

A PROVISIONAL IDENTIFICATION GUIDE TO  
**THE SOCIAL VESPIDS OF HONG KONG**  
( HYMENOPTERA : VESPIDAE )



Christophe Barthelemy

# Table of Content.

<b>1</b>	<b>INTRODUCTION.....</b>	<b>3</b>
<b>2</b>	<b>HOW TO USE THIS GUIDE .....</b>	<b>3</b>
<b>3</b>	<b>ACKNOWLEDGMENTS:.....</b>	<b>4</b>
<b>4</b>	<b>THE HONG KONG SPECIES OF SOCIAL VESPIDAE.....</b>	<b>5</b>
4.1	NATURAL HISTORY .....	5
4.1.1	Generalities .....	5
4.1.2	Diet.....	5
4.1.3	Development.....	5
4.1.4	Colony foundation and cycles.....	6
4.1.5	Nest architecture & construction materials .....	6
4.1.6	Colony social structure.....	7
4.1.7	Approaching active colonies .....	7
4.2	KEY TO SUB-FAMILIES OF VESPIDAE OF HONG KONG. ....	7
4.3	VESPINAE.....	8
4.3.1	General biology of the Vespinae:.....	8
4.3.2	Key to genera and species of Vespinae .....	10
4.3.3	Genus <i>Vespa</i> Linnaeus, 1758.....	13
	<i>Vespa affinis</i> (Linnaeus, 1764). ....	13
	<i>Vespa analis</i> Fabricius, 1775.....	14
	<i>Vespa bicolor</i> Fabricius, 1787.....	15
	<i>Vespa ducalis</i> Smith, 1852.....	15
	<i>Vespa soror</i> du Buysson, 1905.....	16
	<i>Vespa tropica</i> (Linnaeus, 1758). ....	17
	<i>Vespa velutina</i> Lepeletier, 1836.....	17
4.3.4	Genus <i>Vespula</i> Thomson, 1869.....	19
	<i>Vespula</i> sub-genus <i>Paravespula flaviceps</i> (Smith, 1870). ....	19
4.4	POLISTINAE .....	21
4.4.1	General biology of the Polistinae .....	21
4.4.2	Key to genera and species of Polistinae.....	23
4.4.3	Genus <i>Polistes</i> Latreille, 1802: .....	26
	<i>Polistes gigas</i> (Kirby, 1826). ....	27
	<i>Polistes olivaceus</i> (DeGeer, 1773). ....	27
	<i>Polistes rothneyi</i> Cameron, 1900.....	28
	<i>Polistes jokahamae</i> Radszkowski, 1887.....	29
	<i>Polistes japonicus</i> de Saussure, 1858.....	29
	<i>Polistes sagittarius</i> de Saussure, 1853.....	30
	<i>Polistes stigma</i> Fabricius, 1793.....	31
	<i>Polistes strigosus</i> Bequaert, 1940.....	31
4.4.4	Genus <i>Parapolybia</i> de Saussure, 1854.....	33
	<i>Parapolybia indica</i> (de Saussure, 1854). ....	33
	<i>Parapolybia nodosa</i> van der Vecht, 1966.....	34
	<i>Parapolybia varia</i> (Fabricius, 1787). ....	35
4.4.5	Genus <i>Ropalidia</i> Guérin-Méneville, 1831.....	36
	<i>Ropalidia fasciata</i> (Fabricius, 1804).....	36
	<i>Ropalidia hongkongensis</i> (de Saussure, 1854). ....	37
	<i>Ropalidia marginata</i> (Lepeletier, 1836).....	38
	<i>Ropalidia mathematica</i> (Smith, 1860).....	38
4.5	STENOGASTRINAE .....	40
4.5.1	General biology of the Stenogastrinae.....	40
4.5.2	Genus <i>Eustenogaster</i> van der Vecht, 1969.....	41
	<i>Eustenogaster nigra</i> Saito & Nguyen, 2006.....	41
<b>5</b>	<b>GLOSSARY .....</b>	<b>43</b>
<b>6</b>	<b>PLATES. ....</b>	<b>48</b>
	<b>CHECK LIST OF THE SOCIAL VESPIDAE SPECIES OF HONG KONG.....</b>	<b>126</b>
<b>7</b>	<b>BIBLIOGRAPHY.....</b>	<b>127</b>
<b>8</b>	<b>INDEX OF FAMILIES, SUB-FAMILIES, TRIBES, GENERA AND SPECIES .....</b>	<b>130</b>
<b>9</b>	<b>NOTES.....</b>	<b>131</b>

# 1 Introduction.

Wasps are by all means not very popular, for the painful sting they might inflict remains vividly present in many a mind. If this is true with social species - and in particular when colonies are disturbed – it is not for the vast majority: non-social wasps, generally very shy with a timid behaviour, rarely or never using their stings (if any) when confronted<sup>1</sup>. Despite this lack of popularity, wasps are highly important insects due to their predatory or parasitic biology, contributing a great deal in maintaining the balance of ecosystems in which they dwell. On an economic point of view they predate many economic insects and are readily used or respected as such by farmers around the globe. They also perform pollinisation of a great number of flowers due to their feeding habits.]

The word wasp actually refers to a great number of species with an incredible diversity in morphologies and biology, from minute to large, with or without wings, parasitic or opportunist and scavenger, solitary to primitively social and **eusocial**.

Although wasps are distributed world-wide<sup>2</sup>, the greatest diversity is to be found in the tropical regions of the globe. The Hymenoptera, the order to which belong wasps but also ants and bees is one of the most diverse and speciose order of insects, and if to date nearly 100,000 species world-wide have been recorded, the prospective number is certainly well over 300,000.

The order is divided into 2 suborders:

- **Symphyla**: A small suborder and ancestral group that has retained the plant feeding habit<sup>3</sup>. Numerous wing veins and un-differentiated metasomal segments, characterises the early hymenoptera that first appeared as fossils during the Triassic period, 200mybp (million years before present). Most larvae are mobile and have eyes and antennae and walk about eating foliage pretty much as would do a true caterpillar<sup>4</sup>. The **ovipositor** is designed to pierce plant tissue and has a saw like (hence their common name: Sawflies) modified margin.
- **Apocrita**: A vast group of Hymenoptera that present a conspicuous constriction between the thorax and the metasoma, permitting a great flexibility of the metasoma. The vast majority is parasitic during the larval stage (75% of all Apocrita described to date) while the remaining will prey on a variety of **arthropods**, mainly insects and spiders or scavenge.

For practical reasons usually the Apocrita is again divided into 2 sub-groups<sup>5</sup>:

- Parasitica, or **parasitic** wasps, a heteroclite assemblage of a great many Apocrita.
- Aculeata, from the Latin *aculeus*, a sting or wasps that are able to sting. 90% of all aculeate are solitary insects, while the remaining 10% comprises the common and feared social wasps.

In this guide we will deal solely with the eusocial wasp species (Hymenoptera: Aculeata: Vespoidea, Vespidae) of Hong Kong comprising the yellow-jacket, hornets, paper wasps and hover-wasps, referred to generally as “true wasps”<sup>6</sup>. The potter-wasps, Eumeninae are not included here as they are solitary or sub-social at best. For simplification sake, I will use the word “wasps” when referring to eusocial species.

Wasps are collectively placed into one family called the Vespidae. They display elaborate yet relatively stereotyped behaviours that can be easily described and analysed either in the wild or in laboratory conditions and as such have become favourite subjects for the study of the evolution of sociality.

If this group is generally relatively well described, species found in Hong Kong have not yet been systematically recorded<sup>7</sup> and this guide aims at providing the amateur as well as professionals with an easy to use publication for the identification of the twenty four species of social wasps recorded to date in Hong Kong.

## 2 How to use this guide

Identification of species is permitted in two ways: either directly with detailed habitus photography of each species along with other iconographic information such as nest architecture and larvae morphology when available; or indirectly with the aid of the keys.

A key is composed of a couplet or a pair of contradictory statements, for example, “has” and “does not have”. This allows the reader to key in, one step at the time, specimens to the next key by eliminating un-verified statements, ultimately reaching the species level. Here, I have introduced several statements per couplet, permitting finer analysis of each specimen.

In this guide the identification key system is two tiered:

- The first tier allows identification of specimens in the family Vespidae to the sub-family level. Sub-family general biological information is described under the header number referenced in the key.
- The second tier takes the reader down to the genus and species levels. In this case only the two sub-families, Polistinae and Vespinae have a key to species level as the Stenogastrinae has only one record so far and the Eumeninae are excluded from this work. Genus and species general biological information is found under the page number referenced in each ultimate key.

Some keys are illustrated permitting quick and easy reference. The morphological characters used only necessitate a hand held magnifier (x20 or over is better) to be discerned. Morphological terms and other technical words first appear in bold typeface in the text and are either illustrated (Fig. 1, 2 & 3) or referred to in the glossary.

Although morphology might seem a little confusing and difficult to use at first, it becomes easy and fun with a little practice.

Each species is described succinctly through a suite of six headers:

- Geographic Distribution: Where in the world the concerned specie occurs. Data is compiled from Kojima 2001; Carpenter 1996 and Archer 1989.
- Dimensions: Dimensions of species<sup>8</sup> is measured longitudinally from the **frons** to the posterior end of the second **terga**, this because the last **metasomal** segments often collapse in preserved specimens.
- Diet: food sources and modes of appropriation.
- Recognition marks: A suite of characteristic features of each species for rapid visual identification without having to use the keys.
- Nest and Habitat: Architectural typology, materials of nests and biotopes where colonies are supposed to be found; when known.
- Colony size: The number of individuals that can be found on a mature colony. Three levels are used in this book<sup>9</sup>:
  - Small colonies having less than 30 individuals
  - Medium Colonies having between 30 and 100 individuals.
  - Large colonies having over 100 individuals
- Notes: Particular notes on the species.

All the photographs and illustration in this book are from the author, unless otherwise specified. Photographs were taken with a digital Nikon D200 with Nikkor 60mm micro lens, occasionally with macro-extension tubes and an Auto DX 12R Sunpak ring flash.

### 3 Acknowledgments:

- J. Kojima, Ms Saito and Ms Ngyuen for identification of *Eustenogaster nigra* and *Ropalidia mathematica*.
- C.K Starr for confirmation of morphological characteristics of both *P. olivaceus* and *P. jokahamae*.
- John X.Q. Lee, for sharing information and observations.
- The Hong Kong SAR, Agricultural, Fisheries and Conservation Department, particularly Mr K.S. Cheung, Mr Clive C.K Lau and Dr Chen Yi-min, for facilitating surveying, and access to entomological holdings of the Tai Lung Experimental Farm.

## 4 The Hong Kong species of Social Vespidae

### 4.1 Natural History

#### 4.1.1 Generalities

The Vespidae family comprises of six sub-families world-wide: Vespinae, Eumeninae, Polistinae, Stenogastrinae, Euparagiinae and Masarinae, totalising approximately 4000 species. The Euparagiinae are found on the South American continent only and the Masarinae are essentially found in the Southern Hemisphere. The other four sub-families are well distributed locally and are all eusocial, except the Eumeninae.

Vespids are small to large wasps with wings folded longitudinally at rest and all species are prompt fliers, often encountered on sunny days. All but the Eumeninae form colonies of various sizes, morphology and organisation.

