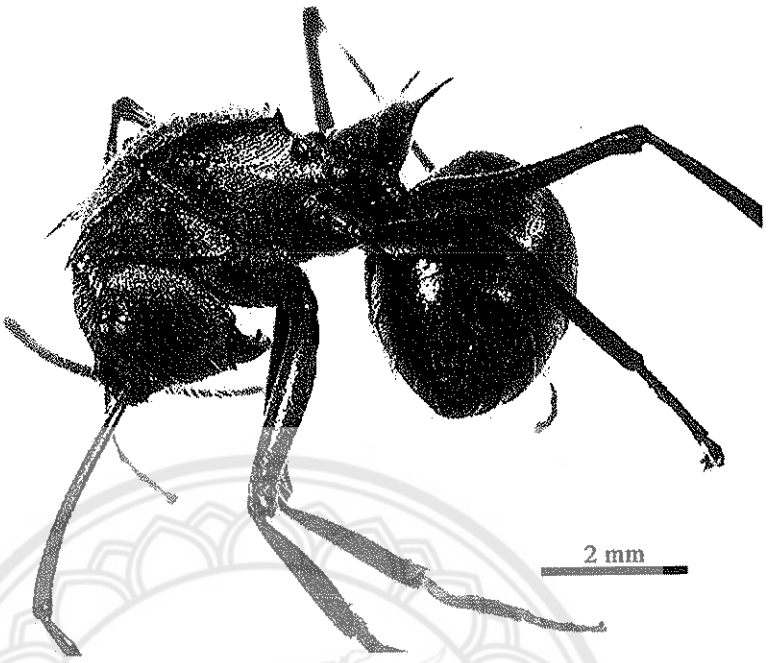


Figure 67 A worker of *Polyrhachis* sp.1.

Figure 68 A worker of *Polyrhachis* sp.2.

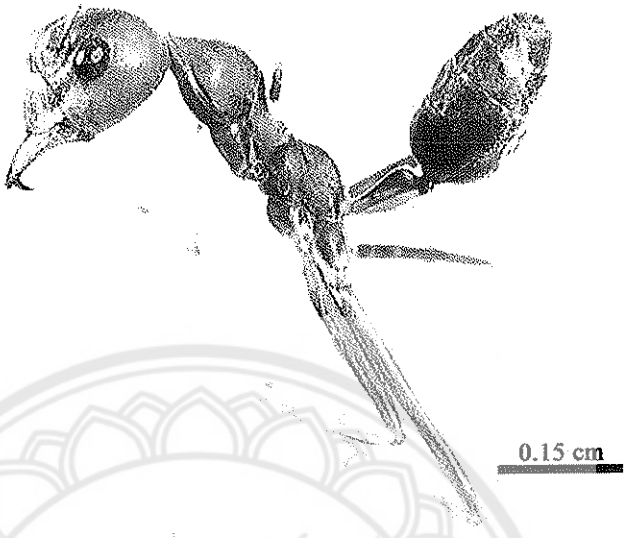


Figure 69 A worker of *Oecophylla smaragdina* (Fabricius, 1775).

Figure 70 A worker of *Anoplolepis gracilipes* (F. Smith, 1857).

Figure 71 A worker of *Lepisiota* sp.

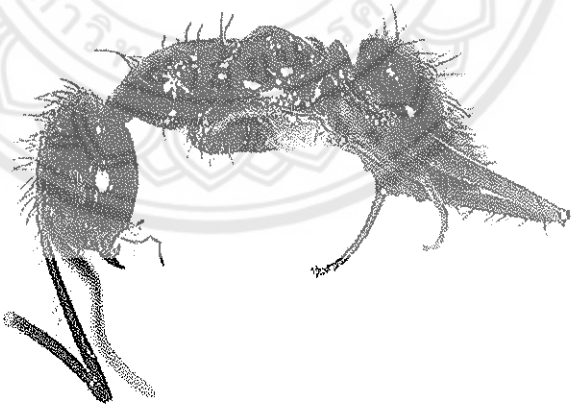


Figure 72 A worker of *Paratrechina longicornis* (Latreille, 1802).

Figure 73 A worker of *Plagiolepis* sp.

Subfamily Myrmicinae

Subfamily Myrmicinae is distributed throughout the world in all major habitats, except the Arctic and Antarctic regions. The myrmicines are the largest subfamily of ants (Shattuck, 1999). From our study, 12 genera in 10 tribes: Cataulacini, Crematogastrini, Formicoxenini, Melissotarsini, Meranoplini, Myrmecinini, Pheidolini, Pheidologetonini, Solenopsidini and Tetramoriini have been identified. The most abundant species was in the genus *Crematogaster*. All of them have 12-segmented antenna. Their frontal lobes are always present and expanded towards and alongside the inner part of the antennal bases. The pronotum and mesonotum are fused into a single plate, even if an intervening suture is present. The abdominal pedicel consists of 2 segments; petiole and postpetiole. The compound eyes, ocelli and sting are present.

Key to the species of Myrmicinae found in northern Thailand

Modified from Bolton, 1997; Shattuck, 1999.

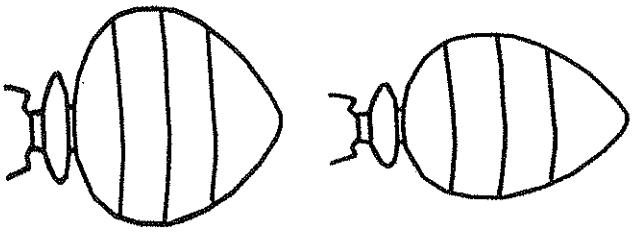
1. a) Antennal scrobe present under compound eyes ..... *Cataulacus*
   - Body covered with coarse punctures ..... *C. granulatus*

   b) Antennal scrobe absent, but if present upper compound eyes ..... (2).

1a) 1b)

2(1a). a) Gaster with heart-shaped ..... *Crematogaster* (3)

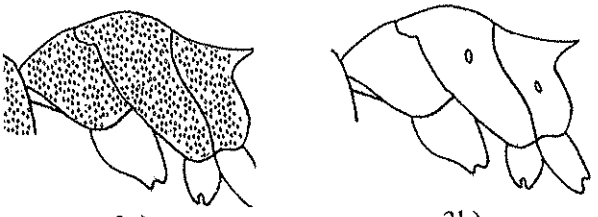
   b) Gaster with oval-shaped ..... (5).



2a) 2b)

3(2a). a) Mesosoma covered with coarse punctures ..... (4).

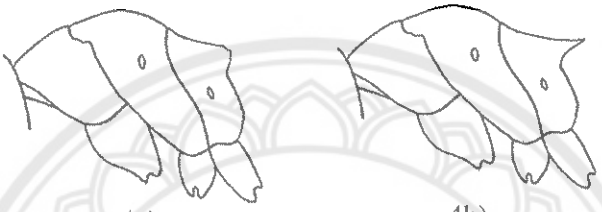
b) Mesosoma covered without coarse punctures ..... *C. coriaria*



3a) 3b)

4(3a). a) Propodeal spines round ..... *C. difformis*

b) Propodeal spines acute ..... *C. rogenhoferi*

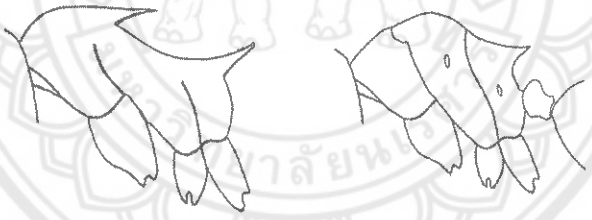


4a) 4b)

5(2b). a) Mesosomal spines with 2 pairs ..... (6).

b) Mesosomal spines with less than 2 pairs or absent; propodeal spines absent ..... *Pristomyrmex*

- Subpetiolar process absent ..... *P. punctatus*

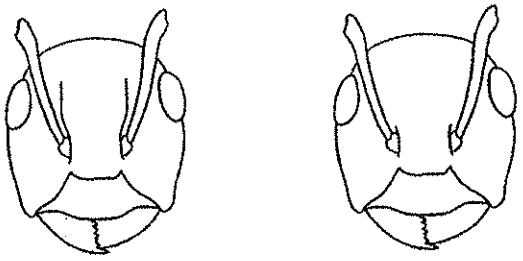


5a) 5b)

6(5a). a) Antennal scrobe obvious present or deep ..... (7).

b) Antennal scrobe unclear or shallow; antenna with 9 segments ..... *Meranoplus*

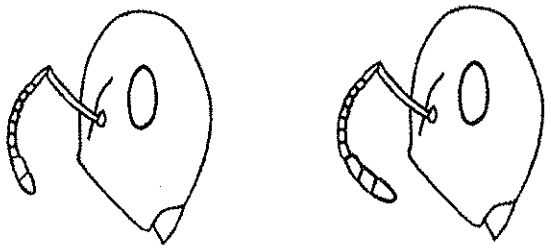
- Propodeal spines sharp and long ..... *M. bicolor*



6a) 6b)

7(6a). a) 2 apical antennal segments form a club ..... (8).

b) 3 apical antennal segments form a club ..... (9).



7a) 7b)

8(7a). a) Propodeal spines present ..... *Pheidologeton*

- Metanotal groove deeply incised ..... *P. diversus*

b) Propodeal spines absent ..... *Solenopsis*

- Antennal club longer than 3rd to 9th antennal segments combined ..... *S. geminata*

8a) 8b)

9(7b). a) Thorax with box-shaped ..... *Rhopalomastix*

- Spines on mesosoma and petioles absent ..... *R. janeti*

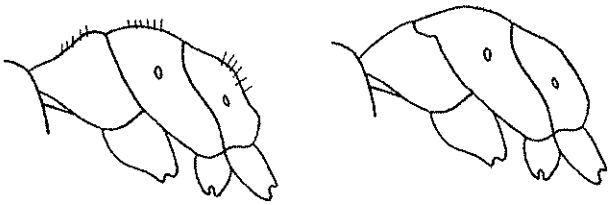
b) Thorax without box-shaped ..... (10).

9a) 9b)

10(9b). a) Hairs on mesosoma present ..... (11).

b) Hairs on mesosoma absent ..... *Cardiocondyla*

- Anterior margin of postpetiole concave ..... *C. wroughtonii*

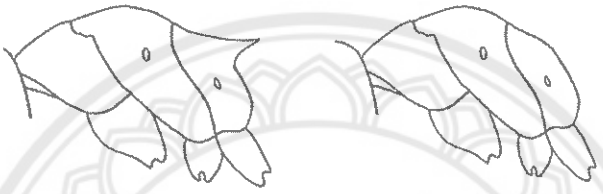


10a) 10b)

11(10a). a) Propodeal spines present ..... (12).

b) Propodeal spines absent ..... *Monomorium*

- Compound eyes large on the middle of head; metanotal groove present ..... *M. destructor*



11a) 11b)

12(11a). a) Pronotum higher than other mesosomal segments; pronotal spine absent ..... *Pheidole*

- Pronotum and mesonotum usually separately raised ..... *P. plagiaria*

b) Mesosoma slightly curved or nearly straight ..... (13).

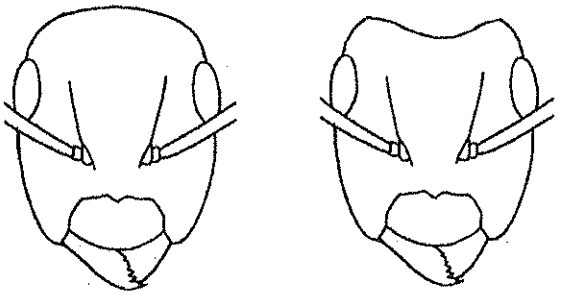
12a) 12b)

13(12b). a) Lower surface of the petiole rounded from side to side ..... *Tetramorium*

- Head without curve ..... *T. flavipes*

b) Lower surface of the petiole narrowed into a keel-like ridge ..... *Rhoptromyrmex*

- Head with curve ..... *R. wroughtoni*



13a) 13b)

Tribe Cataulacini

Genus *Cataulacus* F. Smith, 1853

Cataulacus in tribe Cataulacini is widespread in Africa and Asia (Bolton, 1997). Only one species, *Cataulacus granulatus* was reported in our study. This genus is similar to genus *Polyrhachis* but *Cataulacus* has 2 segments of the petiole. The antennae have 11 segments. The scape and the basal joint of the flagellum of antennae, tibiae and tarsi of the legs are reddish. Spines on the metanotum are sharp, long and diverged.

***Cataulacus granulatus* (Latreille, 1802)**

The length of a worker is about 4 mm. Their body is black while the scape, basal joint of antennae, tibiae and tarsi are red and covered with coarse punctures. Metanotal spines are sharp, long and diverge. The gaster is covered with white hairs (Figure 74).

Tribe Crematogastrini

Genus *Crematogaster* Lund, 1831

The head is subrectangular or oval with a convex curve. The antennae have 11 segments. The mandibles are small and the compound eyes are medium size and located behind the midline of the head. The anterior clypeal margin is straight or widely curved and convex while the frontal carinae and mesosoma are short. The petiole is low and rounded and lacks a node on its upper surface. The postpetiole is attached to the upper surface of the gaster. The propodeal spines vary from absent to long, and the petiole is flat ventrodorsally without a node. The attachment of the postpetiole to the gaster and heart-shaped gaster is highly distinctive and can be used as distinguishing criterion. *Crematogaster* in tribe Crematogastrini is an ecologically

diverse genus of ants found worldwide (Bolton, 1997). Three species of genus *Crematogaster* were found in the north of Thailand in our study.