#### 4.1.2 Diet

Vespidae have a diet composed of liquefied foods<sup>10</sup> from either animal origin for protein supply or plant origin for carbohydrates. Animal provisions are reduced into a pulp by the workers powerful mandible and fed directly to the larvae or other nest mates (queen and workers). Liquids are stored in the expandable **crop** and re-distributed at will to nest mates. Nectar, nectar-like liquids, body fluids of prey (insects in various orders, adults, larvae and nymphs) or carrion, are the near exclusive sources of nourishment for social wasps. The list would not be complete without adding the very common solicitation by workers of larvae saliva as nourishment or the frequent brood cannibalism<sup>11</sup>. Wasps have in fact a varied diet interspecifically: they can either be specialists, relying on one particular type of food or generalists accepting virtually anything containing proteins and carbohydrates. However, little is known about the specific diet of adults (Hunt, 1991) and most records are related to larvae provisions rather than adult food.

Generally speaking in Hong Kong dietary habits of social Vespidae can be summarised as follows:

- Specialist hunters: they rely on an exclusive source of protein, often other Vespidae.
- Near Specialist hunters: they rely on a variety of food source but all in the same group, most commonly caterpillars.
- Generalist hunters and scavengers: they rely on a wide variety of food sources, including live and dead arthropods, carrion, as well as human waste.

#### 4.1.3 Development.

Vespidae, like all Hymenoptera have a complete **metamorphosis (holometabolous insect)**. From the egg hatches a larva, a legless, eyeless grub whitish in colour, with well developed mouth parts provided with powerful muscles that occupy most of the head capsule. Antennae are reduced to small orbits bearing one or several sensory cones. They have five growth stages called instars. When the larva reaches the fifth stage, it continues to feed for a short period of time and soon stops and starts spinning a very fine lining on the cell walls whilst closing the aperture with a silken cap of variable thickness, texture and coloration interspecifically. At this stage faecal matter is expelled from the larva, it is pushed to the bottom of the cell or even extracted by workers (as in the tribe Ropalidiini). The larva enters then a pre-pupal stage that may last a few days after which it moults into the pupal stage. About two to three weeks later the adult wasp (or imago) emerges biting through the **cocoon** cap. The emerging workers are generally smaller than the queen and are responsible for all aspects of nest construction and maintenance as well as foraging activities (food and construction materials).

In a colony males remain on the nest for some time, being fed and sometimes soliciting nest mates or larvae for food, they never actually “work”.

Females of the family are readily differentiated from the males in that they possess twelve segmented antennae (against thirteen in males) - save for the sub-family Belonogaster and Polybioides in which females have eleven antennal segments and the males twelve - six visible metasomal segments (against seven in males) and a stinging apparatus sometimes visible (absent in males).

Queens are generally confined to an oviposition role, while workers are sterile females<sup>12</sup>, although in some cases; particularly within the Polistinae, they can take over the oviposition process.

Males are short lived and only perform a reproductive function generally towards the end of the colony cycle. As with many other hymenoptera, sex determination is controlled by the ovipositing female<sup>13</sup>: eggs that are fertilized (diploid eggs) give birth to females, those that are not (haploid eggs) give birth to males. Within most

of the social Vespidae, haploid eggs are laid towards the end of the season from September to November<sup>14</sup>, along with diploid eggs that are given a special treatment, developing into **gynes** i.e. unfertilised queens.

#### 4.1.4 Colony foundation and cycles.

The process by which the colony is founded is of great biological importance, the Vespidae have two distinct ways:

- By **haplometrosis**: The colony is initiated by one queen.
- By **pleometrosis**: The colony is initiated by several queens.

Personal fragmentary records suggest that all species locally form colonies by haplometrosis, although a number of species in the Polistinae are noted to have pleometrotic colony foundation in places such as the Okinawa islands or Taiwan<sup>15</sup>. In the same way it is suggested that locally, foundation is done without the aid of workers (non-swarming foundation). However, in some cases in Hong Kong it has been observed that colonies of *Polistes japonicus* (Polistinae) may be founded with the collaboration of two or more fertilised queens (pers. obs.).

All colonies in Hong Kong have a more or less synchronic initiation time and development intraspecifically<sup>16</sup> and are all annual, i.e. they disintegrate at the end of the summer, at the latest at the onset or during the winter months. However, it has been observed that *V. affinis* may have active colonies in mid- January (pers. obs.) and that colonies of *V. bicolor* can still be thriving by the end of February (X.Q. Lee, pers.comm.).

However, the colony cycle and foundation type of the locally elusive, *Vespula flaviceps* remain un-recorded for Hong Kong. Workers of this species seem active from November to April, then after the species apparently “disappears” as no sighting of the species have been made in summer. It is probable that when the colony disintegrate in spring or early summer the newly inseminated queens seek shelter underground or other cool places during for hot months of the year.

Locally, wasp colonies, are initiated in spring (March to April) by a single female (queen) - inseminated the previous autumn – that has emerged from a dormant period, or hibernation. At this time she will built singly<sup>17</sup> the nest and forage for food to feed the first larvae. In most cases, especially in the Vespinae, less so in the Polistinae; when the first workers emerge the queen will surrender all activities but oviposition to the new adults.

From personal observation, in Hong Kong colonies display a life cycle similar to that of temperate zone eusocial wasps<sup>18</sup>. However, cases of early male production have been observed for *Polistes japonicus* (pers.obs.):

1. Initiation phase: spanning between the time the queen emerges from hibernation and starts constructing the 1<sup>st</sup> cells until the 1<sup>st</sup> worker emergence. Queen mortality during this phase is apparently high and generally only a few nests succeed in developing beyond initiation (Gauld & Bolton, 1996).
2. Growth phase: period during which only (or mainly workers) are produced. The colony expands.
3. Reproductive phase: Culmination of the growth phase, gynes and males are produced and at or close to emergence they mate, the colony declines and finally dies off and disintegrate between the end of September and January, depending on the species.
4. Solitary phase: The newly fertilised females (queens) seek a shelter (in crevices, under bark etc.) to spend our short winter months, “hibernating”, awaiting a new cycle.

#### 4.1.5 Nest architecture & construction materials

The nests of social Vespidae are made out of a variety of construction material such as dry or rotten ligneous matter from various sources, dry bamboo fibres, plant hairs and fibres, various secretions and occasionally fine mineral matter. The raw material is masticated until it is reduced to a pulp; it is then carried back to the nest where workers (either the forager or another worker) apply the mixture with their mandibles to form the entire structure of the nest.

It is at first formed by a single comb containing a few cells, generally suspended from the substrate by a **pedicel** (save for Stenogastrinae). The pedicel can be reduced or modified in multi-comb constructions with the external envelop hiding the attachment to the substrate. This comb(s) can either be exposed, as in all Polistinae locally or protected by an envelope (complete or incomplete) as in all Vespinae. The original comb may be extended by addition of supplementary cells at its periphery<sup>19</sup> (most Polistinae) and/or by addition of additional suspended combs (most Vespinae). The suspension of combs by reinforcement of the central axis

of the structure is also often complemented by additional ‘ties’ or secondary pedicels between combs (see plate 3)

In this way the nest continues to expand during all summer reaching sometimes impressive dimensions, with colonies exceeding several thousand individuals.

#### 4.1.6 Colony social structure.

Within the colonies thus formed, is established an often well determined hierarchy system of cast divisions, dominated by the queen to whom all workers are subordinated<sup>20</sup>. But perhaps, the most fascinating aspect of eusocial Vespids is the complex division of labour or **polyethism** that exists in colonies: beyond the obvious queen = oviposition vs. worker = foraging + construction division, exists a finer division of sub-casts generally determined by age and task performance. In deed variety of activities such as nest defence, cell construction initiation, pulp foraging (for construction), nectar or prey foraging, larvae feeding, oviposition etc. are key relationships determining the complex hierarchies that underline colonies of eusocial wasps. These relationships are often highlighted by stereotyped postures and behaviours on (and sometimes off) the nest site forming the core of the development pattern of the colony. And it can be said that “*in fact, the remarkable ecological success of the social insects has been attributed largely to the colony’s ability to feed, defend, and reproduce itself through the coordinated activities of its specialised members*” (Jeanne, 1991).

The social complexity is at its highest in the sub-family Vespinae, where species are able to cooperate to perform a collective task (raiding food sources for *Vespa soror*) similar to those that many ants perform. The Polistinae are considered to be at the middle of the road in term of social development, while Stenogastrinae are close to the early stages of social interaction.

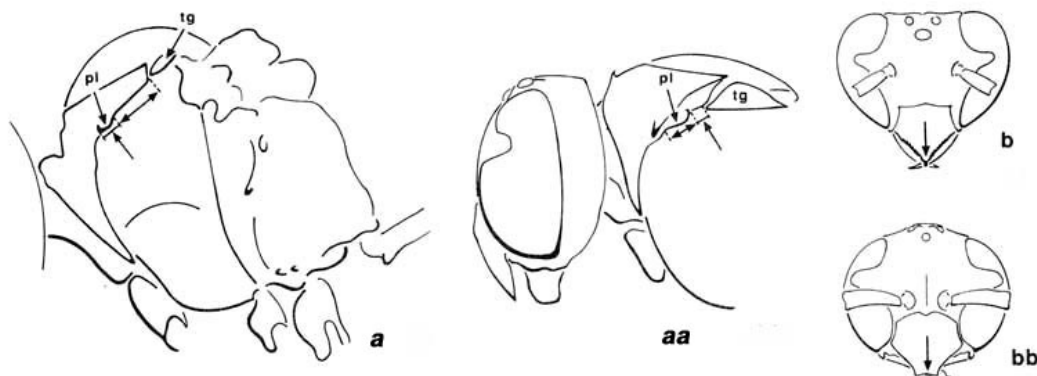
It has been determined that pheromones play a significant role in the social structure of social wasp colonies. However, studies on exocrine gland secretion have mainly focused on the Vespinae where the demonstration is obvious, the other sub-families have been somewhat a little discarded in that respect but strong evidence suggest that chemical cues are used to establish social hierarchy and functions in a number of species of Polistinae (Downing, H.A; 1991).

#### 4.1.7 Approaching active colonies

In most cases, colonies of Vespidae in Hong Kong can be approached easily within a few feet and often less without being attacked or stung. An attack by a colony is a defence response to a felt threat, such as vibrations, impacts, or panicked movements. In all cases one should approach a nest making slow and very gentle strides, avoiding the possible transmission of vibrations to the nest. Odour seems also to play part, notably with *Parapolybia spp*, and a downwind approach is often recommended. However, colonies of *Vespa velutina* apparently display unsolicited attack behaviour and it is recommended that colonies be at least a few meters away from the observer. Outside and away from the colony, wasps will never attack even if disturbed, provided they are not seized; individual foragers can be observed at close range.

## 4.2 Key to sub-families of Vespidae of Hong Kong.

The key is designed for female individuals. The couplets definitions and the illustrations are taken from the reference publication “Hymenoptera of the world: An Identification guide to families” (Goulet & Huber, 1993). This part contains numerous morphological vocabulary, please refer to Fig.1, 2 & 3 for clarification.