***Crematogaster coriaria* Mayr, 1872**

The length of a worker is 3 mm in average. Their body is red-black to black while the scape, basal joint of antennae, tibiae and tarsi are red. There are no coarse punctures on body. The metanotal spines are sharp, long and diverged. The petiole and postpetiole are very long. The gaster is heart-shape, and covered with white hair (Figure 75).

***Crematogaster difformis* F. Smith, 1857**

The length of a *Crematogaster difformis* worker is about 6 mm. Their body is red-black to black while the tarsi are red. The head and pronotum are covered with coarse punctures. Spines on the metanotum are blunt and short. The petiole and postpetiole are as long as the second gaster tergum. The gaster is heart-shape with white hairs (Figure 76).

***Crematogaster rogenhoferi* Mayr, 1879**

The length of a *Crematogaster rogenhoferi* worker is approximately 5 mm. The head to postpetiole and legs are red-orange while the gaster is black. The head and mesosoma are covered with coarse punctures. Metanotal spines are sharp, long and diverged. The petiole and postpetiole are half of the gaster in length (Figure 77).

Tribe Formicoxenini

Genus *Cardiocondyla*, Emery 1869

Cardiocondyla in tribe Formicoxenini is widespread in Australia and Asia (Bolton, 1997). Only one species, *Cardiocondyla wroughtonii* was reported in this study. The total length of workers is approximately 3 mm. The rectangular head has a rounded occipital border. The triangular mandible usually has 5 teeth. The pronotum, mesonotum and propodeum are continuously flat to a weakly arched surface. The metanotal groove is shallow, but absent in some species. The propodeal spine varies in length. The peduncle and subpetiolar processes are slender. The postpetiole is wider than, and much broader than the petiole. Mid and hind legs are without tibial spurs. The combination of these characters can distinguish these ants from one another.

***Cardiocondyla wroughtonii* (Forel, 1890)**

The worker length is approximately 2 mm. The head, mesosoma, petiole and postpetiole are bright brown but the gaster is dark brown. The compound eyes are blackish, and relatively large and convex. The head is rectangular and the occipital border is almost straight, but slightly concave in the middle. Five teeth are arranged on the mandible. The promesonotal area is depressed and almost straight. The metanotal groove is distinct. The dorsal propodeum is roundly convex and higher than other segments. The propodeal spines are longer than their basal width. The petiole has a long peduncle and high node while the anterior margin of postpetiole is concave (Figure 78).

Tribe Melissotarsini

Genus *Rhopalomastix* Forel, 1900

Rhopalomastix is found in India, Sri Lanka and Australia (Shattuck, 1999). Only one species, *Rhopalomastix janeti* in tribe Melissotarsini was recorded from this study. The antennae have 10 segments, and the apical 2 segments of the antenna form a club. The clypeus margin has pairs of elongate hairs. The compound eyes are medium and situated on the midline of the sides of the head. The propodeum is rounded without spines or teeth.

***Rhopalomastix janeti* Donisthorpe, 1936**

The worker length is about 2 mm. The head to postpetiole is red-black in color while the gaster is darker than other segments. Their bodies are covered with black hairs. Their head is wider than long. The mesosoma is longer than the total length of gaster. The compound eyes are small and located on the midline of the sides of the head. Mesosomal and petiolar spines are absent. The petiole has arched nodes on their upper surfaces (Figure 79).

Tribe Meranoplini

***Meranoplus* F. Smith,1853**

Genus *Meranoplus* in tribe Meranoplini is distributed from Africa, India, Indonesia, New Guinea and Australia (Shattuck, 1999). Only one species, *Meranoplus bicolor* was found in this study. This genus is similar to *Crematogaster* but their antennae have only 9 segments. The upper surface of the mesosoma forms a broad shield with thin and sharp lateral edges which project outwards over the sides of the

mesosoma. The shield-like upper surface of the mesosoma can distinguished these ants from all others.

***Meranoplus bicolor* (Guerin-Meneville, 1844)**

The length of a worker is 6 mm in average. The head, thorax, legs and postpetiole are dark red while the gaster is black with white hairs. Their head to their postpetiole is covered by coarse punctures. The antennal scrobe is well-developed but narrow. Spines of pronotum are sharp and very long but the metanotal spines are short pairs. The petiole and postpetiole are very long. The petiolar node is an inverted-V-shaped crest but the postpetiolar node is an inverted-U-shaped crest. The petiole and the postpetiole are long, about one-half of the total length of the gaster (Figure 80).

Tribe Myrmecinini

Genus *Pristomyrmex* Mayr, 1866

Pristomyrmex in tribe Myrmecinini is distributed through Africa, Japan, Indonesia, New Guinea and Australia (Shattuck, 1999). Only one species, *Pristomyrmex punctatus* was found in this study. The length of the workers is about 4 mm. The frontal lobes are slightly developed. They have 11-segmented antennae, and the club has 3 segments. Clypeus has a longitudinal carina. The pronotal and propodeal spines are unique. The compound eyes are small to medium in size. Gastral hairs are absent.

***Pristomyrmex punctatus* Smith, 1860**

The length of workers is about 5 mm. Their body color is brown to red-brown while the gaster is black-brown. The compound eyes are small size and located on the midline of the sides of the head. The antennal scapes are longer than their head. Propodeal spines and the subpetiolar process are absent. The petiolar and postpetiolar nodes are subtriangular. The mesosoma to postpetiole are covered by coarse punctures. The gaster is very smooth (Figure 81).

Tribe Pheidolini

Genus *Pheidole* Westwood, 1839

Pheidole is the second most diverse genus of ants in the world. They are found worldwide (Bolton, 1997). Only one species, *Pheidole plagiaria* in tribe Pheidolini was recorded from this study. They are similar to *Pheidologeton.* 12-segmented antennae are their main characteristics which differ from *Pheidologeton.*

The 3 apical antennal segments form a club. The propodeum is lower than the pronotum and on the forward section of the mesonotum. The propodeum and mesonotum are connected by the sloping section of the mesonotum. In soldiers, the anteroventral margin of the cranium carries 1 or 2 pairs of small spines and a median projection.

***Pheidole plagiaria* F. Smith, 1860**

The major worker of this species is necessary for identification. The length of the body is about 4 mm in soldiers. The body color is brown to red-brown while the gaster is darker than the other segments. Their heads are large. Along the head to the postpetiole are covered by coarse punctures. The pronotum and mesonotum are separated with a groove. The petiole has arched nodes on their upper surfaces. The metanotum has 1 pair of small spines. The gaster is slender with white hairs (Figure 82).

Tribe Pheidologetonini

Genus *Pheidologeton* Mayr, 1862

Genus *Pheidologeton* is found in Africa, India, Indonesia and Australia (Shattuck, 1999). Only one species, *Pheidologeton diversus* in tribe Pheidologetonini was discovered in this study. The length of workers is about 5 mm. Mandibles have 5 or 6 teeth. The propodeum is lower than the pronotum and the forward section of the mesonotum. The pronotum and mesonotum are separated by a groove. The subpetiolar process is absent while the subpostpetiolar process is often present but small. This genus is similar to *Pheidole* with 11-segmented antennae and 2-segmented club are their main characteristics.

***Pheidologeton diversus* (Jerdon, 1851)**

The body length is approximately 2.5 mm with brown to red-brown body color. The mandibles have 5 teeth. The antennal scapes are shorter than posterior margin of head which is slightly convex. The compound eyes are small on the midline of the sides of the head. The promesonotum is strongly convex while the dorsum of propodeum is slightly convex. The metanotum has a groove. The propodeum have a pair of spines with acute apices (Figure 83).

Tribe Solenopsidini

Genus *Monomorium* Mayr, 1855

Monomorium is an ecologically diverse genus of ants found worldwide (Bolton, 1997). Only one species, *Monomorium destructor* in tribe Solenopsidini was found in this study. Their mandibles have 3-5 teeth (mostly 4). The compound eyes vary in size. The antennal segment varies from 10-12 segments, and the club has 3 segments. The front margin of the clypeus is more or less pronounced, with a single median hair. The upper surface of the head is smooth and lacks of grooves or depressions for the antennal scapes. Pronotum and mesonotum are fused to a single segment. The propodeal spines are absent. The petiole and the postpetiole are distinct, arched nodes on their upper surfaces.

***Monomorium destructor* (Jerdon, 1851)**

The length of a worker is about 3.5 mm. Their body is brown to red-brown from head to postpetiole while the gaster is black-brown. The mandibles have 4 teeth. The compound eyes are large and located on the midline of the sides of the head. The metanotal groove is present. The ventral outline of the petiole is less convex than in other species. The postpetiole is equal to its width (Figure 84).

Genus *Solenopsis* Wesrwood, 1840

Solenopsis geminata in tribe Solenopsidini are found worldwide (Bolton, 1997). They were recorded from our study. The compound eyes are small to medium in size. The antennae have 10 segments and the apical antenna has a 2 segmented club. Mandibles have 4 or 5 teeth. The clypeus margin above the mandibles has a single elongated hair. The clypeus has a pair of longitudinal carinae. The propodeal dorsum is convex and without spines. The petiolar node is higher than the postpetiolar node. A subpetiolar process is present.

***Solenopsis geminata* (Fabricius,1804)**

Major workers are used for species identification. Their body length is about 5 mm, and red-brown in color. The head is square shaped and the mandibles are very strong. The posterior margin of the head is convex. Compound eyes and ocelli are present. The length of the antennal club is longer than that of the third to ninth antennal segments combined. The legs, mesosoma and gaster have erect hairs. The

petiolar node is an inverted-V-shaped crest but the postpetiolar node is an inverted-U-shaped crest. (Figure 85).

Tribe Tetramoriini

Genus *Rhoptromyrmex*

Rhoptromyrmex are found in tropical areas of Africa, India, Indonesia, New Guinea and Australia (Shattuck, 1999). Only one species, *Rhoptromyrmex wroughtoni* in tribe Tetramoriini was discovered in this study. Although Genus *Rhoptromyrmex* is similar to *Rhopalomastix*, the ridge-like structure of the clypeus and the projection on the tip of the sting of *Rhoptromyrmex* are the main characteristics that differentiate them from *Rhopalomastix*. The clypeus margin is strongly arched and projected forward over the mandibles. The lower surface of the petiole is narrowed into a keel-like ridge. The propodeum near the insertion of the petiole is rounded flanges. The tip of the sting is triangular.

***Rhoptromyrmex wroughtoni* Forel, 1902**

The worker's length is about 2.5 mm. From the head to postpetiole is red-black while the gaster is darker than other segments. Moreover, the legs are red-brown. Their bodies are covered with hairs. The length of the mesosoma is longer than that of the gaster. The compound eyes are small and are above the midline of the sides of the head. The mesosoma are covered by coarse punctures. The mesosomal and petiolar spines are absent but the petiole has arched nodes on their upper surfaces (Figure 86).

Genus *Tetramorium* (Mayr, 1855)

Tetramorium in tribe Tetramoriini is found worldwide (Bolton, 1997). Only one species, *Tetramorium flavipes* was recorded from this study. The length of workers is less than 4 mm. The compound eyes are more or less developed, and situated on the midline of the head. The antennae have 11 or 12 segments and 3 apical segments form a club. The area of the clypeus beneath the antennal sockets is raised into a sharp-edged ridge. The front margin of the clypeus is weakly convex or flat. The lower surface of the petiole is rounded. The propodeal spines are variously developed, ranging from small to elongate spiniform. The petiolar node is generally distinct.

***Tetramorium flavipes* Emery, 1893**

The length of the workers is about 3.5 mm. Head to postpetiole are brown to red-brown and covered with coarse punctures. The gaster is dark brown to black. The antennae have 12 segments and the apical 3 segments form a club. The anterior margin of clypeus is concave. The propodeal spines have 1 pair while the petiolar node lacks spines. The petiole and postpetiole are arched nodes on their upper surfaces. The gaster is very smooth and covered with hairs (Figure 87).

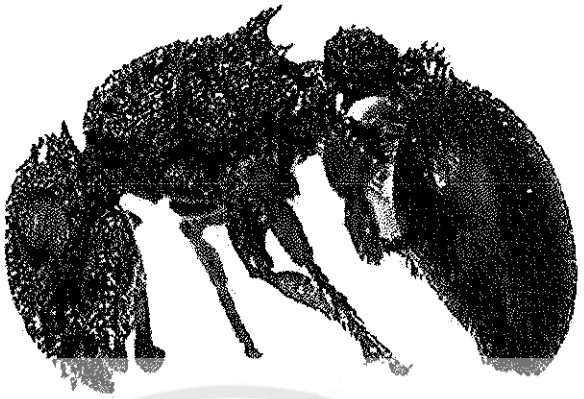


Figure 74 A worker of *Cataulacus granulatus* (Latreille, 1802).

Figure 75 A worker of *Crematogaster coriaria* Mayr, 1872.