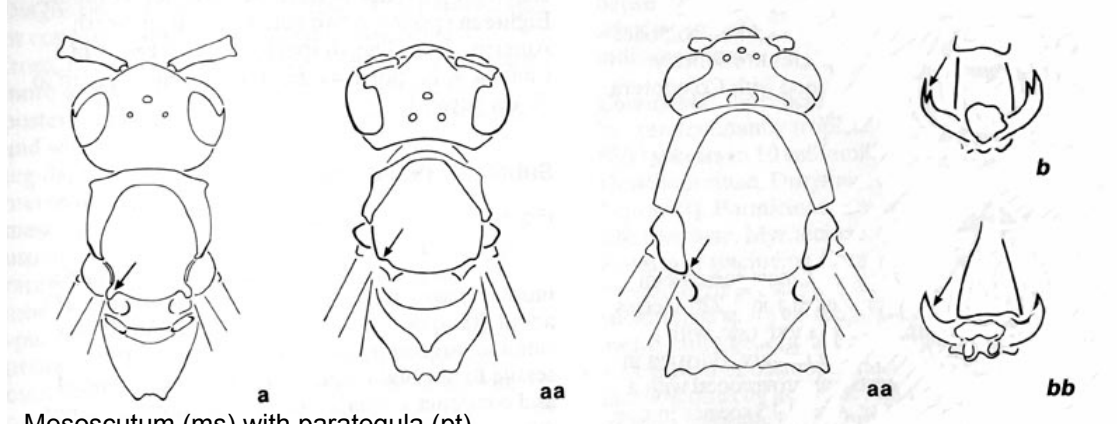


1.
  - a. Pronotal lobe (pl) separated from tegula (tg) by a distance greater than the length of lobe.
  - b. Clypeus projecting and acute or narrowly rounded ventrally.
  - c. Fore wings not longitudinally folded at rest, not reaching beyond metasomal segment 3.  
 -----**Stenogastrinae** (Only one species in Hong Kong: ***Eustenogaster nigra***; Section 4.5).
- aa. Pronotal lobe (pl) separated from tegula (tg) by a distance equal to or less than the length of lobe.



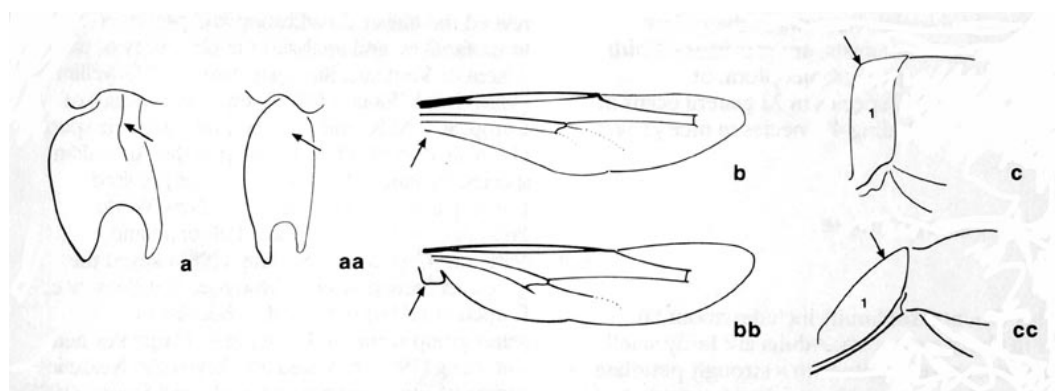
- bb. Clypeus not projecting, neither acute nor rounded ventrally.  
 cc. Fore wings longitudinally folded at rest, reaching beyond metasomal segment 3.

-----2.



- 2.(1) a. Mesoscutum (ms) with parategula (pt).  
 b. Tarsal claws usually cleft, but rarely simple and smooth ventrally.  
 c. Solitary and sub-social. -----Eumeninae (outside the scope of this guide)

- aa. Mesoscutum (ms) without parategula (pt).  
 bb. Tarsal claws simple and smooth ventrally.  
 cc. Eusocial. -----3.



3. (2) a. Metacoxa with dorsal longitudinal carina.  
 bb. Hind wing without jugal lobe (J).  
 cc. Metasoma sessile; tergum 1 abruptly declivous anteriorly. -----Vespinae (Section 4.3)

- a. Metacoxa smooth dorsally.  
 bb. Hind wing with jugal lobe (J).  
 cc. Metasoma more or less sessile or petiolate; tergum 1 gradually declivous anteriorly.  
 -----Polistinae (Section 4.)

## 4.3 Vespinae.

### 4.3.1 General biology of the Vespinae:

The Vespinae comprises the most familiar albeit the most feared wasps, the yellow-jackets and true hornets.

The sub-family is composed of four genera: *Vespa* (Hornets), *Vespula* (Yellow-jackets), *Provespa* and *Dolichovespula*, totalising approximately 60 to 70 species worldwide. While the two first genera are well represented in Hong Kong, *Provespa* is limited to the Indochinese peninsula down to Borneo. *Dolichovespula* is largely represented in the Old World and in the Nearctic region (North America) and not recorded in Hong Kong.

This guide describes the following eight species occurring in Hong Kong:

- *Vespa affinis*



- *Vespa analis*.
- *Vespa bicolor*.
- *Vespa ducalis*.
- *Vespa soror*.
- *Vespa tropica*.
- *Vespa velutina*.
- *Vespula flaviceps*.



Plate I. A big nest of *V. affinis*, measuring 75cm in height and a maximum circumference of 38cm. The nest is exposed at the AFCD's Tai Lung Experimental Farm. (photo author)

Queens of *Vespa* and *Vespula* emerge from hibernation in spring (March to April) and seek an appropriate nesting site either underground or aerial at various heights. The nest starts as a simple comb with several cells, suspended from a short pedicel, shielded by an umbrella like structure above. The envelope is often, at the beginning incomplete and as the nest develops this construction eventually encloses the comb(s) in most species<sup>21</sup>. The envelop is frequently multi layered adding structural integrity to this crucial membrane but also certainly ways of environmental control within the nest<sup>22</sup> assisting with homeothermy (Wenzel, 1991). Nesting sites vary and can be aerial or concealed in excavations or cavities either in the ground or in tree hollows. The nest materials- are in all species, composed of various plant fibres, mainly if not only dead wood, masticated by the workers, forming a rather "brittle" carton like material. Cells are generally made of the same materials, albeit more resistant to shear.

Despite their annual cycle, in Hong Kong vespine colonies can sometimes reach impressive proportions depending on the prevailing environmental conditions: food supply, predation, nesting sites and weather. But small colonies are by all means not exceptional if not the rule for some species of *Vespa* (*V. ducalis*).

Generally, all species are rather defensive of their nesting site and any disturbance will result invariably by collective defence behaviour: workers rush out the exit hole, inspect the nest surface or fly towards any moving object (animal) within the vicinity, stinging anything too close.

The queen never leaves the nest after the initiation period and is confined to an egg laying role, fed and protected by the workers. Laboratory experimentations have shown that although the queen of *Vespa* and *Vespula* do not display obvious physical dominance behaviour over other females they exert control on the rest of the colony through pheromone release (Spradbery, 1991).

Vespinae have a highly versatile diet: some species (*V. bicolor*, *V. velutina* and *V. flaviceps*) display a generalist diet, while others (*V. tropica* and *V. soror*) are generally speaking, specialist predators of species of Polistinae. The diet of the local Vespinae is detailed in the following table (from various sources and personal observation):

Food source		Carbohydrates							Proteinaceous											
		Tree sap	Nectar from flowers	Nectar from extra-floral nectaries	honeydew	larva saliva	fruits	others	Dead arthropods	Vertebrate carrion	Polistinae and Stenogastrinae eggs, larvae & pupae	cannibalism	Apis sp, Honey bees, other bees	Adult Lepidoptera	Lepidoptera larvae	Diptera	Odonata	Hemiptera	Spiders	
Genus	Species																			
Vespa	affinis	•	•			c	•		a	b		e								
Vespa	analís																			
Vespa	bicolor		•				•		•	•		l			•	•				
Vespa	ducalis	•					j				b	•								
Vespa	soror	•					h	m	•		bq	•					g	•	k	
Vespa	tropica	•					•				b		d							
Vespa	velutina	•	•				d		•						•	•			d	
Vespula	flaviceps								•											

- Notes:
- a. Left-over dog food. (pers. obs.).

b. On the sub-families Polistinae and Stenogastrinae (So. Yamane 1994), particularly *Parapolybia* spp, *Polistes* spp and *Ropalidia* spp. In Hong Kong *P. indica* seems to be a preference but also *P. olivaceus* and *P. japonicus*.

c. These records are from personal observation but larvae saliva nourishment is a very wide spread behaviour in Vespidae (Hunt, 1991) and could be expected in other species.

d. From Van den Vecht (Vecht, 1957).

e. In Taiwan (Se. Yamane & Wang).

f. Notably *Parapolybia indica*. *Polistes japonicus* colonies are also preyed upon by *V. ducalis* and *V. soror* (pers.obs).

g. *Cryptotympana mimica* that was killed by the hornet (pers.obs). As well as locusts experimentally fed in-situ (X.Q.Lee).

h. *Syzygium jambos*, Rose apple. (pers.obs).

j. Unknown fruit from a climber plant (pers.obs.).

k. preying of *Nephila* sp on the web. 12/06/07 (pers.obs.).

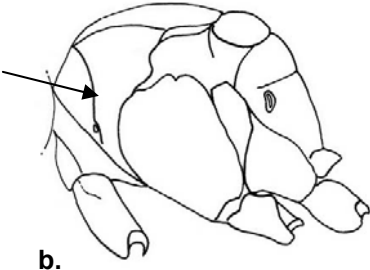
l. *Amegilla* sp. 08/08/07.

m. Specimen observed feeding on spider (*Nephila* sp) on the web.

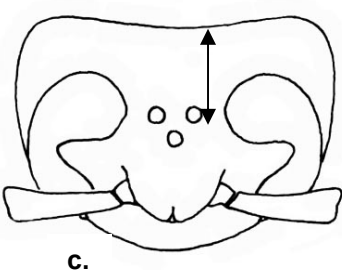
4.3.2Key to genera and species of Vespinae

This key is designed for females (workers) found in Hong Kong. It is partly adapted from various sources (Yamane, 1999 Gupta, 1989, and Starr, 1992), partly deduced from local species characteristics. Refer to Fig.1, 2 & 3 for definition of morphological features.

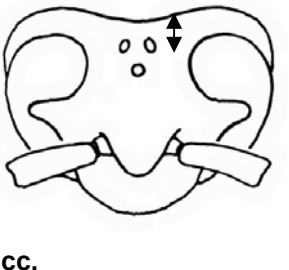
1.



b.



c.



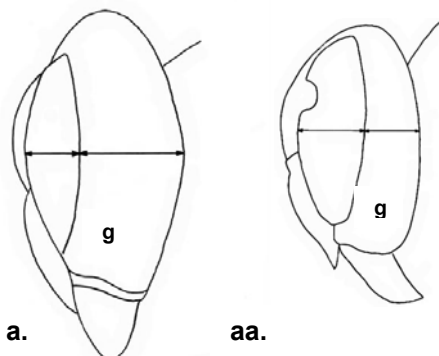
cc.

a. Large wasp, body length exceeding 15-20mm in workers.

b. Pronotal carina (pc) well defined and complete, sometimes forming a conspicuous short curve latero-dorsally.

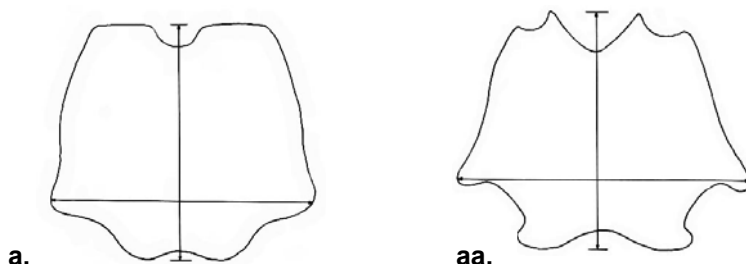
c. Vertex (ve) long, posterior ocelli at least as far from the back of the head as from each other.

- d. On the fore wings, vein Rs meeting vein R+ Sc far from the stigma. ----- **Vespa (2).**
- aa. Smaller wasps body length not exceeding 15-20mm in workers.
- bb. Pronotal carina (pc) weak or/and incomplete.
- cc. Vertex (ve) short, posterior ocelli about as far from each other as from the back of the head.
- dd. On the fore wings, vein Rs meeting vein R+ Sc close to the stigma.  
----- **Vespula** (Only one species in Hong Kong **Vespula flaviceps**)



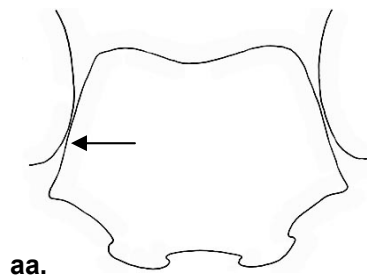
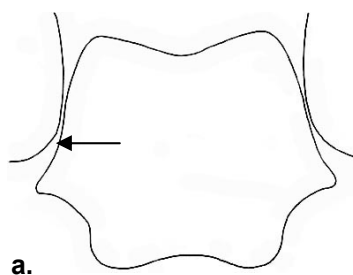
- 2. (1)**
- a. In profile, gena (g) conspicuously wider than eyes.
- b. Large wasp, (L > 24mm). ----- **V. soror**
- aa. In profile, gena (g) equal to or less wide than eyes.
- bb. Smaller wasps, (L < 24mm). ----- **(3)**

- 3. (2)**
- a. Scutellum, metanotum 1<sup>st</sup> and 2<sup>nd</sup> terga orange. Apical end of 3<sup>rd</sup> tergum and sternum with thin orange band apically, not exceeding in width 1/6 of the dorsal length of the tergum. ----- **V. ducalis**
- aa. Not as above. ----- **(4)**



- 4. (3)**
- a. In frontal view, height of clypeus longer or sub-equal to its width.
- b. Vertex and ocellar region same colour as the rest of the head.
- c. First metasomal sternum and tergum black.
- e. Generally fossorial colonies. ----- **V. tropica.**
- aa. In frontal view, height of clypeus smaller than its width.
- bb. Vertex and ocellar region black or vertex with medial black stripe reaching the level of the lateral ocellus.
- cc. First metasomal sternum and tergum variously coloured, sometimes with darker pigmentation anteriorly.
- ee. Mostly aerial colonies. ----- **(5)**

- 5. (4)**
- a. Clypeus with dense puncturation
- b. Vertex with medial black strip reaching lateral ocellus, the rest the same colour has the head
- c. Metasomal segment 3 to 5 entirely black. ----- **Vespa affinis.**
- aa. Clypeus with sparse and fine puncturation.
- bb. Vertex and ocellar region black.
- cc. Metasomal segment 3 to 5 orange/yellow, sometimes with black markings. ----- **(6)**



## 6. (5)

- a. In frontal view, eye lower inner margin intersecting the lower lateral side of the clypeus, clypeus lateral margin concave.
- b. Body entirely yellow, except vertex (ve), ocellar region and Mesoscutum (ms). ----- ***V. bicolor***.
- aa. In frontal view, eye lower inner margin tangent to the lower lateral side of the clypeus, clypeus lateral margin convex or straight.
- bb. Head and thorax entirely black, 1st and 2<sup>nd</sup> metasomal terga black with a fine yellow/orange band apically. ----- ***V. velutina***.

### 4.3.3 Genus *Vespa* Linnaeus, 1758.

The genus *Vespa*, or hornets, comprises of 22 species world-wide of which seven are confirmed in Hong Kong and described here.

*Vespa* species show a great deal of colour and size variability in tropical lowlands and a number of sub-species have been identified (Vecht, 1957; Se. Yamane), although recently authors have synonymised all subspecies under nominate species (Carpenter & Kojima)

They are, generally speaking, large insects, variously coloured but predominantly black with shades of yellow/orange. They are all strong and noisy flyers.

The nesting period from colony initiation to disintegration varies from species to species, between 4-5 months for *V. tropica* and 7-8 months for *V. affinis* (Matsuura, 1991) or even 9 months for *V. bicolor*. In lower latitudes colonies of some species are perennial and can be initiated at any time of the year (Matsuura, 1991).

Nesting sites for the genus varies also from one species to another and can also vary intra-specifically (Matsuura, 1991 & Vecht 1957). Nests are started as a simple affair, containing at initiation approximately 4-6 cells constructed on the tip of a pedicel. At this stage it often has an incomplete envelop shaped liked an inverted bowl. Later at emergence of workers, the combs will be protected from the outside by a carton-like envelop which may be composed of several layers in which one entrance hole is created, either at the bottom, at the top or on the side. By the time the first workers emerge the nest may contain up to 20 cells.

There is generally a clear size **dimorphism** in all hornets, with queens markedly larger than workers, save maybe for *V. tropica* in which workers emerging late in the nesting period are often larger than the queen (Matsuura, 1991). Males are always produced during the final stage of the colony (Vecht, 1957).

Hornets are generally aggressive defenders of their colonies and because of their large sizes; we humans have learned to avoid them. Although perfectly equipped to repulse any attack, Vespinae nests may fall prey to a variety of birds (Vecht 1957; pers. obs).



Fig.3.2.3, Distribution of the genus *Vespa*. Redrawn from M. Matsuura, 1991.

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

Sub family: Vespinae.

**Distribution:** India; Assam; Burma; Indochinese peninsula; South-east China to central China; Hong Kong Taiwan to the Ryukyus Islands; Peninsular Malaysia; Borneo; Sumatra; Java, Bali and all Lesser Sunda Islands; Sulawesi and Halmahera; Palawan to New Guinea.

#### **Dimensions:**

Body length:

- Workers: 16-20mm.
- Queens: 19-21mm.
- Males: 15-16mm.

**Diet:** Generalist hunter and scavenger in Hong Kong.

**Recognition marks:**

- A medium large Hornet.
- 1<sup>st</sup> metasomal segment yellow/orange.
- Head entirely rufous no black markings.
- Clypeus wider than high.

Can be confused with:

- *Vespa tropica*, however the yellow coloration of the 1<sup>st</sup> metasomal segment distinguishes it from *V. tropica* in which this segment is generally black. Nesting habits are also a defining character as *V. tropica* is mainly fossorial.

**Nest & Habitat:**

Nests are found above ground on a variety of supports: trees, bushes, shrubs and even buildings. It has been observed locally (X.Q Lee, pers. comm.) that there is a correlation between height of the nest and size of the colonies: the higher the bigger the nest becomes, although large nests have been recorded in New Guinea and Halmahera at elevation below 2,5m (Kojima, pers. comm.). Occasionally nests can reach impressive sizes (over 1m tall), with several thousand individuals.

They have a ball shape structure slightly or conspicuously elongated with a side entrance whole. The multi-layered external envelop protects a stacked multi-comb structure with a main central column (pers. obs.) and secondary peripheral supports

The white cocoon caps are loosely woven and protrude only slightly from the cell rims (pers. obs.).

There is apparently a great deal of variation in the nests features within the vast geographical distribution of this species (Starr, 1992).

**Colony size:** Medium to large colonies.

**Note:** This species is rather aggressive and nests should be approached with great care. Generally, when disturbed these wasps focus their attack mainly towards the head of the observer. In Taiwan this species is considered a serious beekeeping pest: individuals landing at the hive entrance, snatch incoming and outgoing bees which are promptly dismembered and killed.

## ***Vespa analis* Fabricius, 1775.**

Sub family: Vespinae.

**Distribution:** India; Kashmir, Uttar Pradesh, West Bengal, Tamil Nadu, Meghalaya, Sikkim, Assam; Nepal; China: Hong Kong, Sichuan, Yunnan, Hainan, Guangxi, Fujian, Hubei, Zhejiang, Heilongjiang; Myanmar; Thailand; Laos; Malaysia: Peninsular Malaysia; Singapore; Indonesia: Sumatra, Bangka, Sunda Islands, Java, Bawean, Bali; Taiwan; Korea; Japan, including Ryukyu Islands; Russia: Amur, Primor'ye.

**Dimensions:**

Body length:

- Workers: +/- 25mm
- Queens: Not recorded by the author
- Males: Not recorded by the author

**Diet:** Unknown, although probably generalist.

**Recognition marks:**

- A medium to small size hornet.

Can be confused with:

- None of the local species of hornets save maybe for *V. ducalis*, from which it can be easily differentiated by its smaller size and distinct yellow banding of the posterior parts of the terga and its yellow/orange 6<sup>th</sup> tergum.

**Nest & Habitat:** Unknown

**Colony size:** Unknown for Hong Kong.

**Note:** *V. analis* has only been recorded recently from Hong Kong and from only a few localities. Very little local information is available at date of printing.

### ***Vespa bicolor* Fabricius, 1787.**

Sub family: Vespinae.

**Distribution:** Sikkim; North-eastern India to Central and South China, Northern Burma, Northern Vietnam, Northern Thailand.

**Dimension:**

- Workers: 13-16mm.
- Queens: 17-20mm.
- Males: 13-14mm.

**Diet:** Generalist hunter and scavenger.

**Recognition marks:**

- A small to medium hornet.
- Body entirely yellow except frons and mesoscutum.
- Lateral margins of clypeus concave.

Can be confused with:

- None of the local species of hornets

**Nest & Habitat:** Nests are often aerial and found in protected locations, such as undersides of roofs and open cavities, but also in grassland fixed to tall grasses. Colonies have been observed in cavities, such as tree hollows or construction cavities. They have a more or less spherical shape with a lateral entrance. The external envelop protects a stacked multi-comb structure (pers. obs.). Colonies are known to be still active well into the month of February and sometimes early March. In one exceptional case, a colony as been observed to last for more than one year (X.Q.Lee, pers.comm.), it was located in a hollow inside a Ficus tree.

**Colony size:** Medium size colonies.

**Note:** This hornet is probably the most common of all locally. Although this species will defend its colony, it is a rather un-aggressive species and will not attempt attacks if the observer backs away after disturbance, colonies can be approached carefully.

*V. bicolor* seems adept at usurping pre-existing *V. velutina* colonies as witnessed directly by detaching a young *V. velutina* nest from its support: there was one comb filled with larvae and pupae, about 7 *V. Velutina* workers and one queen *V. bicolor*.

### ***Vespa ducalis* Smith, 1852.**

Sub family: Vespinae.

**Distribution:** Central, southern, eastern and north-east China; Hong Kong; Hainan; North & South Vietnam; Taiwan, Japan; Korea and Siberia (Ussuriland).

**Dimension:**

- Workers: 20 to 24mm
- Queens: not recorded by the author.
- Males: not recorded by the author.

**Diet:** Considered a near specialist hunter on nests of Polistinae (Starr, 1992) in many parts of its distributional range, particularly colonies of *Parapolybia indica* which are commonly attacked by this species locally

**Recognition marks:**



- A large hornet.
- Head Orange with no black markings except in the ocellar region.
- Scutellum, metanotum and propodeum orange. Anterior part of pronotum also orange.
- 3<sup>rd</sup> metasomal segment with a thin yellow band apically.

Can be confused with:

- *V. soror*, however, *V. ducalis* is generally smaller and the reduced gena of the latter species is a confirming character.

**Nest & Habitat:**

*V. ducalis* is mostly a fossorial species although aerial nests have been found locally. In Hong Kong colonies are generally situated in existing cavities, further enlarged by the hornet. The nests do not have a complete envelop but a reduced cover formed by an umbrella like structure above the 1<sup>st</sup> comb. The white cocoon caps protrude conspicuously from the cell rims, forming an extension of the cell terminated by a hemispherical dome.

**Colony size:**

The colonies are small with few individuals: fifty workers would be a near maximum locally.

**Note:**

This species has often been treated as variant of *V. tropica* (Starr, 1992). However, it is recognised now as a rightful species on its own.