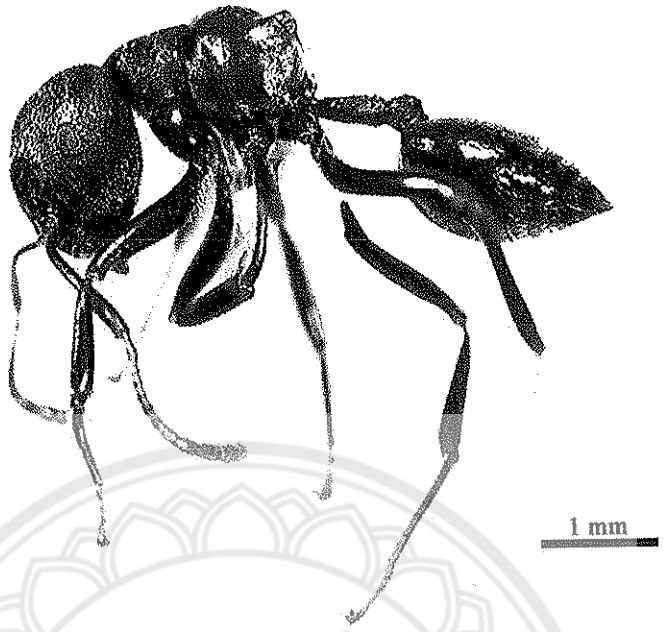


Figure 76 A worker of *Crematogaster difformis* F. Smith, 1857.

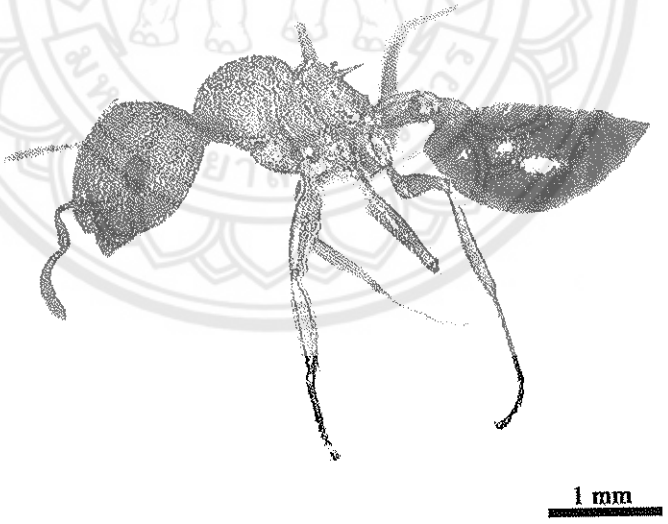


Figure 77 A worker of *Crematogaster rogenhoferi* Mayr, 1879.

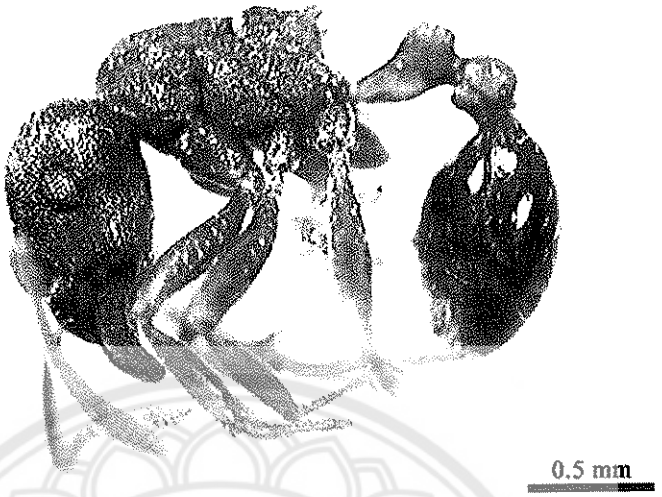


Figure 78 A worker of *Cardiocondyla wroughtonii* (Forel, 1890).

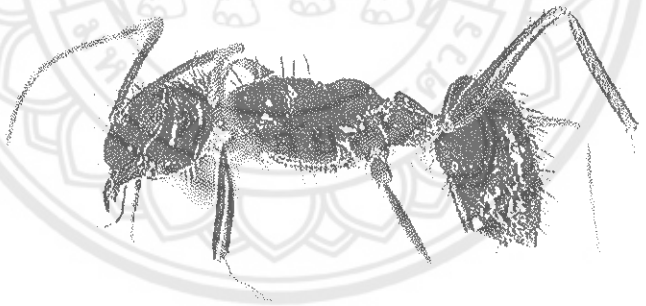


Figure 79 A worker of *Rhopalomastix janeti* Donisthorpe, 1936.

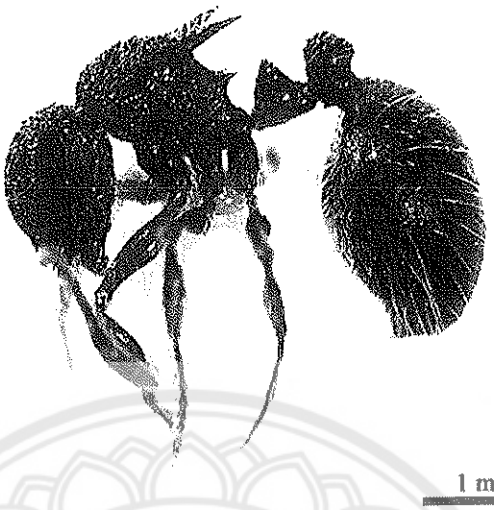


Figure 80 A worker of *Meranoplus bicolor* (Guerin-Meneville, 1844).

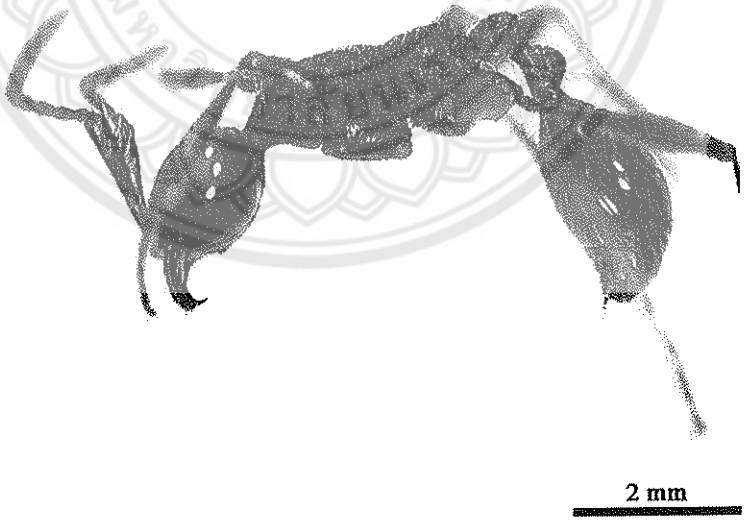


Figure 81 A worker of *Pristomyrmex punctatus* Smith, 1860.

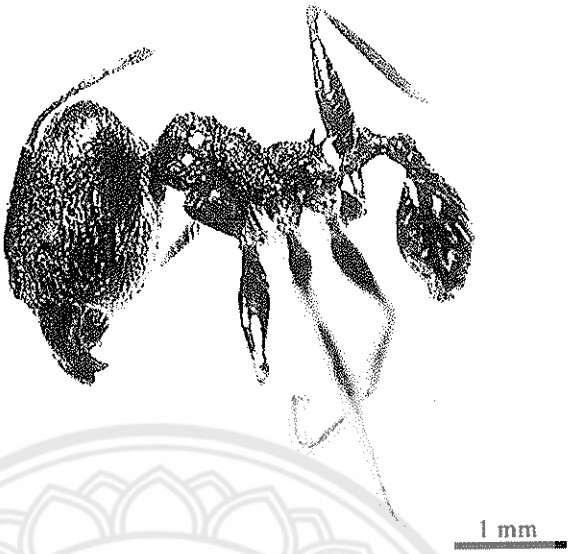


Figure 82 A major of *Pheidole plagiaria* F. Smith, 1860.

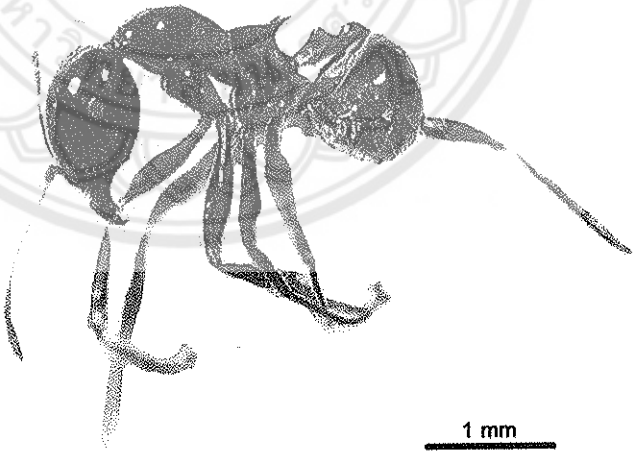


Figure 83 A worker of *Pheidologeton diversus* (Jerdon, 1851).

Figure 84 A worker of *Monomorium destructor* (Jerdon, 1851).

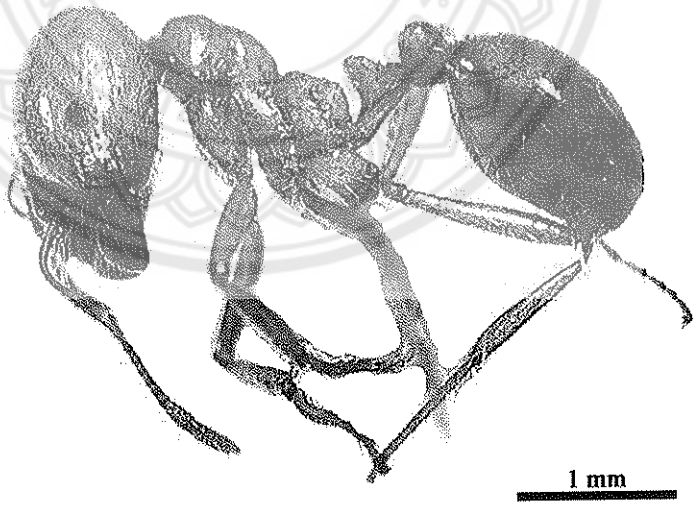


Figure 85 A worker of *Solenopsis geminata* (Fabricius, 1804).

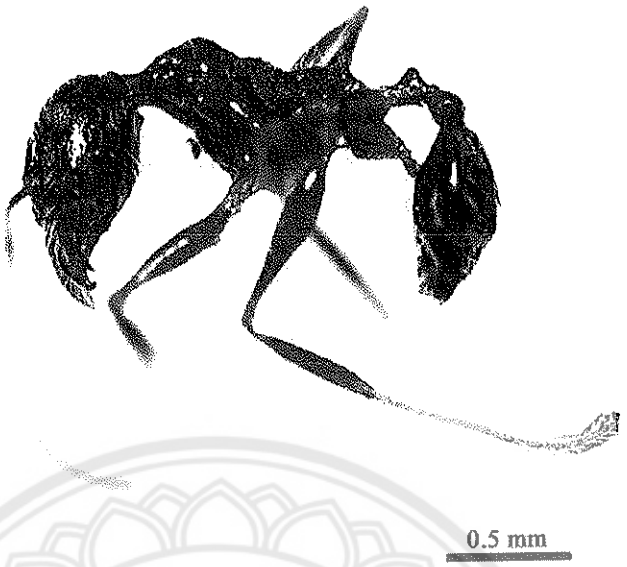


Figure 86 A worker of *Rhoptromyrmex wroughtoni* Forel, 1902.

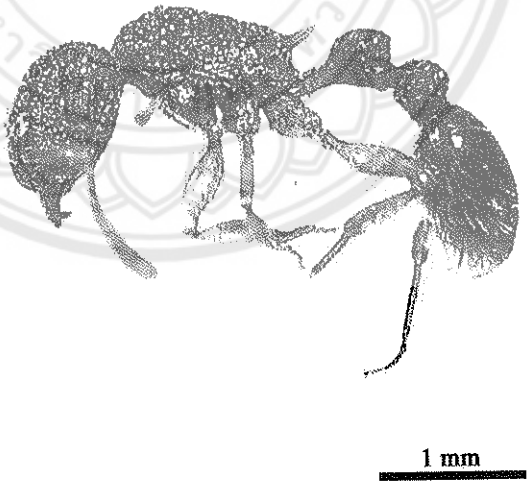


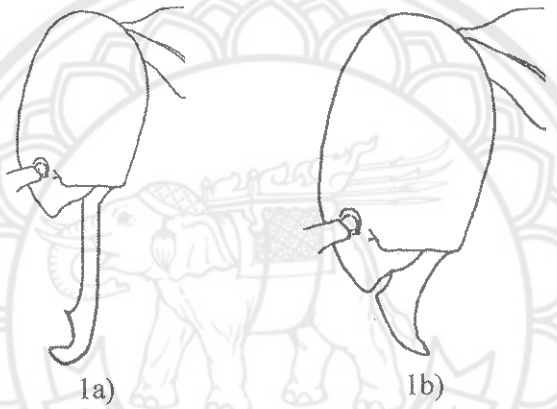
Figure 87 A worker of *Tetramorium flavipes* Emery, 1893.

Subfamily Ponerinae

These ants are abundant in the Pantropical region (Hölldobler and Wilson, 1990). From our study, 7 genera in 4 tribes: Ectatommini, Leptogenyini, Odontomachini and Ponerini were identified. The ponerine workers are generally elongated. The petiole has 1 segment which is usually large and lacks an anterior peduncle. The pygidium is rounded shape and lacks a row of spines or teeth on this segment. Tibial apices have pectinate spurs. The sting is present at gastral apex.

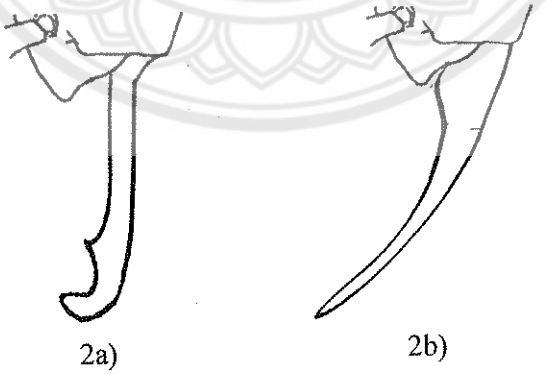
Key to the Species of Ponerinae found in northern Thailand
Modified from Bolton, 1997; Shattuck, 1999.

1. a) Mandibles longer than half of head ..... (2).
   b) Mandibles shorter than half of head ..... (4).



1a) 1b)

2(1a). a) Mandibles straight or triangle ..... *Odontomachus* (3).
   b) Mandibles forward curve ..... *Harpegnathos*
   - Hind tibia with two spurs, 1 large and 1 small ..... *H. venator*



2a) 2b)

3(2a). a) A single of petiolar spine ..... *O. rixosus*
   b) A pair of petiolar spine ..... *O. simillimus*

3a) 3b)

4(1b). a) Pronotum and mesonotum separate ..... (5).

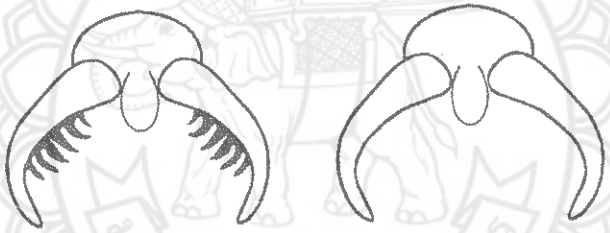
b) Pronotum and mesonotum fuse ..... *Gnamptogenys*

- Mesosomal and petiolar spines absent ..... *G. bicolor*

4a) 4b)

5(4a). a) Claws of hind legs with comb ..... *Leptogenys* (6).

b) Claws of hind legs with simple ..... (7).



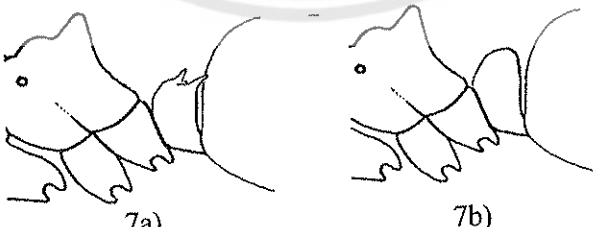
5a) 5b)

6(5a). a) Black body ..... *L. diminuta*

b) Red-black body ..... *L. kitteli*

7(5b). a) Petiolar spines present ..... *Diacamma* (8).

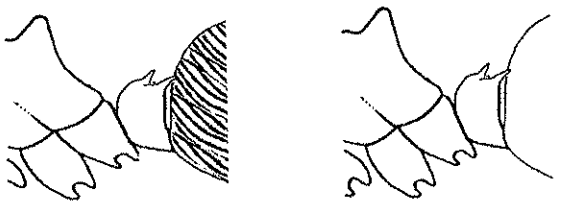
b) Petiolar spines absent ..... (9).



7a) 7b)

8(7a). a) Longitudinal line on anterior portion of 1st gastral segment present ..... *D. vargens*

b) Longitudinal line on anterior portion of 1st gastral segment absent ..... *D. sculpturata*



8a) 8b)

9(7b). a) Lateral surface of mesosoma with longitudinal line ..... *Odontoponera*

- Petiole acute ..... *O. denticulata*

b) Lateral surface of mesosoma without longitudinal line ..... *Pachycondyla* (10).

9a) 9b)

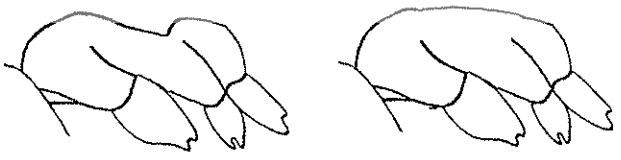
10(9b). a) Petiolar node connected to 1st gastral segment ..... *P. rufipes*

b) Petiolar node not connected to 1st gastral segment ..... (11).

10a) 10b)

11(10b). a) Metanotal groove present ..... (12).

b) Metanotal groove absent or slightly ..... *P. astuta*



11a) 11b)

11(10b). a) Red legs ..... *P. luttipes*

b) Black legs ..... *P. chinensis*

Tribe Ectatommini

Genus *Gnamptogenys* Roger, 1863

Gnamptogenys are found in America, Burma, Indonesia and Australia (Shattuck, 1999). Only one species, *Gnamptogenys bicolor* in tribe Ectatommini was reported in this study. Their head is elongate with the presence of compound eyes and ocelli. The antenna is filiform, and lacks a club. The propleura are separated from other segments while the pronotum is fused to the mesonotum. The promesonotal suture varies from present to absent. The anterior frontal lobe and the antennal socket are separated by rounded plate of the clypeus. Their coxa of the hind leg has a spine on its upper surface. The petiolar node is mostly a convex plate. The subpetiolar process varies in shape.

***Gnamptogenys bicolor* (Emery, 1889)**

The length of workers is about 4.5 mm. The head and the first gaster segment are red-brown to black while the mesosoma and petiole are bright red-brown. Their antennae have 12 segments. The occipital lobes are prominent. The compound eyes are situated on the posterior half of the head. The head to first gaster segment were covered with coarse punctures. The mesosomal and petiolar spines are present. The petiole has arched nodes on their upper surfaces. The metacoxal tooth is slender and straight. The gaster is covered with hairs, except the first gaster segment (Figure 88).

Tribe Leptogenyini

Genus *Leptogenys* Roger, 1861

Leptogenys are found in tropical regions of the world (Shattuck, 1999). Their body is long and slender. The body length is less than 15 mm. The clypeal margin is strongly angular. The antennal scapes are long. The compound eyes are well developed. Mandibles are variable in shape. Mid and hind tibiae have a pectinate spur. The claws on the hind legs have a series of small teeth (comb-like). Two species, *Leptogenys diminuta* and *Leptogenys kitteli* in tribe Leptogenyini were found from this study.

***Leptogenys diminuta* (F. Smith, 1857)**

The total body length of workers is approximately 8 mm. Their body is red-black to black. Head to mesosoma is slender. The anterior margin of the clypeus is a triangular shape. The compound eyes are large and situated on the midline of the head.

The pronotum is convex. The mesonotum has a groove. The petiole has a convex dorsal outline. The legs have small teeth on tarsal claws (Figure 89).

***Leptogenys kitteli* (Mayr, 1870)**

The anterior margin of clypeus is triangular. The compound eyes are large and situated above the midline of the head.. The mandible and mesosoma are elongated while the pronotum is convex. The mesonotal groove is distinct. This species is similar to *L. diminuta* in shape but *L. kitteli* are bright red in body color (Figure 90).

Tribe Odontomachini

Genus *Odontomachus* Latreille, 1804

Odontomachus is widespread in tropical and subtropical regions (Shattuck, 1999). Two species, *Odontomachus rixosus* and *Odontomachus simillimus* in tribe Odontomachini were found in this study. Their legs are long, and have pectinate spurs at the tibial apices. The head margin has a groove. The mandibles have 1-3 teeth near the tip. The antennae have 12 segments. The compound eyes are present, situated above on the midline of head. The petiole has a single spine and lacks an anterior peduncle. Their sting is present.

***Odontomachus rixosus* F. Smith, 1857**

The total length of workers is 1 cm on average. Their body is dark brown to black-brown while the legs are bright brown. The length of mandible is equal to head. Their scape is longer than the mandible and head. The truncate tooth of the apical mandibular dentition is short. A mesosomal groove is present on the mesonotum. The petiole is an inverted-V-shaped crest with a single spine. The gaster is smooth (Figure 91).

***Odontomachus simillimus* F. Smith, 1858**

The length of workers is about 6 mm. Their body is red-black. Their petiolar spines are short. The head to mesosoma were covered with longitudinal lines. The petiole has a pair of spines. The gaster is smooth and covered with erect hairs. The petiole is an inverted-V-shaped crest (Figure 92).

Tribe Ponerini

Genus *Diacamma* Mayr, 1862

This genus is found worldwide (Shattuck, 1999). From our study, 2 species in tribe Ponerini have been identified. Their bodies are large and are black to dark gray in

color. The head is an oval shape. The anterior clypeal margin is triangularly produced. The compound eyes are large and distinct, situated on the midline of the head. All of them have 12-segmented antennae which are filiform without a club. The mesosoma have pocket-like pits on each plate. The promesonotal suture is present. The petiole is large and usually has spines. The head, mesosoma and petiole have longitudinal lines.

***Diacamma sculpturata* (F. Smith, 1859)**

This species is a large ponerine ant. The length of the workers is about 1 cm. Their body is black. The gaster is light brown and is covered with erect hairs. The mandible and femur are red-brown. There is a pair of petiolar spines in a posterodorsal direction. The head to petiole are covered with longitudinal lines (Figure 93).

***Diacamma vargens* (F. Smith, 1860)**

The total length of workers is 8 mm in average. This species is similar to *D. sculpturata* in body color and shape. To differentiate *D. sculpturata* from *D. vargens*, longitudinal lines on the first gastral segment are remarked in *D. vargen* (Figure 94).

Genus *Harpegnathos* Jerdon, 1851

Harpegnathos in tribe Ponerini is found in south and southeast Asia (Bolton, 1997). Only one species, *Harpegnathos venator* was reported in this study. The compound eye and ocelli are present. The frontal lobes are blunt triangles. The mandible is a forcep-like shape. The mandibular base lacks small pit. The hind tibia has 2 spurs: 1 large and 1 small. The pretarsal claws have 1 or more teeth.

***Harpegnathos venator* (F. Smith, 1858)**

The length of the worker is 1 cm in average. Their body and abdomen is red-black to black while the mandibles, legs and antennae are red-brown to dark brown. The mandibles are long and forcep-like shape. Their antennae have 12 segments, and the club has 3 segments. The compound eyes are very large, and situated on the midline of the head. The head to petiole is covered with coarse punctures and erect hairs (Figure 95).

***Odontoponera* Mayr, 1862**

Odontoponera in tribe Ponerini is found in Asia and New Guinea (Bolton, 1997). Only one species, *Odontoponera denticulata* was reported in this study. The mandibles have 5 large teeth. The antennal sockets are behind the clypeal margin. The

mesosoma tagma lacks a pocket-like excavation above the mesopleuron. The petiolar spines are absent, but in some species, a node has tridentate to multidentate.

***Odontoponera denticulata* (F. Smith, 1858)**

The worker length is about 7 mm. Their bodies are brown-black while antennae, mandibles and legs are red-brown. The gaster is smooth. The compound eyes are small and situated on the midline of the head. The petiole is an inverted-V-shaped crest. The lateral surface of head to mesosoma has a longitudinal line while gaster is smooth (Figure 96).

Genus *Pachycondyla* F. Smith, 1858

Pachycondyla is found worldwide in the tropics and subtropics (Shattuck, 1999). Four species, *P. astuta*, *P. chinensis*, *P. luteipes* and *P. rufipes* in tribe Ponerini were recorded in this study. Their compound eyes are present. The mandibles are a triangular shape. Antennal insertions are covered with the frontal lobe. The clypeus extends across the entire width of the head. The frontal lobes and antennal sockets are well developed behind the front margin. The outer margin of the mid tarsus is simple without a distinct setae. The claws of tarsus are simple.

***Pachycondyla astuta* F. Smith, 1858**

The worker length is approximately 1.2 cm. Their bodies are black while legs and the first to second gasteral segments are red-brown. The body is covered with erect hairs. The compound eyes are small and situated on the midline of the head. The head to petiole have coarser punctures. The petiolar node is without a spine. The tibiae of the hind legs have 2 spurs: 1 large (comb-like) and 1 small (simple) (Figure 97).

***Pachycondyla chinensis* (Emery, 1895)**

The length of *Pachycondyla chinensis* workers is 4 mm in average. Their body is black while the mandibles and legs are light brown. The compound eyes are large, situated on the midline of the head. The propodeal surface is smoother than petiole and gaster. Although this species is similar to *P. luteipes*, the antennal scape of *P. chinensis* is longer than those in *P. luteipes* (Figure 98).

***Pachycondyla luteipes* (Mayr, 1862)**

The worker's length is about 5 mm. Their body is reddish black while the legs are reddish brown. Although this species is similar to *Pachycondyla chinensis*, *Pachycondyla luteipes* have relatively short antennal scapes which exceed the

posterior margin of the head by less than the length of the second antennal segment. Their propodeum is unsculptured, smooth and shining (Figure 99).