It is a non aggressive species as long as individuals are not seized and nests can be approached at close range, provided that no brutal movement is made.

This hornet has also been noted to take workers of *Apis cerana* (honey bee) in a different manor to that of *V. affinis*: while *V. affinis* lands at the entrance of the nest, *V. ducalis* takes bees in flight (Starr, 1992).

## ***Vespa soror* du Buysson, 1905.**

Sub family: Vespinae.

**Distribution:**

China: Yunnan, Hainan, Fujian, Hong Kong; Northern Thailand; Laos and Vietnam.

**Dimension:**

- Workers: 21-30mm.
- Queens: 30+mm.
- Males: not recorded by the author.

**Diet:**

Locally this hornet accepts a great many proteinaceous food sources, but with a clear preference for colonies of *Parapolybia indica* on which it has been observed to mount collective raids (pers.obs.). I have also observed this hornet taking grubs and pupae out of a destroyed nest of *V. affinis* (pers. obs.).

**Recognition marks:**

- A very large hornet, in fact the largest locally.<sup>23</sup>
- In lateral view, gena conspicuously wider than eyes
- Head Orange with no black markings except on the ocellar region.
- Scutellum, metanotum and propodeum orange.
- First two metasomal segments orange, third to sixth black

Can be confused with:

- With *V. ducalis*, however the expanded gena of *V. soror* is a confirming character.

**Nest & Habitat:**

The specific nesting habits of this species in its distributional range are not well known. However, nests are constructed in underground cavities dug out from existing hollows generally in clayish embankments. Nest are noticeable by the big pile of excavated soil that the workers deposit at the entrance, the closely related *V. mandarinia* is also known to found colonies high up in trees (Veht, 1957). The nest envelope is partial, only covering approximately 2/3 of the combs

**Colony size:**

The colonies are suspected to be of medium to large size, with a few hundred individuals at maximum; although no direct observation has been made by the author

**Note:**

This species is closely related to *V. mandarinia* (Smith), a species not found locally with whom it shares the raiding behaviour of food sources. This behaviour most certainly involves pheromones to mark the site and to recruit nest mate (pers.obs.). This species is often observed locally to mount group raids on colonies of *Parapolybia indica* (Polistinae).

Despite its size, *V. soror* shows little aggression towards humans and individuals can easily be approached and even fed artificially with captured flies, grasshoppers etc.

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

Sub family: Vespinae.

**Distribution:** India; Afghanistan; Nepal; Sikkim; Bhutan; Burma; Sri-Lanka' Andaman and Nicobar Islands; Indochinese peninsula; South China; Hong Kong; Malaysia; from Sumatra and Java to Borneo and New Guinea. Some specimens have been collected from Korea and Southern Manchuria (Vecht, 1957).

**Dimension:**

- Workers: 18-22mm.
- Queens: 24-26mm.
- Males: +/-19mm.

**Diet:** Near specialist hunter, mainly in the genus *Parapolybia* and *Polistes*.

**Recognition marks:**

- Medium size hornet.
- 1<sup>st</sup> metasomal segment black.
- Ocellar region marked with black.
- Scutellum rufuous/red.

Can be confused with:

- *Vespa affinis*, however the black coloration of the 1<sup>st</sup> metasomal segment, the nesting habits and the clypeus proportions (see key) are generally distinguishing characters.

**Nest & Habitat:** Nests are generally found underground in Hong Kong, most commonly in pre-existing cavities that have been enlarged. J. Van den Vecht observed that in some instances nest could be found above ground but in concealed locations such as hollows in trees, attics and the like (Vecht 1957). In Hong Kong a nest has been found affixed to the beams of a roof in an old village house (see plate). The cocoon caps do not protrude excessively from the cell rims forming only an hemispherical cap

**Colony size:** Medium to large colonies.

**Note:** Larvae and pupae of these wasps are often considered a delicacy in various parts of South-East Asia.

### ***Vespa velutina* Lepeletier, 1836.**

Sub family: Vespinae.

**Distribution:** Assam; North-east India to South and Central China; Hong Kong Indochinese peninsula; Taiwan; Peninsular Malaysia; Sumatra; Java; South Sulawesi and Lesser Sunda Islands.

**Dimension:**

- Workers: 14-17mm.
- Queen: +/-18mm.
- Males: +/-16mm.

**Diet:** Generalist hunter and scavenger.

**Recognition marks:**

- Small to medium size hornet.
- Head and thorax entirely black.
- Clypeus orange.
- 1<sup>st</sup> and 2<sup>nd</sup> sterna with fine apical yellow band.
- 4<sup>th</sup> to 6<sup>th</sup> sterna with orange zones.

Can be confused with:

- None of the local *Vespa* species save for *Vespula flaviceps*, which is in fact much smaller with distinct yellow lines on the apical circumference of the metasomal segments.

**Nest & Habitat:**

Nests are aerial, found in trees and shrubs. As with *V. bicolor* this species is known to initiate nests underground and later to relocate them in aerial locations. However, very little is known about the specific architecture and material of the nests of *V. velutina*. Nests in Hong Kong are near spherical at the beginning with a lateral entrance, flush with the surface of the envelop. It develops into an ovoid as the colony matures. It has several combs suspended by many columns. The envelope is multi-layered. Van der Vecht (1957) reports that the largest nest he ever saw was that of this species was a specific item containing 11912 cells in 11 combs measuring 75cm in height.

**Colony size:**

Colonies are known to become rather large (Starr, 1992) containing thousands of individuals.

**Note:**

This species is considered to be one of the most aggressive amongst hornets and possibly Vespidae; characteristic which may account for the very little attention it has received (Starr, 1992) despite a relative abundance in its geographical range. *V. velutina* is to be found at elevations over 1000m in more southern latitudes (Starr 1992 & Vecht 1957), but it is common in lowlands in Hong Kong.

Larvae and nymphs of these hornets are often considered a delicacy in various parts of South-East Asia.

Although of South-East Asian origin *V. velutina* has recently been recorded from continental Europe<sup>24</sup> (Haxaire et al, 2006) and it has since then well established itself in the South West of France.

*V. velutina* often preys on bees (*Apis cerana*): it hovers at the colony's entrance seizing or attempting to seize incoming workers, which she then dispatches promptly by decapitation and amputation.

#### 4.3.4 Genus *Vespula* Thomson, 1869.

The genus *Vespula*, or yellow-jackets, comprises of approximately 20 to 22 species worldwide, mostly present in temperate regions of the Northern hemisphere. In Hong Kong only one species has been, as of yet, identified.

They are generally small wasps with yellow/black markings. All species are expert flyers.

The biology of these wasps is extremely varied particularly with regards to nest size: in sub-arctic latitudes nests rarely exceed a few dozen individuals whereas in tropical regions, colonies can exceed 300,000 workers with nests weighting up to ½ a ton. (Greene, 1991).

In Yellow-jackets, a clear size dimorphism is observed between queens and workers.

Nests are generally initiated by a single inseminated queen, although nest usurpation is a common behaviour of this genus.

The genus is traditionally divided in two groups according to the nest/colony size (Greene, 1991):

- Small colonies: workers are reared on a single comb that is expanded to accommodate the new brood, whereas the subsequent combs have larger cells used to rear reproductive (Males and queens). Colony cycles are usually short. Population in this group rarely exceeds several hundred individuals.
- Large colonies: Workers are reared in several combs, queens have an increased longevity and production of reproductives takes place towards the end of the colony cycle. Colonies can be perennial in warmer latitudes. Colony population often exceeds several thousand individuals.



Fig.4.2.3, Distribution of the genus *Vespula*. Redrawn from A. Greene, 1991

#### ***Vespula flaviceps* (Smith, 1870).** sub-genus *Paravespula*

Sub family: Vespinae.

**Distribution:** Northern India; Assam; Nepal; Sikkim; Burma; Southern, Eastern and Northern China; Hong Kong; Taiwan; Japan; Korea and Siberia (Ussuriland)

**Dimension:**

- Workers: 8-9mm.
- Queens: 12-13mm.
- Males: Not recorded by the author.

**Diet:** Generalist hunter and scavenger.

**Recognition marks:**

- A small wasp.
- Body mainly black with thin yellow bands on the posterior end of each metasomal segments

Can be confused with:

- So far only one species in the *Vespula* genus has been identified in Hong Kong. By stretching it, one could mis-qualify this species for *V. velutina*; however, the distinct yellow bands on the posterior circumference of the metasomal segments and its small size permits differentiation.

**Nest & Habitat:**

Nests are generally found in underground cavities (Starr, 1992), although exposed (aerial nests) have been found in Japan. In fact little is known about the specific architecture of the colonies.

**Colony size:**

Colonies are known to become rather large and there are records in Japan of colonies with up to 17,000 cells (Starr, 1992).

**Note:**

Very little is known about the local *Vespula* species. The most intriguing aspect of this wasp being that individuals are mainly seen during the winter months (from November to April), with occasional records in May, then after the wasp “disappears” (pers. obs. & X.Q. Lee, pers. comm.) and colonies are yet to be recorded locally.

## 4.4 Polistinae

### 4.4.1 General biology of the Polistinae

The Polistinae is the most diverse sub-family of social wasps in terms of both speciosity (species richness) –with about 800 species described to date – morphologies, behaviours and nest architecture (Evans & West Eberhard. 1970).

The Polistinae are primarily tropical (especially New-World tropics) in distribution but can be found world-wide.

To date 29 genera world-wide have been recognised (Carpenter, 1991) distributed in 4 tribes: Ropalidiini, Polistini, Mischocyttarini and Epiponini, of which only the first two are found in Hong Kong

Polistinae are small to very large wasps (*P.gigas*), with a declivous or petiolate first metasomal segment.

Fifteen species in two tribes (Polistini and Ropalidiini) have been recorded in Hong Kong and described in this guide:

- Tribe Polistini:
  - *Polistes gigas*.
  - *Polistes olivaceus*.
  - *Polistes jokahamae*.
  - *Polistes rothneyi*
  - *Polistes japonicus*.
  - *Polistes sagittarius*
  - *Polistes stigma*.
  - *Polistes strigosus*.
- Tribe Ropalidiini:
  - *Parapolybia indica*.
  - *Parapolybia nodosa*.
  - *Parapolybia varia*.
  - *Ropalidia fasciata*.
  - *Ropalidia hongkongensis*.
  - *Ropalidia marginata*.
  - *Ropalidia mathematica*.

Individuals in this sub-family are commonly referred to as “paper wasps” for their habit of forming sometimes complex multi-cellular nests out of a paper like material: chewed plant fibres, notably dry or rotten wood and other plant fibres (hairs). They are sometimes multi-combed and covered with an envelope but in Hong Kong all species recorded fabricate a single comb un-enveloped construction. They can be located either in the open or in sheltered locations.

Generally speaking world-wide, Polistinae are characterised by two major behavioural traits, based on their mode of colony founding and mechanism of reproductive dominance (Jeanne, 1991):

- Independent founders: colonies are initiated by one or several inseminated individuals (queens), independently of any workers. The nests are generally simply constructed without an external protective envelope. Soon after nest establishment, one of the founding queens becomes the sole egg layer. Reproductive dominance is maintained by the most aggressive queen. This group is made up of 5 genera: *Mischocyttarus*, *Belonogaster*, *Parapolybia*, *Polistes* and some *Ropalidia*.

- Swarm founders: colonies are initiated by a swarm of a large number of workers accompanied by a few queens. It is the workers that select the nesting site while the queen(s) wait until enough cells have been completed. Reproductive dominance in this group appears to involve pheromones. This group is made up of 20 genera of the tribe *Epiponini*, the genus *Polybioides* and some *Ropalidia*.