***Pachycondyla rufipes* (Jerdon, 1851)**

Their major worker length is about 1.2 cm. The body is reddish black to black but the legs are red-brown. This species is stronger and bigger than other species in the genus *Pachycondyla*. Their bodies are covered with coarse punctures. The petiolar node is wide and connects to gaster. Petiole is an inverted-V-shaped crest. The gaster is very smooth with erect hairs (Figure 100).

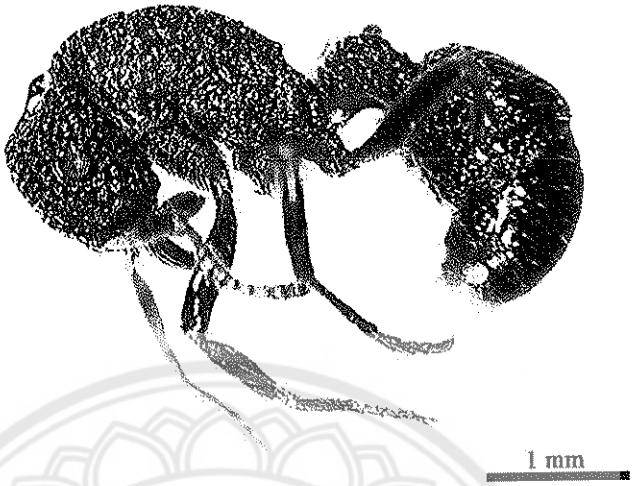


Figure 88 A worker of *Gnamptogenys bicolor* (Emery, 1889).

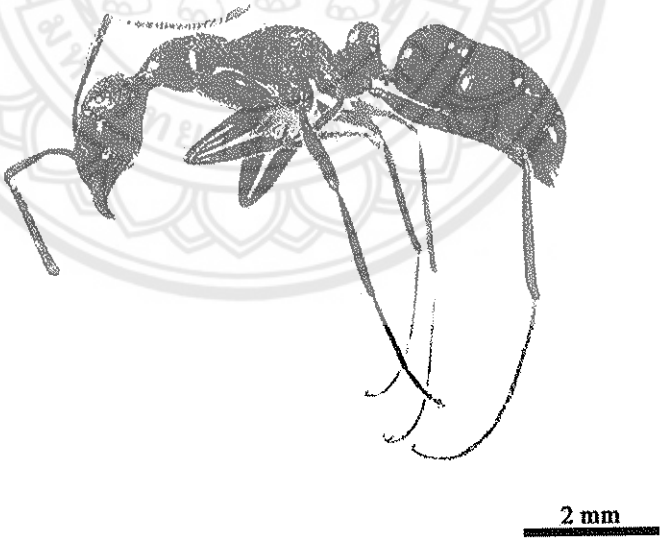


Figure 89 A worker of *Leptogenys diminuta* (F. Smith, 1857).

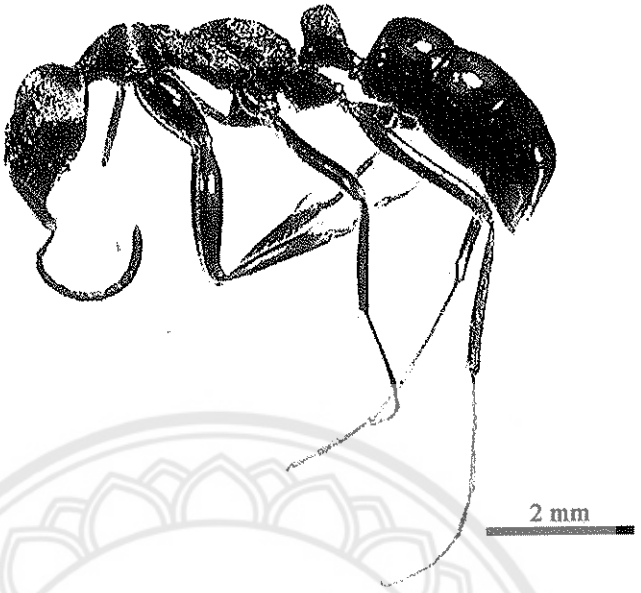


Figure 90 A worker of *Leptogenys kitteli* (Mayr, 1870).

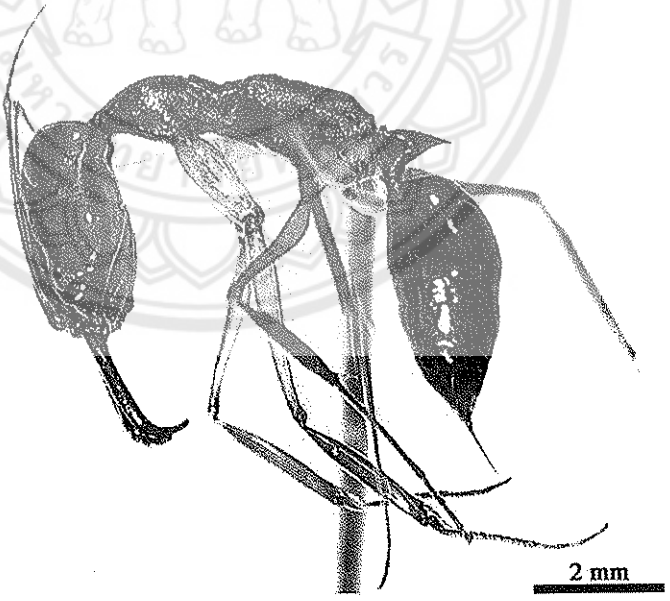


Figure 91 A worker of *Odontomachus rixosus* F. Smith, 1857.

Figure 92 A worker of *Odontomachus simillimus* F. Smith, 1858.

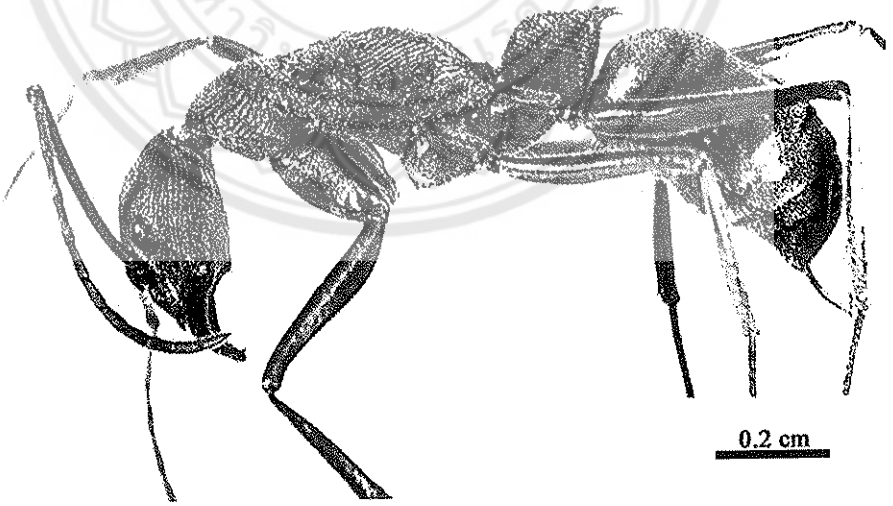


Figure 93 A worker of *Diacamma sculpturata* (F. Smith, 1859).

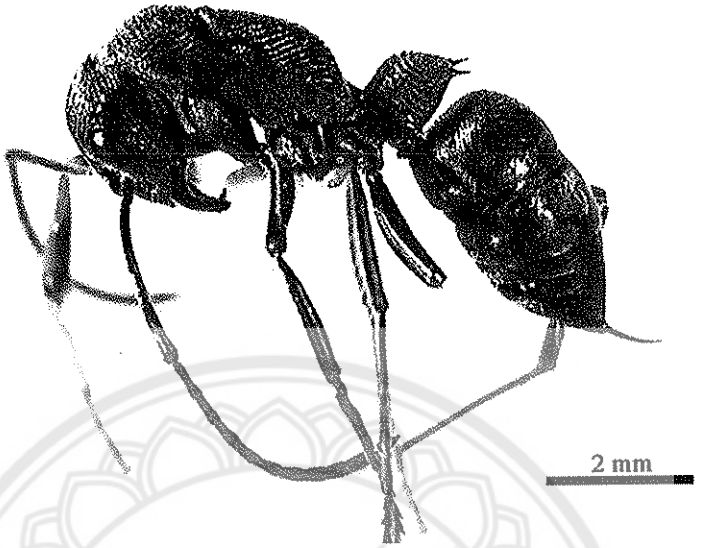


Figure 94 A worker of *Diacamma vargens* (F. Smith, 1860).

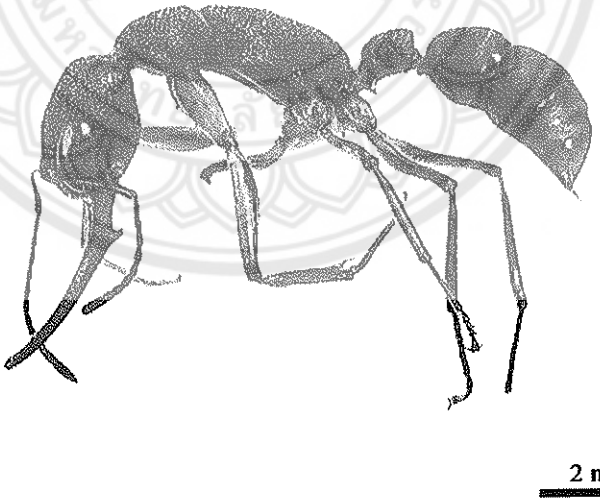


Figure 95 A worker of *Harpegnathos venator* (F. Smith, 1858).

Figure 96 A worker of *Odontoponera denticulata* (F. Smith, 1858).

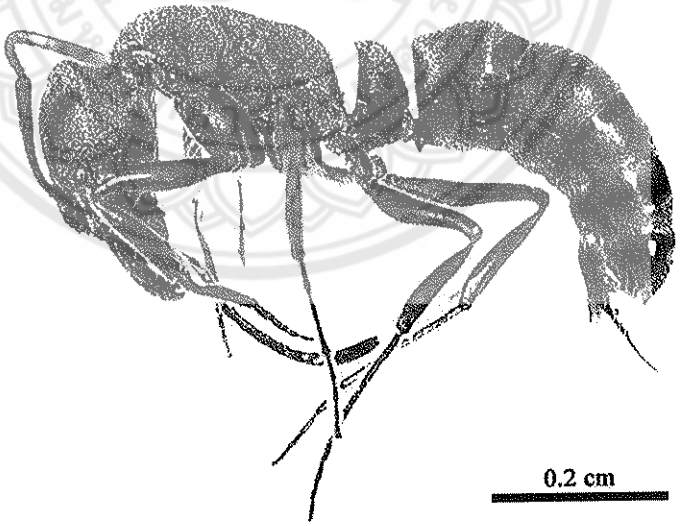


Figure 97 A worker of *Pachycondyla astuta* F. Smith, 1858.

Figure 98 A worker of *Pachycondyla chinensis* (Emery, 1895).

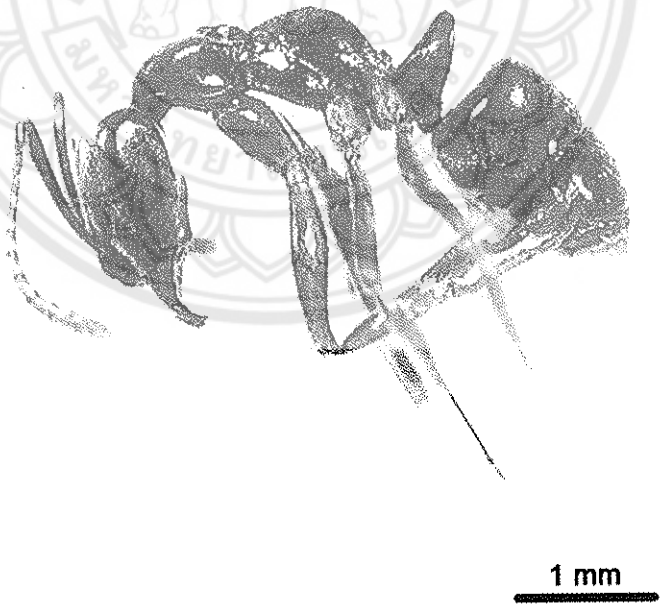


Figure 99 A worker of *Pachycondyla luteipes* (Mayr, 1862).

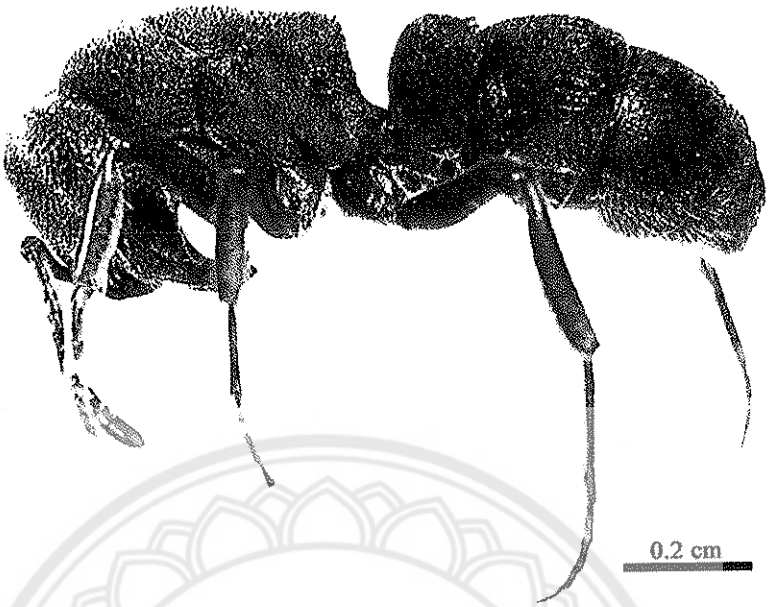


Figure 100 A worker of *Pachycondyla rufipes* (Jerdon, 1851).