Generally in Hong Kong colonies of all species of Polistinae are independently founded by a single queen (haplometrosis). The dominance pattern in Polistinae follows a linear hierarchy in which each individual occupies a specific rank in the scale: at the top the  $\alpha$ -female (queen) which is dominant over all others, then the  $\beta$ -female dominant over all except the  $\alpha$ -female, and so on (Spradbery, 1991).

Queen status is maintained by an over-aggressive behaviour of the  $\alpha$ -female, and colony regulation is achieved by behavioural control rather than pheromones control<sup>25</sup>. However, a dominant female other than the  $\alpha$ -female can usurp the status, either directly by aggression or if the queen disappears (Spradbery, 1991).

Whilst queens of Polistinae are mainly confined to the nest, they are in fact responsible for many of the interactions that happen on the nest maintaining the social integrity of the colony as if "*the queen apparently directs her aggressive actions more towards the inactive workers than towards the active members of the colony, thus stimulating their participation in the activity of the colony*" (Spradbery, 1991). Additionally, queens are often responsible for the initiation of new cells.

The social development and cast organisation of Polistine wasps, places them between the primitive eusocial wasps (such as Stenogastrinae) and the more evolved Vespinae (yellow-jacket and hornets) and as such have become a favoured material for studies in socio-biology<sup>26</sup> and ethology as a paradigm of an intermediate stage in the evolution of eusociality. Analysis of the social organisation of species in genera such as *Polistes* and *Ropalidia* have permitted the definition of important features of eusociality such as, the quantification of the cost to benefit ratio of solitary nest foundation versus co-operative foundation; the understanding of the importance of relatedness and the behaviour of the sterile/subordinate workers within the context of the colony (Turillazzi, 1996).

A variety of ecological factors influence the colony cycle of *Polistes* (So., Yamane, 1996): climatic conditions, brood and egg **parasitoids** (Lepidoptera, Hymenoptera, Diptera) as well as direct predation by other insects (notably ants and some *Vespa* spp.) and vertebrates such as birds and mammals.

Predation by ants is possibly the single most important threat that small colonies face; particularly when the nest has to be left un-attended at foundation stage while a single foundress is away foraging. Consequently a number independent-founding species have developed a chemical defence mechanism against ants: they rub on the nest pedicel and sometimes on the apical part of the comb an ant repellent substance secreted by a gland situated on the sixth metasomal sternum, called the van der Vecht's gland (Reeve 1991).

The diet of the local Polistinae is summarized from various sources and personal observation in the following table:



Food source		Carbohydrates							Proteinaceous											
		Tree sap	Nectar from flowers	Nectar from extra-floral nectaries	honeydew	larva saliva	fruits	others	Dead arthropods	Vertebrate carrion	Polistinae and Stenogastrinae eggs, larvae & pupae	cannibalism	Apis sp, Honey bees	Adult Lepidoptera	Lepidoptera larvae	Diptera	Odonata	Hemiptera	Spiders	
Genus	Species																			
Polistes	gigas	•		• <sup>o</sup>		• <sup>h</sup>		•												•
Polistes	japonicus		•	• <sup>o</sup>		• <sup>h</sup>			• <sup>a</sup>	•					•					
Polistes	olivaceus					• <sup>h</sup>		• <sup>p</sup>	• <sup>a</sup>					•						
Polistes	rothneyi																			
Polistes	sagittarius													• <sup>d</sup>						
Polistes	jokahamae							• <sup>p</sup>							•					
Polistes	stigma		• <sup>n</sup>												•					
Polistes	strigosus	•		• <sup>o</sup>											•					
Parapolybia	indica	•	• <sup>k</sup>	• <sup>eo</sup>	•	• <sup>h</sup>		•	• <sup>c</sup>			• <sup>m</sup>		• <sup>l</sup>						
Parapolybia	nodosa	•	• <sup>l</sup>	• <sup>eo</sup>		• <sup>h</sup>					• <sup>a</sup>									
Parapolybia	varia					• <sup>h</sup>														
Ropalidia	fasciata					• <sup>j</sup>														
Ropalidia	hongkongensis			• <sup>e</sup>																
Ropalidia	marginata																			
Ropalidia	mathematica																			
Eustenogaster	nigra							• <sup>g</sup>	• <sup>f</sup>											

- Notes:
- a. Inter colonial brood cannibalism (Kasuya & Ito, 1980). This is a wide spread behaviour in Polistinae and Vespinae (Hunt, 1991) and could be expected for other species.

c. *P. indica* has been observed stealing provisions from spider webs. (pers. obs.)

d. *P. Sagittarius* takes many different species of Lepidoptera larvae as food provision (pers. obs.).

e. From *Ricinus* spp. (pers. obs.)

f. *Eustenogaster* spp are known to take small insects primarily collected from spider webs (Turillazzi, 1991).

g. *Eustenogaster nigra* provides a gelatinous abdominal secretion in empty cells, which amongst other function, is also a food supply for the larva.

h. These records are from personal observation but larvae saliva nourishment is a very wide spread behaviour in Vespidae (Hunt, 1991) and could be expected in other species.

j. From Raghavendra Gadagkar (Gadagkar, 1991).

k. Frequent forager of nectar on *Psychotria asiatica* (wild coffee). (pers.obs.)

l. From AFCD, Tai Lung Farm specimen label.

m. after nest attacked by *V. ducalis*

n. From flowers of *Lagerstroemia speciosa*, Queen Carpe Myrtle. (X.Q. Lee)

o. From *Mallotus paniculatus*, 23/03/07

p. Specimens seen feeding on Longan fruits

4.4.2Key to genera and species of Polistinae

This key is designed for females (workers) found in Hong Kong. It is partly adapted from various sources (Das & Gupta, 1989; Starr, 1992, Yamane, Se. 1999) partly deduced from local species characteristics. Refer to Fig.1, 2 & 3 for definition of morphological features.

- a. metasomal segment 1 gradually narrowed anteriorly, not petiolate.
  - b. Small to very large wasps. ----- genus ***Polistes*** (2)
  - aa. Metasomal segment petiolate, usually strongly swollen posteriorly.
  - bb. Small to medium wasps.----- (9)
- 2(1).**
- a. Head from above with frontal keel produced conspicuously.
  - b. Clypeus with dense puncturations.
  - c. Very large wasp, exceeding 25mm, body entirely dark black/rufous. ----- ***Polistes gigas***.
  - aa. Frontal keel not produced conspicuously.
  - bb. Clypeus with less dense puncturations.
  - cc. Medium wasps never exceeding 20mm, body variously coloured. ----- (3).
- 3(2).**
- a. Pronotum (pn) distinctly striate.
  - b. Pronotum (pn) with conspicuous carina separating its dorsal and lateral sides. -- ***Polistes strigosus***.
  - aa. Pronotum (pn) not striate.
  - bb. Pronotum (pn) without a conspicuous carina separating its dorsal and lateral sides. ----- (4).
- 4(3).**
- a. Mesoscutum (ms), propodeum (pp) and 3 last metasomal tergum black. ----- ***Polistes sagittarius***.
  - aa. Mesoscutum (ms), propodeum (pp) and 3 last metasomal tergum of various colorations, not black----(5).
- 5(4).**
- a. Fore wing with a conspicuous black stigma apically.
  - b. Body mainly brown with lateral sides of propodeum (pd) and apical part of terga 2 and 3 yellow.
  - c. Small wasps not exceeding 14mm. ----- ***Polistes stigma***.
  - aa. Fore wing without a conspicuous black stigma apically.
  - bb. Body mainly yellow/orange with black markings on the coxae (cx), femurs and thoracic sterna.
  - cc. Medium size wasps superior to 14mm. ----- (6).
- 6(5).**
- a. Epicnemial carina (ec) absent or incomplete.
  - b. Mesopleural signum (sg) absent.
  - c. Dorsal groove (dg) absent or incomplete. ----- ***Polistes japonicus***
  - aa. Epicnemial carina (ec) present and well developed.
  - bb. Mesopleural signum (sg) present.
  - cc. Dorsal groove (dg) present and well developed. ----- (7)
- 7(6).**
- a. Mesopleuron (ms), metapleuron (mt) with obvious puncturations.
  - b. Propleuron (pl), mesepisternum (ms), metapleuron (mt) and coxae (cx) coloured in black.
  - c. Medium large wasp, body exceeding 17mm in length. -----(8)
  - aa. Mesopleuron (ms), metapleuron (mt) with no obvious puncturations.
  - bb. Propleuron (pl), mesepisternum (ms), metapleuron (mt) and coxae (cx) coloured in yellow.
  - cc. Smaller wasp, body not exceeding 16.5mm in length. -----***Polistes olivaceus***
- 8(7).**
- a. Transverse striations of the propodeum weak, not reaching the interface with ventral metapleuron.
  - b. Dorsal part of pronotum without a black line.
  - c. Occipital carina incomplete not reaching the base of the mandible, or faint on the lower third.
  - d. Body colour orange with black markings-----***Polistes jokahamae***
  - aa. Transverse striations of the propodeum strong, reaching the interface with ventral metapleuron.

- bb. Dorsal part of pronotum with a black line.
- cc. Occipital carina completes reaching the base of the mandible.
- dd. Body Colour mainly bright yellow with black markings ----- *Polistes rothneyi*

**9(1).**

- a. Metasomal sternum 2 and tergum fused.
- b. Small wasps, not exceeding 14mm. ----- genus *Ropalidia* (12)
- aa. Metasomal sternum and tergum 2 not fused, overlapping
- bb. Larger wasps exceeding 14mm. ----- genus *Parapolybia* (10)

**10(9).**

- a. Occipital carina complete.
- b. Larger wasps, body often exceeding 15mm in workers. ----- *Parapolybia indica*
- aa. Occipital carina incomplete.
- bb. Smaller wasps, body rarely exceeding 14mm in workers. ----- (11)

**11(10).**

- a. Mesoscutum (ms) uniformly coloured in red.
- b. Clypeus divided in two with a brown mark enlarged ventrally
- c. Ground colour dark brown with conspicuous white markings.
- d. Interocular distance less at clypeus than at vertex ----- *Parapolybia nodosa*.
- aa. Mesoscutum (ms) with 2 yellowish bands laterally.
- bb. Clypeus not divided in two, brown mark only present on the dorsal side.
- cc. Ground colour brown with conspicuous yellow markings.
- dd. Interocular distance equal at clypeus and vertex ----- *Parapolybia varia*.

**12 (9).**

- a. Lateral sides of propodeum (pr) striate
- b. Clypeus same colour as head ----- (13)
- aa. Lateral sides of propodeum (pr) not striate
- bb. Clypeus generally mostly yellow ----- (14)

**13 (12).**

- a. Clypeus rounded ventrally.
- b. Body with black markings.
- c. 2<sup>nd</sup> metasomal segment with faint white/yellow dot latero-ventrally.
- d. Body not exceeding 12mm ----- *Ropalidia hongkongensis*.
- aa. Clypeus pointed ventrally.
- bb. Body without black markings.
- cc. 2<sup>nd</sup> metasomal segment without faint white/yellow dot latero-ventrally.
- dd. Body exceeding 12mm ----- *Ropalidia marginata*

**14 (12).**

- a. Posterior face of propodeum (pr) with medium groove extending to the basal side of the metanotum (mt).
- b. 2<sup>nd</sup> metasomal segment with a small yellow dot latero-dorsally.
- c. 2<sup>nd</sup> metasomal segment with large yellow band apically ----- *Ropalidia fasciata*.
- aa. Posterior face of propodeum (pr) with medium groove interrupted half way or obsolete, faint on the superior half, not apparently reaching metanotum (mt).
- bb. 2<sup>nd</sup> metasomal segment with a large yellow dot latero-dorsally.
- cc. 2<sup>nd</sup> metasomal segment with very narrow yellow band apically ----- *Ropalidia mathematica*

### 4.4.3 Genus *Polistes* Latreille, 1802:

Over 200 species of *Polistes* have been described to date (Reeve, 1991). The genus is represented worldwide. Locally five species in three sub- genera are recorded: *Gyrostoma*, *Megapolistes* and *Polistella*. *Polistes* can be either small (*P. stigma*) or very large (male *P. gigas*) wasps, with a great deal of variation in colour intra and inter-specifically, from dark brown/rufous to bright yellow.