Subfamily Pseudomyrmecinae

This subfamily contains 3 genera which are found in tropical and subtropical regions (Shattuck, 1999). From our study, a single genus, *Tetraponera*, was recorded. This subfamily is slender in body shape. The compound eyes and ocelli are present. The antennae have 12 segments. The mesosoma is attached to the gaster by the petiole and postpetiole. The mandibles are triangular in shape and short. The pronotum is fused to the mesonotum. This subfamily is frequently confused with species in the subfamily Myrmicinae. To differentiate between Myrmicinae and Pseudomyrmecinae, the pronotum and mesonotum combined is remarkable in Pseudomyrmecinae.

Key to the species of Pseudomyrmecinae found in northern Thailand

Modified from Bolton, 1997; Shattuck, 1999.

1.	a)	Thorax red	*T. rufonigra*
	b)	Thorax black	2.
2(1b).	a)	Mesonotum with slope	*T. allaborans*
	b)	Mesonotum without slope	*T. attenuata*

2a) 2b)

Tribe Pseudomyrmecini

Genus *Tetraponera* F. Smith, 1852

This genus is found in Africa, southeast Asia, New Guinea and Australia (Shattuck, 1999). Three species in tribe Pseudomyrmecini were found in our study. Their elongate and slender body are distinguishing characteristics of these ants. The anterior clypeus is raised. The petiole and postpetiole are rounded in shape.

***Tetraponera allaborans* (Walker, 1859)**

Their bodies are about 4 mm. The body is slender, and red-black color. The mandibles have 5 teeth. The anterior margin of clypeus has a pair of teeth. The propodeum is higher than the rest of the mesosoma. Mesosomal spines are absent. (Figure 101).

***Tetraponera attenuata* F. Smith, 1877**

A total length of female is approximately 8 mm. Their bodies are slender, and black. The mandibles have 5 teeth. Anterior margin of clypeus has a pair of teeth. Propodeum is higher than the rest of mesosoma. Mesosomal spines are absent. Although this species is similar to *T. allaborans*, mesosomal spine of *T. attenuata* is longer than that of them (Figure 102).

***Tetraponera rufonigra* (Jerdon, 1851)**

Their body is slender and long with the total length of the female about 12 mm. Their head and gaster are black while mesosoma to postpetiole is orange-brown to red. The antennae and tibia to tarsus are marked with red color. The compound eyes are large and situated on the midline of the head. The mesosoma is covered with coarse punctures. (Figure 103).

Figure 101 A worker of *Tetraponera allaborans* (Walker, 1859).

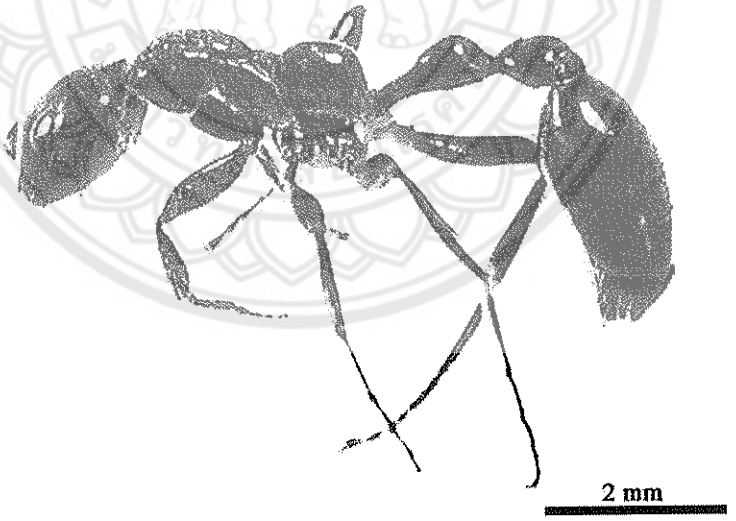


Figure 102 A worker of *Tetraponera attenuata* F. Smith, 1877.

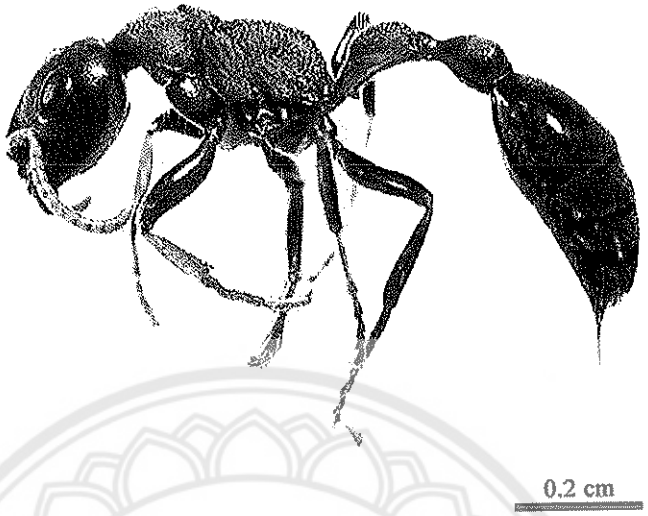


Figure 103 A worker of *Tetraponera rufonigra* (Jerdon, 1851).

Family Scoliidae

The Scoliidae is distributed in Palearctic, Neotropical, Mediterranean, and Australasian (Brothers and Finnamore, 1993; Gauld and Bolton, 1996; Tüzün, 2004). Their body is covered with hairs or a punctuate band on the metasoma. The fore and hind wings are uniformly transparent or metallic brown. The distal section of the wings has longitudinal wrinkles. The first marginal cell (M) is usually shorter than the first marginal and cubital (Cu) combined cell. The mesosternum and metasternum are separated by a straight transversed suture. In this study, we found 2 genera within 2 tribes; Campsomerini and Scoliini.

Key to the species of Scoliidae found in northern Thailand

Modified from Yamane, Ikudome and Terayama, 1999.

1. a) 2M-Cu vein of fore wing present ..... Campsomerini
   - 2nd tergite of abdomen with a pair of small yellow band ..... *Campsomeris* sp.

   b) 2M-Cu vein of fore wing absent ..... Scoliini
   - 2nd tergite of abdomen with a pair of large black band ..... *Scolia* sp.

1a) 1b)

Subfamily Scoliinae

Scoliidae is divided into 2 tribes: Campsomerini and Scoliini (Gupta, and Jonathan, 2003). Scoliids are variable in color patterns, body size and shape. Their body is usually black and marked with spots of yellow, white or red. Their wings are a metallic iridescence or uniformly transparent. Fore wings have 2 cubital cells (Cu). The abdomen has black bands with pairs of yellow or red markings that differ in pattern and shape.

Tribe Campsomerini

***Campsomeris* Guérin, 1838**

This genus is identified in tribe Campsomerini. They are represented in America, Mexico and the Old World (Tüzün, 2004). Their dorsum of mesosoma and metanotum are extensively exposed and covered with a few hairs. The antenna of the males is longer than the females: 13 segments in male, and 12 segments in female. A 3-pronged plate is found at the tip of the abdomen. The fore wings have 2 submarginal cells. The second recurrent vein of the fore wing is absent, but they have origin from cubital cell.

***Campsomeris* sp.**

The total length of a female is 1.8 cm in average. Their bodies are black with yellow-brown markings. All appendages on the head are black. The pronotum is yellow-brown. The width of mesonotum is equal to metanotum with black plate, and both are covered with yellow hairs. The posterior corner of the metanotum is yellow-brown. The posterior margin of the metasomal tergum is covered with hairs. The apical bands on the metasomal tergum are yellow and narrow, and curved in a "V" shape in the middle. The fore wing is brown. The tip of the abdomen has 3 spines (Figure 104).

Tribe Scoliini.

***Scolia* Fabricius, 1775**

The members of *Scolia* have a black body with yellow or red markings. The flagellate length of the female is shorter than that of the male and curved in a "C" shape. This genus is identified in tribe Scoliini. They are found around the world (Tüzün, 2004). They differ from Campsomerini as the upper portion of the mesopleuron is laterally produced, and the second recurrent vein of the fore wing is absent, but they do not have origin from cubital cell.

***Scolia* sp.**

The body length is about 2.5 cm. The head and third abdominal segment are red while other appendages are black. Their wings are metallic brown. The mesosoma to second abdominal segment are covered with black hairs. The third to the last abdominal segments are covered with red hairs. The second tergite of the abdomen has a pair of large black bands. The third tergite of the abdomen has a pair of large red band (Figure 105).

Figure 104 A female of *Campsomeris* sp.

Figure 105 A female of *Scolia* sp.

Family Vespidae

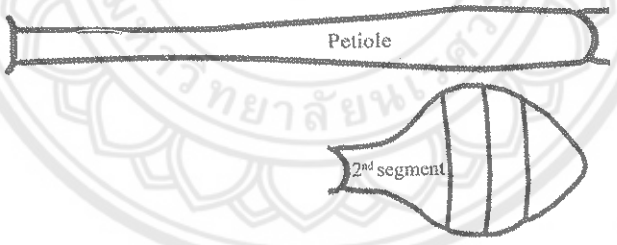
The distribution of Vespidae is in the Holarctic and Oriental Region (Archer, 1989). From our study, we reported 4 subfamilies: Eumeninae, Polistinae, Stenogastrinae and Vespinae. The inner margin of the compound eye has a notched area. The folded wings are parallel with their body at rest. The submarginal cells have 3 cells. The first discoidal cell of the fore wing is greater than half of the wing length. The length of jugal lobe in hind wing is shorter than that of the first marginal and cubital combined cell (1M + Cu). Pronotum reaches the tegulae. The posterior margin of pronotum is horseshoe-shaped or U-shape.

Key to the species of Vespidae found in northern Thailand

Modified from Vecht, 1966; Archer, 1989; Carpenter and Nguyen, 2003; Yamane, Ikudome and Terayama, 1999; Nguyen, 2006.

1. a) Fore wings not longitudinally folded at rest ..... Stenogastrinae
   - Anterior of 2nd abdominal segment in dorsal view nearly parallel sided ..... *Parischnogaster*
   - length twice longer than that of gaster ..... *Parischnogaster* sp.

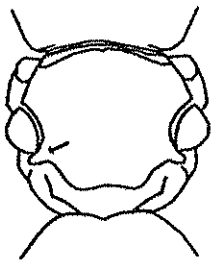
   b) Fore wings longitudinally folded at rest ..... (2).



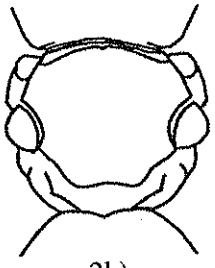
1a)

2(1b). a) Parategula present; bifid claws ..... Eumeninae (3).

b) Parategula absent; simple claws ..... (5).



2a)

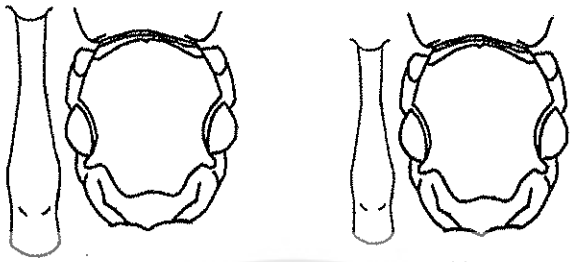


2b)

3(2a). a) Petiole much longer than mesosoma ..... *Phimenes*

- 1st abdomen with 3 pairs yellow markings ..... *P. flavopictus*

b) Petiole slightly longer than or equal that of mesosoma ..... *Delta* (4).



3a) 3b)

4(3b). a) 3rd to last metasomal tergum yellow ..... *D. pyriforme*

b) 3rd to last metasomal tergum reddish brown ..... *Delta* sp.

5(2b). a) Dorsal carina of hind coxa absent; jugal lobe of hind wing present ..... Polistinae (6).

b) Dorsal carina of hind coxa present; jugal lobe of hind wing absent ..... Vespinae (10).

5a) 5b)

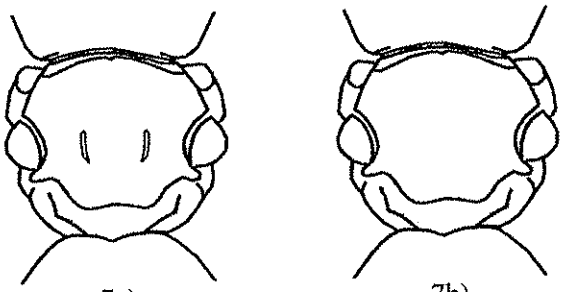
6(5a). a) Petiole funnel-shaped as petiole absent; dorsal propodeum narrow ..... Polistini, *Polistes* (7).

b) Petiole varies in shape; petiole long; propodeum with orifice often broadly rounded dorsally ..... Ropalidiini (8).

6a) 6b)

7(6a). a) Mesosoma with yellow markings and 2 vertical yellow lines ..... *P. olivaceus*

b) Mesosoma without yellow markings and without 2 vertical yellow lines ..... *Polites* sp.



7a) 7b)

8(6b). a) Petiolar near linear ..... *Polybioides*

- Posterior abdominal margins with yellow bands ..... *Polybioides* sp.

b) Petiole not parallel; mesepisternum without scrobal sulcus ..... *Ropalidia* (9).

8a) 8b)

9(8b). a) Posterior abdominal margins with yellow bands ..... *Ropalidia* sp.1

b) 2nd to last abdominal segments black, except the posterior margin of 2nd abdominal segment with yellow band ..... *Ropalidia* sp.2

10(5b). a) Ocelli very large; posterior ocelli closer to inner eye than to each other; vertex short; distance from the posterior ocellus to posterior margin of vertex nearly shorter than or equal that between posterior ocelli ..... *Provespa*

- Body slender and brownish; clypeus brownish .... *P. anomala*

b) Ocelli not large; posterior ocelli closer to each other than to eye; vertex long; distance from the posterior ocellus to posterior margin of vertex greater than distance between posterior ocelli and eye; normally brightly colored; stout body ..... *Vespa* (11).

10a) 10b)

11(10b). a) 1st and/or 2nd abdominal segments yellow bands ... 12.

b) 1st and 2nd abdominal segments orange-brown bands at the posterior margins ..... 14.

12(11a). a) 1st and 2nd abdominal segments yellow orange ..... *V. affinis*

b) 2nd abdominal segments yellow orange ..... 13.

13(12b). a) Mesoscutellum black ..... *V. tropica*

b) Mesoscutellum dark yellow to bright brown ..... *V. soror*

14(11b). a) 3rd abdominal segments dark orange with an irregular black marking in the middle ..... *V. velutina*

b) 3rd abdominal segments orange-brown bands at the posterior margins ..... *V. mandaria*

Subfamily Eumeninae

The subfamily Eumeninae is distributed in various zoogeographical regions; the Palearctic, Nearctic, Ethiopian, Oriental and Australian and Neotropical regions (Yamane, 1990; Carpenter and Garcete-Barrett, 2002; Carpenter and Nguyen, 2003). We reported 4 species in 3 genera in this study; *Delta*, *Rhynchium* and *Phimenes*. Their wings are longitudinally folded at rest. Most species are black or brown, and commonly marked with strikingly contrasting patterns of color: yellow, white, orange, or red. The clypēus is variable in shape: pointed, truncate or rounded in the males of some species. The acroglossal buttons are present on the apices of glossa and paraglossae. Their mandibles are often developed into a lobe or tooth. The pronotal lobe is separated from the tegula. The horizontal lobe projects from the posterolateral corner of the mesoscutum known, as the parategula is usually present. Fore wings have 3 submarginal cells. The hind coxae have a longitudinally dorsal carina. The claws are usually bifid.

Tribe -

Genus *Delta* Saussure, 1855

The genus is distributed in Southern Palearctic, Oriental, Australian, Ethiopia and Neotropical regions (Yamane, Ikudome and Terayama, 1999; Carpenter and Garcete-Barrett, 2002). We found 2 species of *Delta* in this study. The clypeal length is longer than the width. The mandible is very long but lack of mandibular teeth. The compound eyes have a notch. The mesosoma is short. The first metasomal segment (petiole) is very slender. The petiole is slightly longer than the mesosoma, but the posterior of the petiole is wide. The second metasomal segment is bell-shaped and posteriorly narrowed.

***Delta pyriforme* Fabricius, 1781**

The body length is approximately 2 cm in females. Their body is black with yellow and red-brown markings. Clypeus, pronotum and mesonotal apex are yellow. The metanotum and the first metasomal tergum are red-brown while the anterior, inferior and posterior petioles are black. The anterior half of the second metasomal tergum is red-brown but the posterior half is yellow. The third to the last metasomal tergum are yellow. The middle of the metasomal tergum has a small black spot (Figure 106).

***Delta* sp.**

The female body is about 2 cm in the total length. Their body is red-brown with yellow and black markings. The clypeus is yellow. The metanotum has a black line. The anterior petiole is black with red-brown markings. The second abdominal segments have black bands at the inferior and anterior part. The third to the last metasomal tergum are red-brown (Figure 107).

Tribe -

Genus *Phimenes* Giordani Soika, 1992

This species of genus *Phimenes* is distributed from tropical Asia to Oceania (Yamane, Ikudome and Terayama, 1999). Only one species, *Phimenes flavopictus* was recorded from this study area. Their second metasomal segment is bell-shaped. The anterior of the second metasomal segment is narrower than the posterior petiole. Even though this genus is very similar to the genus *Delta*, their petiole is linear and much longer than the mesosoma.

***Phimenes flavopictus* (Blanchard, 1841)**

This species is widely distributed in south and southeast Asia (Yamane, Ikudome and Terayama, 1999). Their body length is about 2.5 cm in females and the body color is bright yellow with black markings. The antennal scape is black and rather curved. The pronotum is yellow. The mesonotum have 2 vertical and 2 longitudinal yellow lines on the mesosoma. The tegula is yellow with black marking. The first abdominal targa has 3 pairs of yellow markings while the second to sixth abdominal targa have a pair of yellow markings (Figure 108).

Tribe -

Genus *Rhynchium* Spinola, 1806

This genus is widespread in Middle East and Africa (Yamane, Ikudome and Terayama, 1999). Only one species, *Rhynchium* sp. was recorded from this study area. The parastigma is longer than half of the stigma length. The tegula margin does not reach the parategula. The scutellum and posterior part of the mesoscutum are smooth and sparsely punctate.

***Rhynchium* sp.**

This species is similar to species of *Vaspa* but *Rhynchium* sp. has parategula and bifid claws. The female is about 1.6 cm in the total length. The body color is red-brown with black marking. The fore wings have 3 submarginal cells. The wings are bright brown and uniformly transparent. The clypeus is pyriforrn, moderately punctate, with the apex narrowly truncate. The ocellar region is a narrow longitudinal depression near to the outer side of each posterior. Posterior margin of the pronotum is U-shaped. The abdominal band is black and brown. Half of the anterior first and second metasomal segments is black (Figure 109).

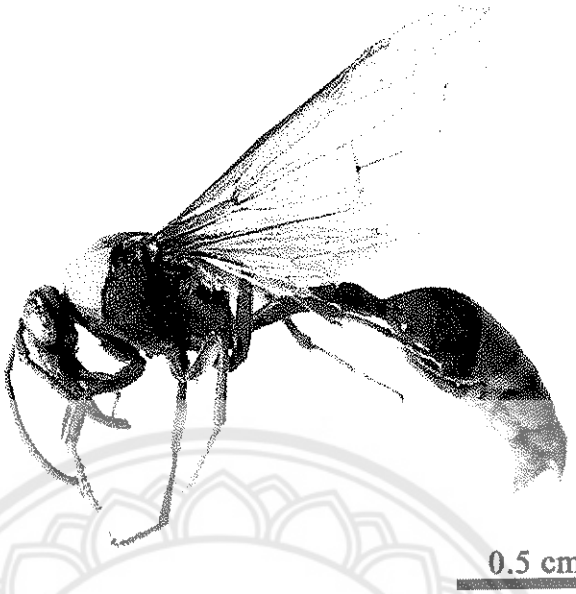


Figure 106 A female of *Delta pyriforme* Fabricius, 1781.

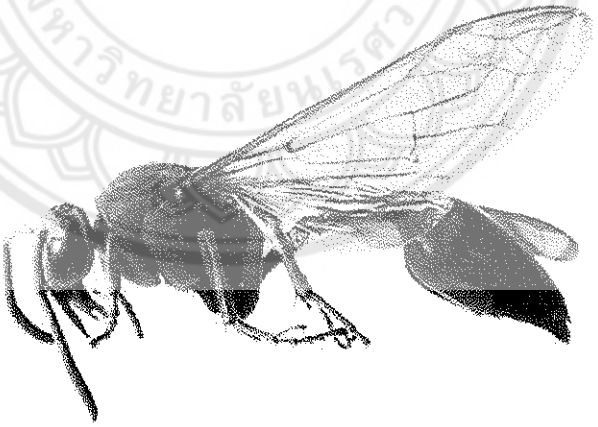


Figure 107 A female of *Delta* sp.

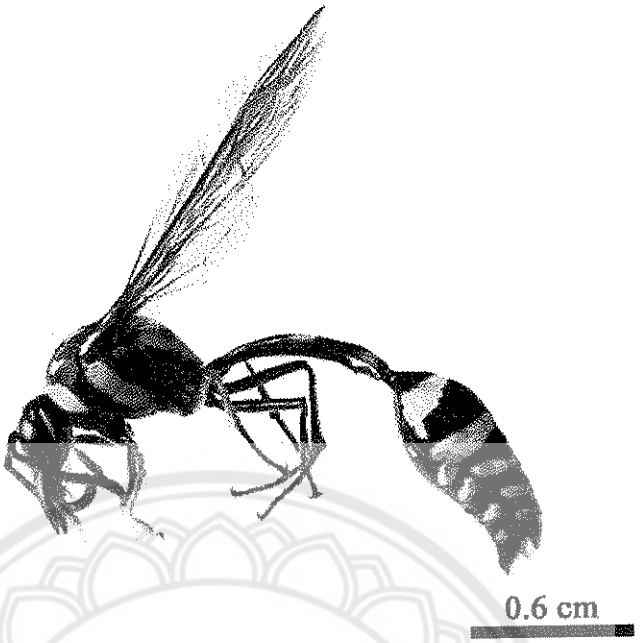


Figure 108 A female of *Phimenes flavopictus* (Blanchard, 1841).

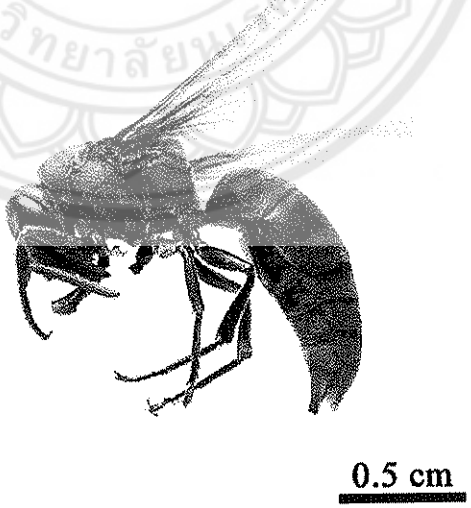


Figure 109 A female of *Rhynchium* sp.

Subfamily Polistinae

Polistinae (paper wasps) is the second largest subfamilies in the Vespidae. They are social wasps. Polistinae are distributed all over the world. The Brazilian Polistinae fauna is also recorded as having the largest number of this subfamily. The 2 tribes; Polistini (comprising only the cosmopolitan genus *Polistes*) and Ropalidiini (comprising all the Old World genera; *Ropalidia*, *Parapolybia* and *Polybioides*) were found in southeast Asia (Carpenter, 1993; Mancini et al., 2006). From our study, 4 genera, *Parapolybia*, *Polybioides*, *Polistes* and *Ropalidia* were recorded. This subfamily is similar to subfamily Vespinae in parategula and vertical lamella on the mesoscutum. Vespinae differs from Polistinae as the hind coxa of Polistinae lacks a dorsal carina. The hind wing has a jugal lobe. The metasoma is variable in shapes.

Tribe Polistini

Genus *Polistes* Latreille, 1802

The paper wasps, *Polistes* are classified in tribe Polistini of the Polistinae. Most of them are found in tropical or subtropical areas (Carpenter 1993; Mancini et al., 2006). From our study, we found 2 species, *Polistes olivaceus* and *Polistes* sp. in this genus. Their petiole is funnel-shaped in a dorsal view. The first metasomal segment is shorter than second metasomal segment. The dorsal propodeum is narrow. The posterior pronotum has a carina.

***Polistes olivaceus* (DeGeer, 1773)**

Polistes olivaceus is a native species from the Oriental region and Australia (Harris, 1979). Their bodies are approximately 2 cm in total length. Their bodies are almost brown with yellow markings. The mesosoma has 2 vertical yellow lines. This species is similar to *Parapolybia varia* in body color. To differentiate between *P. varia* from *P. olivaceus*, the 11-segmented antennae in the female and the linear petiole of *P. olivaceus* are distinctive (Figure 110).

***Polistes* sp.**

The female is about 1.5 cm in total length. Their head and mesosoma are red-brown while the abdomen is black with yellow marking on the first metasomal segment. The third to fourth metasomal margins have a yellow band. Their wings are bright brown and uniformly transparent. The apex of the fore wings has black spot.

The coxa of the hind legs has yellow marking. The lateral surface of the metanotum has longitudinal lines (Figure 111).

Tribe Ropalidiini

Genus *Parapolybia* de Saussure, 1854

The distribution area of *Parapolybia* extends from southeast Asia, Iran, Japan, the Philippine Islands and New Guinea (Vecht, 1966). We found only one species, *Parapolybia varia* from this area. The pronotum has a pretegular carina and mesepisternum. A scrobal sulcus is present. Both *Parapolybia* and *Ropalidia* have 12-segmented antennae in the female and carina on the pronotum. *Parapolybia* is identified by the petiole which is not linear.