Individuals in colonies of *Polistes* display very little cast dimorphism. The queen is generally un-conspicuous but can be spotted by its behaviour: if not active (initiating cells, laying eggs, feeding) she will generally occupy the apical part of the comb at the pedicel attachment.

The nests generally consist of a single pedicelate (be it vertical or horizontal but generally at 90° to the substratum) un-enveloped comb fabricated from chewed plant fibres, weathered wood and other materials including old nests. In some localities in Hong Kong, dry bamboo fibres are used predominantly<sup>27</sup> at initiation stage (pers. obs.). The material, resembling paper –hence the common name of these wasps - is generally finer but also more resistant to shear than that of most Vespinae species. Multiple petiolate nests with multiple combs are also encountered in various species of *Polistes* (Reeve, 1991) worldwide.

The length, position and orientation of the pedicel relatively to the cells longitudinal axis, is a constant intraspecifically, there is an identical comb attachment typology that is found across species that are closely related.

Colonies are; as a rule, annual whether located in tropical, sub-tropical or temperate climates (Yamane, 1996). In our sub-tropical climate with a marked cold and dry season the colony cycle of *Polistes* can be divided as following<sup>28</sup>:

1. The colony is initiated during March by one fertilised queen that has over-wintered.
2. The 1<sup>st</sup> offspring emerge in May and worker production will continue till September to November, depending on the species.
3. Males and **gynes** appear with the end of worker activity. Copulation is performed soon after.
4. The colony disintegrates between October and December and finally dies off.

There is considerable intraspecific variation in the degree of sexual dimorphism, and males can be either smaller, the same size or bigger than females, reaching gigantic proportions in *P. gigas*.



Fig.4.3.2, Distribution of the genus *Polistes* redrawn from H.K. Reeves 1991

***Polistes gigas* (Kirby, 1826).**

Tribe: Polistini Lepeletier, 1836; Sub-genus: *Gyrostoma* Kirby, 1828.

**Distribution:** Taiwan; South China to North India; Hong Kong

**Dimension:**

- Workers: 21-26mm.
- Queens: 25-27mm.
- Males: 27mm up to 45mm.

**Diet:** Specialist hunter, although it probably takes various species of caterpillars (mainly large larvae of the Papilionidae family) as food provision for its larvae. Adults are known to feed on tree sap, notably from various *Citrus* trees locally. Emerging queens have been observed feeding on extra-floral nectaries of *Mallotus paniculatus* (Turn in the Wind tree).

**Recognition marks:**

- Large wasp.
- Body entirely dark red/brown. Sometimes with faint banding of the metasomal segments.
- Female clypeus strongly punctuate with prominent frontal keel.
- Pronotum puncto-striate, other parts of the thorax densely punctuate.
- Dorsal mesepisternal groove absent; epicnemial carina present.

Can be confused with:

- *P. strigosus* but can be differentiated by the absence in *P. gigas* of a distinct angle between the dorsal and lateral portion of the pronotum that runs towards the tegula in. Additionally In *P. strigosus* the epicnemial carina is absent a

**Nest & Habitat:**

Un-protected, one sided asymmetrical and elongated paper comb construction with eccentric pedicel. Cells unspecialized i.e. there is no major difference in size for queens and workers, although male cells are exceptionally large. The nest material is composed of masticated plant fibre, bamboo is regularly used.

The nests are generally small containing commonly less than 100 cells (Yamane, 1996); although in Hong Kong fewer than 20 individuals seem to be the norm. They are to be found in concealed locations such as hollows in trees or other cavities (Lee, J.X.Q & Starr, C.K.; 2007.), but also in dense bushy vegetation sheltered from light, abandoned agricultural sheds and general dark places. The white cocoon caps; later maculated with brown are rather big affairs, densely woven, opaque and protrude by 5-10mm from the cell rims (see Plate 34 & 35. pers. obs.). The pedicel, the apical part of comb and a portion of the substrate is smeared with a hard coating secretion.

**Colony type:**

Small colonies in Hong Kong, never exceeding twenty individuals locally. No apparent size dimorphism between queens and workers.

**Note:**

Although widely distributed from China to India, *Polistes gigas* is not common generally; however in Hong Kong it seems to be the dominant species of paper wasp in some localities (pers. obs). It is recorded as one of the largest social wasps in the world with males measuring up-to 5cm in length. The species is known to be non-aggressive towards humans, although they possess a powerful sting that they will use if seized or colonies disturbed. Males are seen in November/December at the end of the colony cycle in Hong Kong when they are generally spotted outside the nest exhausted, often mutilated, after having fought with other males for mating privilege. They fight violently often in a form of ritualistic combat over apparently a small portion of territory (Lee, J.X.Q; 2007).

In Hong Kong inseminated females hibernate in group in crevices under tree bark and possibly other sheltered places.

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

Tribe: Polistini Lepeletier, 1836; Sub-genus: *Gyrostoma* Kirby, 1828.

**Distribution:**

Indian ocean Islands; Egypt; Oman; Iran; Afghanistan; North India; Sri Lanka; Nepal; Myanmar; South China; Hong Kong; Okinawa; Philippines; Indo-Chinese peninsula; Singapore; Borneo; Pacific Islands. Introduced in Chile, USA, Australia and New Zealand.

**Dimension:**

- Workers: 14-17mm.
- Queens: 16-18mm.
- Males: 18-20mm.

**Diet:** Near specialist hunter, although it probably takes various species of caterpillars as food provision for its larvae, and possibly plant nectar or plant fluids for adult feeding, although no record of adult feeding has been made locally.

**Recognition marks:**

- Medium large wasp.
- Body extensively yellow/orange in colour with few black markings on the thoracic sutures. Thoracic sterna and coxae yellow.
- Complete occipital carina.
- Epicnemial carina present, dorsal mesepisternal groove present.
- Mesopleural signum present.
- Very fine mesopleural puncturation.
- Mesosoma except propodeum with no puncturation.
- Clypeus higher than wide

Can be confused with:

- *P. japonicus*. The apparent difference between the two species is very tenuous but generally the ground colour of *P. olivaceus* is lighter and the specimens are also generally bigger. The recognition marks above should allow identification

**Nest & Habitat:** Un-protected, one sided symmetrical and compact (disk-like) paper comb construction with eccentric pedicel. Cells unspecialized (i.e. no major difference in size for males, queens and workers). Nests of this species are similar in shape and size to those of *P. japonicus*. Cocoon caps generally white, densely woven forming a depressed dome but sometimes with a short tubular cell extension with hemispherical end. The pedicel, the apical part of comb and a portion of the substrate is smeared with a hard coating secretion.

**Colony size:** Small to medium colonies, rarely exceeding fifty individuals in Hong Kong, although bigger colonies can be found. This is an aggressive species and nests should be approached with great care.

**Note:** Preparations from the nests of *Polistes olivaceus* are commonly used in Traditional Chinese Medicine as an anti-cancer decoction. *P. olivaceus* is rather defensive and nest should be approached carefully without disturbing the surrounding vegetation. The wasps will be quick to spot, locate and attack all that moves and comes too close. Colonies often fall prey to hornet attacks, particularly, *V. affinis*, *V. soror*, *V. tropica* and *V. ducalis*.

### ***Polistes rothneyi* Cameron, 1900.**

Tribe: Polistini, Lepeletier 1836; Sub-genus: *Gyrostoma* Kirby, 1828.

**Distribution:** East Asia: India, Nepal; South East Asia: China, Hong Kong, Indochina and Japan

**Dimension:**

- Workers: +/-16mm.
- Queens: Not recorded by the author.
- Males: +/-17mm.

**Diet:** Diet unknown locally, although like other *Polistes* it certainly takes a variety of caterpillars as food provision for its larvae and possibly plant nectar or plant fluids for adult feeding, although no record of adult feeding has been made locally.

**Recognition marks:**

- Medium large wasp.
- Mesopleuron mainly black, metapleuron black, Mesoscutum black with two fine yellow lines. Ground colour bright yellow.
- Epicnemial carina, dorsal groove, scrobal sulcus and mesopleural signum present.
- Mesopleuron with coarse puncturation posteriorly

Can be confused with:

- To some extent with *P. japonicus* or *P. olivaceus* but the extensive black markings on the thorax, the femurs and the antennae allows differentiation

**Nest & Habitat:** No nest has been recorded to date locally, however nests found in Taiwan have a centric pedicel and a flat comb made out of chewed plant matter and may have up to 700 cells, which is rather large for any *Polistes* species (Starr; 1992).

**Colony size:** Not recorded by the author locally.

**Note:** This species has so far only been recorded from specimens collected in the northern New Territories but it could be a common species in southern Guangdong. Locally it is not overly common and only a few sightings have been made so far. Most of the literature applies sub-species denomination to this species which I have not used in this work as only one species seems to be present locally.

### ***Polistes jokahamae* Radszkowski, 1887.**

Tribe: Polistini, Lepeletier 1836; Sub-genus: *Gyrostoma* Kirby, 1828.

**Distribution:** India; China; Hong Kong; Mongolia; Korea; Japan (including Ryukyu Islands); Taiwan; Society Islands (Bora Bora, Tahiti, Tuamotu Archipelago: Napuka; Introduced in Hawaii.

**Dimension:**

- Workers: 17-18mm.
- Queens: Not recorded by the author.
- Males: 18-19mm.

**Diet:** Diet not well documented locally, although like other *Polistes* it certainly takes a variety of caterpillars as food provision for its larvae and plant nectar or plant fluids for adult feeding.

**Recognition marks:**

- Medium large wasp.
- Epicnemial carina, dorsal groove, scrobal sulcus and mesopleural signum present.
- Mesopleuron, metapleuron and coxae black. Ground colour dark orange
- Clypeus wider than high

Can be confused with: None of the local *Polistes*. Additionally this species with *P. rothneyi* is the only *Polistes* that has a nest with a central pedicel.

**Nest & Habitat:** Un-protected, one sided symmetrical and compact (disk-like becoming near hexagonal) paper comb construction with centric pedicel. Cells unspecialized i.e. no major difference in size for males, queens and workers. Only one colony has been recorded, although this nest contained many individuals it was in fact abandoned with no eggs, brood or pupae. Found on the underside of the roof overhang of a tin shed.

**Colony size:** Small to medium size colonies in Hong Kong. Fifty individuals might be a maximum locally

**Note:** This species as so far only been recorded in the northern New Territories but could be a common species in southern Guangdong.

### ***Polistes japonicus* de Saussure, 1858.**

Tribe: Polistini Lepeletier, 1836 ; Sub-genus : *Polistella* Ashmead, 1904.

**Distribution:** China; Hong Kong; Korea; Japan (including Ryukyu Islands); Taiwan.

**Dimension:**

- Workers: 12.5-15mm.
- Queens: 14-15mm.
- Males: +/- 12.5-13.5mm

**Diet:** Near specialist hunter, although it probably takes various species of caterpillars as food provision for its larvae. Occasional records of tree sap have been made for adult feeding. Emerging



queens have been observed feeding on extra-floral nectaries of *Mallotus paniculatus* (Turn in the Wind tree).