***Parapolybia varia* (Fabricius, 1787)**

The lesser paper wasp, *Parapolybia varia* is approximately 1.7 cm in total length. Their bodies are mostly brown with yellow markings. The mesosoma has 2 vertical yellow lines. This species is similar to *Polistes olivaceus* in body color but *Parapolybia varia* is a slender bodied wasp with a long petiole (Figure 112).

Genus *Polybioides* du Buysson, 1913

Polybioides is classified in tribes Ropalidiini of Polistinae. They are found in the Oriental area, southeast Asia and Africa (Vecht, 1966). We found only one species, *Polybioides* sp. in our study. This genus differs from to *Ropalidia* and *Parapolybia* as *Polybioides* have 11-segmented antennae in the female, linear petiole and a pronotal carina.

***Polybioides* sp.**

The female is about 1.6 cm in total length. The body is brown-black with yellow markings. The width and length of their head are equal. The compound eyes and ocelli are black. Their occipital carina is complete and slightly curved. The clypeus is yellow and convex. The second metasomal segment is longer than other segments. The posterior margins of the abdominal segments have yellow bands. The legs are yellow with brown-black markings. Even though this species is similar to *Parapolybia varia* in body color, *Polybioides* sp. is easily identified as they have a petiole (Figure 113).

Genus *Ropalidia* Guérin-Méneville, 1831

Paper-wasps, *Ropalidia* are mainly distributed in tropical and subtropical areas and the Old World. A few species are distributed in Australia and South Africa. They are classified in tribes Ropalidiini of Polistinae (Kojima and Carpenter 1997; Carpenter and Nguyen, 2003; Saito and Kojima, 2005). From our result, 2 species in this genus were recorded. Their antennae have 12 segments in the female. A pronotal carina is present. Although *Ropalidia* is similar to *Parapolybia* in antennal segments and pronotal carina, we can clearify the genus *Ropalidia* with the pronotum that lacks a pretegular carina and the scrobal sulcus of mesepisternum.

***Ropalidia* sp.1**

Their female is approximately 1.7 cm in total length. The head, pronotum and mesonotum are red-brown. The width of the head is as wide as the length. The compound eyes and ocelli are black. Their occipital carina is complete, and slightly curved. The clypeus is convex and slightly wider than the length. The antennal scape is slightly curve. The mandible is stout. The propodeum has a furrow or depression. Their metasoma is black. The anterior part of the first metasomal segment is narrower than the posterior part. The second metasomal segment is wider than the other segments. The posterior margins of the first and second abdominal segments have yellow bands (Figure 114).

***Ropalidia* sp.2**

The total length of a female is 1 cm in average. The head is black while the gena is red-brown. The mesonotum are black, except the pronotum which is red-brown. The compound eyes and ocelli are brown-black. An occipital carina is present. The clypeus is convex and slightly wider than its length. The antennal scape has a curved shape. The mandible is stout. The propodeum has a furrow but is smaller than *Ropalidia* sp.1. The metasoma is black. The anterior part of the first metasomal segment longer than the posterior part which their anterior part has black band. The posterior part has a red band. The second metasomal segment is wider than the other segments. The second to last abdominal segments are black, except the second abdominal segment which has a yellow band at the posterior margin (Figure 115).

Subfamily Stenogastrinae

The subfamily Stenogastrinae is distributed in India, Indo-Malayan and New Guinean (Turillazzi, 1989). They are a group of social wasps and an endemic species in the Oriental Region (Carpenter and Starr, 2000). They are distinguished from other subfamilies by the pronotal lobe that is separated from the tegula. The wings do not fold longitudinally at rest. The clypeus projects ventrally. There are no acroglossal buttons. In our study, a single species, *Parischnogaster* sp. in the genus *Parischnogaster* was record.

Tribe Stenogastrini

Genus *Parischnogaster* von Schulthess, 1914

The genus in tribe Stenogastrini is distributed throughout southeast Asia (Carpenter, and Nguyen, 2003). The posterior margin of their hind wings is covered with short hairs. The vertex lacks the longitudinal groove. The anterior part of the second abdominal segments in dorsal view is nearly parallel in shape.

***Parischnogaster* sp.**

The female body is approximately 1.3 cm in the total length. Their body is dark brown with yellow markings. The compound eyes are large. The mandibles are yellow and have 3 teeth. The clypeus is bright brown to yellow and the apex of the clypeal margin has a small spot. The gena is narrower than the length of the second flagella segment. The antenna is club-shaped. The posterior pronotum and mesonotum are denser and deeper than in other areas. The propodeum are smoother than the pronotum and mesonotum. The petiole is twice as long as the length of the gaster. The legs are red-brown (Figure 116).

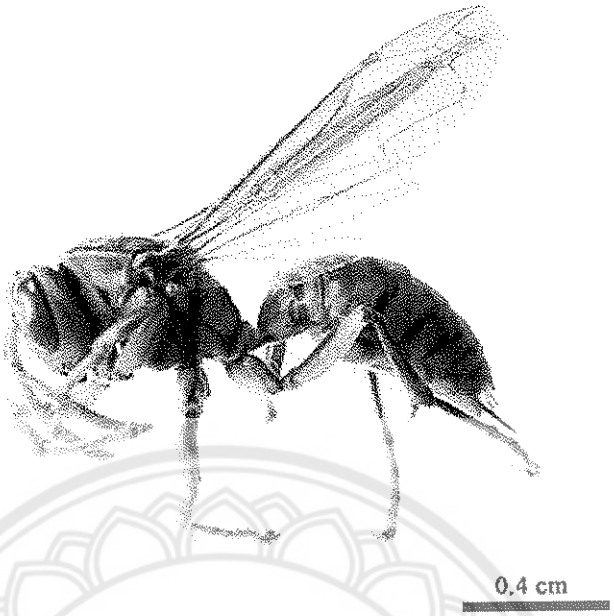


Figure 110 A female of *Polistes olivaceus* (DeGeer, 1773).

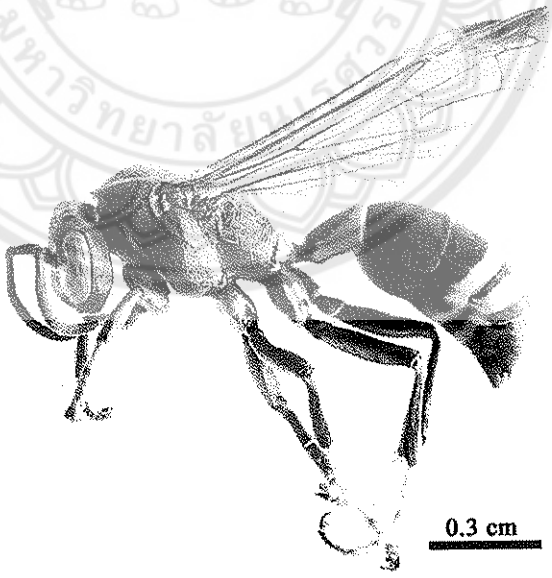


Figure 111 A female of *Polistes* sp.

Figure 112 A female of *Parapolybia varia* (Fabricius, 1787).

Figure 113 A female of *Polybioides* sp.

Figure 114 A female of *Ropalidia* sp.1.

Figure 115 A female of *Ropalidia* sp.2.

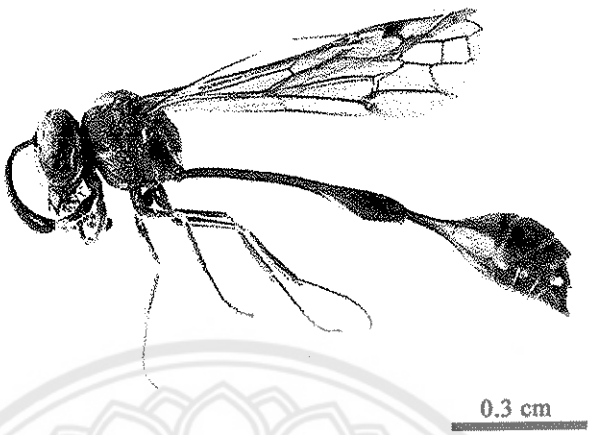


Figure 116 A female of *Parischnogaster* sp.

Subfamily Vespinae

Vespinae are found in southeast Asia (Archer, 1989). In this study, 2 genera; *Provespa* and *Vespa* were recorded. They lack the parategula. Mesoscutum have vertical lamella. This subfamily differs from subfamily Polistinae as their hind coxa has dorsal carina. The jugal lobe on hind wing is absent. The first metasomal segment does not form a petiole.

Tribe -

Genus *Provespa* Ashmead, 1903

They are widespread in Bhutan, Assam, southeast Asia, China, Borneo, and Sumatra (Archer, 1989). A single species, *Provespa anomala* was found in this study. Their ocelli are very large. The posterior ocelli close to the compound eyes. The distance between the lateral ocelli, and the distance between the lateral ocelli to the head margin are equal in length. Their vertex is short.

***Provespa anomala* (de Saussure, 1854)**

The female body is approximately 2 cm in total length. Their body is uniformly brown, except the clypeus is dark brown. The clypeal margin has truncated edges while the lateral angles are blunt. The mesoscutal length is longer than width. The width of the first gastral tergum is longer than its length (Figure 117).

Tribe -

Genus *Vespa* Linnaeus, 1758

The genus *Vespa* is commonly known as hornet. They are distributed in tropical Asia, European regions, North America, the Middle East and the Mediterranean region. There are 23 species recognized in this genus. (Archer, 1989; Carpenter and Nguyen, 2003). From our study, 5 species were found. They are identified with long vertex. The distance between the lateral ocelli to the occiput is longer than that of the lateral ocelli to compound eyes. Their pronotal carina is nearly complete. The head and mesosoma are marked with red spots.

***Vespa affinis* (Linnaeus, 1764)**

They are median *Vespa*. The total length of worker is 2 cm in average. Their head, clypeus and mesosoma are black. The antennae, compound eyes and ocelli are dark brown to black. The thorax is covered with coarse punctures. The pronotum and mesonotum are covered with erect hairs. The wings and tegulae are dark brown. They

are easily identified by a yellow-orange band on the first and second metasomal segment. The third to the last metasomal segment are black (Figure 118).

***Vespa mandarinia* Smith, 1852**

This species is the largest *Vespa* in this study. The total length is about 3.5 cm in workers. The head and antennae are brown to dark brown. The compound eyes are dark brown. The mesosoma is black while the mesoscutum is bright brownish with gold-colored. The scutellum has a deeply impressed line. The gaster is black. The posterior margins of each abdominal tergite have orange-brown bands. The sixth abdominal segment is orange-brown (Figure 119).

***Vespa soror* du Buysson, 1905**

The total length of worker's body is 3 cm in average. All head appendages are dark yellow to brown. The compound eyes are dark brown to black. The pronotum and mesonotum are covered with erect hairs. The wings and tegulae are dark brown. They are identified from other species in *Vespa* by dark yellow to brown on the mesoscutellum (Figure 120).

***Vespa tropica* (Linnaeus, 1758)**

The workers are medium size hornets with a total length of approximately 2.5 cm. The head, antennae and clypeus are dark brown-red. The third to last abdominal segment is black. Although this species is very similar to *Vespa affinis*, they are easily clearified from *Vespa affinis* by yellow orange band on the second abdominal segment (Figure 121).

***Vespa velutina* Lepeletier, 1836**

The total length of worker is about 2 cm. All head appendages are bright brown. Their compound eyes are dark brown. The abdomen is black while the first and second abdominal segments are dark brown. The posterior margin of the first and second abdominal segments is orange-brown band. The middles of the third to sixth gasteral segments are dark orange with black marking. The last gasteral segment is orange brown (Figure 122).

Figure 117 A worker of *Provespa anomala* (de Saussure, 1905).

Figure 118 A worker of *Vespa affinis* (Linnaeus, 1764).

1 cm

Figure 119 A worker of *Vespa mandarinia* Smith, 1852.

0.5 cm

Figure 120 A worker of *Vespa soror* du Buysson, 1905.

Figure 121 A worker of *Vespa tropica* (Linnaeus, 1758).

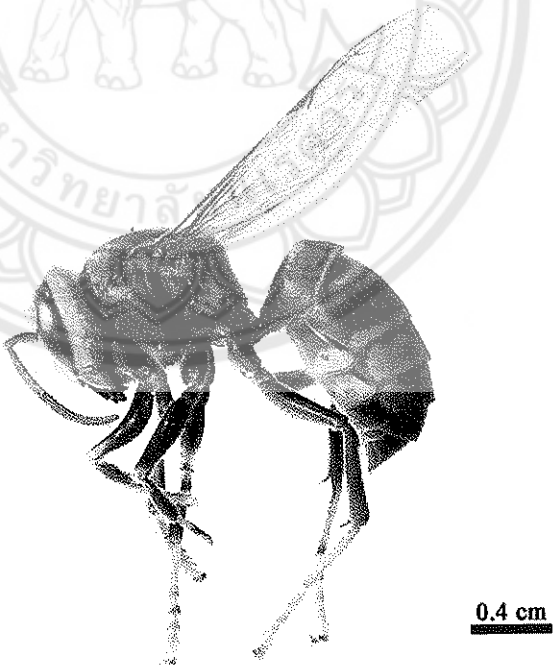


Figure 122 A worker of *Vespa velutina* Lepeletier, 1836.