#### Recognition marks:

- Medium large wasp
- Body extensively yellow/orange in colour with black markings on the thoracic sutures. Thoracic sterna, basal and dorsal sides of coxae black.
- Incomplete occipital carina
- Epicnemial carina and mesopleural signum absent
- Dorsal mesepisternal groove present.
- Coarse mesopleural puncturation.
- Mesosoma except propodeum with dense puncturation.
- Clypeus width equal to its height.

Can be confused with:

- *P. olivaceus*. The apparent difference between the two species is very tenuous but generally the ground colour of *P. japonicus* is darker, and specimens are also generally smaller. The recognition marks above should allow identification.

#### Nest & Habitat:

Un-protected, one sided asymmetrical and compact (disk-like) paper comb with eccentric pedicel. Cells unspecialized (i.e. no major difference in size for males, queens and workers). The nest material is composed of masticated plant fibre. Nests are found on the underside of broad leaves shrubs; bushes, ferns and trees, generally quite close to the ground. The cocoon caps are coloured bright yellow/cream, densely woven forming a depressed dome but sometimes with a short tubular cell extension with hemispherical end. The pedicel, the apical part of comb and a portion of the substrate is smeared with a hard coating secretion.

#### Colony size:

Small to medium size colonies, rarely exceeding twenty workers locally. Temporary pleometrosis is observed in Japan (Spradbery, 1991). There is no distinct size dimorphism between queens, workers and males.

#### Note:

Foundress queens of *P. japonicus* are known to cannibalise nests of the same species found in its vicinity, devouring eggs, larvae or pupae (Kasuya, 1980). *P. japonicus* is a common paper wasp in Hong Kong. It is an aggressive species and nest should be approached with great care. Colonies often fall prey to hornet attacks, particularly, *V. soror*, *V. affinis*, *V. tropica* and *V. ducalis*.

In one instance co-operative founding of nest had been observed locally, where 2 females collaborated on a single nest. In effect the number of cells during initiation stage on that nest was higher than on other colonies nearby. The colony will produce males as early as end of July locally.

### ***Polistes sagittarius* de Saussure, 1853.**

Tribe: Polistini Lepeletier, 1836 ; Sub-genus : *Polistella* Ashmead, 1904.

#### Distribution:

North India; Sikkim; Nepal; China; Hong Kong; Myanmar; Thailand; Malaysia; Singapore; Sumatra; Sulawesi.

#### Dimension:

- Workers: 14-16mm.
- Queens: +/-17mm.
- Males: not recorded by the author.

#### Diet:

Near specialist hunter, although it takes various species of caterpillars as food provision for its larvae and possibly plant nectar or plant fluids for adult feeding, although no record of adult feeding has been made locally.

#### Recognition marks:

- Medium large wasp.
- Scutellum, metanotum and anterior part of pronotum rusty red.
- First metasomal segment with black zone at the anterior margin of the terga, the rest rusty red in colour. Second metasomal segment yellow/orange. Third to fifth metasomal terga black.
- Ocellar region black.

- Propodeum striate

Can be confused with:

- None of the local *Polistes*, but by stretching it there is some resemblance to *Vespa tropica*, although the difference in morphology of the 1<sup>st</sup> metasomal segment is a quick identification rule.

**Nest & Habitat:** Un-protected, one sided asymmetrical and compact (disk-like) paper comb construction with eccentric pedicel perpendicular to the cell longitudinal axis. Cells unspecialized i.e. no major difference in size for males, queens and workers. The cocoon caps are white, densely woven and protrude only slightly from the cell rims. The nests are always exposed and affixed to the vertical side of major branches of various trees and bushes.

**Colony size:** Small size colonies in Hong Kong with a maximum of 10-15 workers.

**Note:** Nests of *P. sagittarius* fall prey to larger Vespids such as *V. soror*, *Vespa affinis* or *V. ducalis*. The wasp is protective of her nest surroundings and care should be taken if a colony is approached.

### ***Polistes stigma* Fabricius, 1793.**

Tribe: Polistini Lepeletier, 1836 ; Sub-genus : *Polistella* Ashmead, 1904.

**Distribution:** Thailand; Malaysia; Singapore; Indonesia; Taiwan; Hong Kong; Philippines and Australia

**Dimension:**

- Workers: 11-14mm.
- Queens: Not recorded by the author
- Males: +/- 10mm

**Diet:** Specialist hunter, although it probably takes various species of caterpillars as food provision for its larvae. Adults are known to forage pollen and plant nectar.

**Recognition marks:**

- Small wasp, the smallest of the local *Polistes*.
- Fore wings with a distinctive black stigma on the apical end.
- Body largely rufous with bright yellow markings on the dorsal edge of the pronotum, on the metanotum, and as bands on the apical ends of metasomal segment 1&3.

Can be confused with:

- None of the local *Polistes*.

**Nest & Habitat:** No nests have been yet recorded locally by the author. But C.K. Starr (Starr 1992) notes that the nests have an eccentric pedicel and never become very large. They are formed by a light brown carton material and have evidently a varnish like substance smeared on the pedicel.

**Colony type:** Possibly small colonies in Hong Kong.

**Note:** A not so common paper wasp in Hong Kong. *P. stigma* is the smallest of local Polistine wasp. Individuals are often spotted in urban parks (X. Q. Lee, pers. comm.).

### ***Polistes strigosus* Bequaert, 1940.**

Tribe: Polistini Lepeletier, 1836 ; Sub-genus : *Polistella* Ashmead, 1904.

**Distribution:** Taiwan; Continental China; Hong Kong; Philippines and Vietnam.

**Dimension:**

- Workers: 18-19mm.
- Queens: 18-19mm.
- Males: 18-20mm.

- Diet:** Specialist hunter, although it probably takes various species of caterpillars as food provision for its larvae. Adult have been recorded to feed on tree sap, notably on various species of *Citrus* trees.
- Recognition marks:**
- Medium large wasp. Body entirely dark reddish to reddish brown.
  - Dorsal and lateral portion of the pronotum separated by a distinct angle running towards the tegula
  - No dorsal mesepisternal groove.
  - Clypeus higher than wide.
- Can be confused with:
- *P.gigas*. However, it lacks the conspicuous distinct angle between the dorsal and lateral portion of the pronotum present in *P. strigosus*. Additionally only *P. strigosus* has its clypeus higher than wide and is smaller than *P. gigas*.
- Nest & Habitat:** Nests are generally small and affixed to leaves of various trees but also grasses and small bushes close to the ground. The nest architecture is similar to that of *P. sagittarius* with a pedicel forming a right angle to the longitudinal axis of the cells.
- Colony type:** Small to medium size colonies in Hong Kong.
- Note:** *Polistes strigosus* is not common across the territory and little is known about its biology. This species is closely related to *P. sagittarius* and may share similar biological traits such as, food provisions and cast structure.

#### 4.4.4 Genus *Parapolybia* de Saussure, 1854.

The genus *Parapolybia* contains five species distributed from Iran in the West to Japan the Philippines and New Guinea in the East (Vecht, 1966). Of those, three are found locally.

All species have the first metasomal segment strongly petiolate and more or less pronounced yellow or white markings.

Within species of the genus *Parapolybia* there is a considerable regional variability in colour patterns, particularly in *P. varia*<sup>29</sup> (Vecht, 1966). Additionally, amongst the same species locally one can be surprised by the varying degrees of sizes and colorations according to the stage of the colony and age of workers.

Colonies, in Hong Kong, are founded by a single inseminated female, although multiple foundress colonies have been observed in *P. varia* (Gadagkar, 1991). The colony in Hong Kong is annual and of medium size at best (rarely more than 100 individuals).

The Queens in this genus rarely leaves the nest and monopolises the oviposition process by physically disturbing any attempt of oviposition by a sub-ordinate worker (Gadagkar, 1991).

Although in *Parapolybia* colonies, as with the more advanced eusocial Vespidae, a reproductive division of labour exists between the queens and the workers there is no marked morphological difference between the two.

The nests generally consist of an un-enveloped comb assuming a toroid (folded) surface, fabricated from chewed plant fibres and secretions. At initiation the pedicel is always centred on a cell (Wenzel, 1991) and as the nest develops it becomes eccentric relative to the comb.

The **meconium** (larvae faeces) is removed by the workers through a hole made at the base of the cell; just before pupation; later plugged with a capsule by adults with saliva, for larvae pupation. After emergence of the worker the cell is often re-used.

*Parapolybia* species are known to rub ant repellent on the nest pedicel; this has been observed locally for *P. nodosa* and known to occur in *P. indica* (Kojima, 1983).



Fig.4.3.3, Distribution of the genus *Parapolybia*. Redrawn from R. Gadagkar, 1991

#### *Parapolybia indica* (de Saussure, 1854).

Tribe: Ropalidiini.

**Distribution:** India, Myanmar; Borneo; South China; Hong Kong; Taiwan; Korea and Japan.

**Dimension:**

- Workers: 13-18mm.
- Queens: 14-18mm.
- Males: 12-14mm.

**Diet:** Generalist hunter and scavenger. Adults are known to feed on sap from various *Citrus* trees locally as well as extra floral nectaries of *Ricinus communis* (Castor plant), *Mallotus paniculatus* (Turn in the Wind tree) and honeydew.

**Recognition marks:**

- Medium wasp, entirely orange/yellow with faint darker markings on the second metasomal terga.
- Clypeus entirely orange/yellow.
- Occipital carina reaching the base of the mandibles.

Can be confused with:

- *P. varia*.
- *P. nodosa*.

However, *P. indica* is markedly larger than both species and is the only local *Parapolybia* that has a complete occipital carina. The ground colour is also less contrasting with less conspicuous white/yellow marks on the metasomal segments. Because of their light coloration and small sizes, the first workers to emerge can be superficially confused with *P. varia*.

**Nest & Habitat:**

Un-protected, one sided, asymmetrical paper comb construction. The pedicel is composed as a vertical reinforced sheet of paper as if several pedicels had been fused together. The nest material is composed of masticated plant fibre, principally plant hairs (pers. obs.). The fine plant fibres are generally loosely woven together with secretions, and the paper resembling rice paper. The cells are unspecialized (i.e. no major difference in size for males, queens and workers). Colonies are generally located in semi-concealed locations such as undersides of broad leaves, inside creepers and vines (*Ficus pumila*, *Piper sp.* *Pandanus austrosinensis*) and low bushes. They can be found close to the ground or up in trees (*Prunus mume*. pers. obs.) and on building ledges and soffits.

**Colony type:**

Medium colonies rarely exceeding 100 workers locally.

**Note:**

*P. indica* is a common species in Hong Kong. The wasp is relatively un-aggressive and nests can be approached carefully without being attacked. Colonies of *P. indica* often fall prey to larger Vespids notably *Vespa soror*, *Vespa ducalis*, *V. affinis* and *V. tropica* that seek the nutritious larvae and pupae. *P. indica* may put up a fight but the fragile paper-wasps are no match for the local hornets and soon the colony retreats and later abandons the nesting site, the remaining brood being cannibalised (pers. obs.). The heavy predation of mature colonies by *Vespa spp* in Hong Kong is the cause of the demise by early to mid August of nearly all nests recorded. This happens generally close to or a few weeks after reproductives emergence (pers. obs.)

The newly emerged wasps are normally lighter in colour and at the beginning of the season (May) young individuals may be markedly smaller than those emerging later (pers. obs.). Males are often produced early in the season in mid July with the colony disintegrating as soon as September or October.

*P. indica* applies an ant-repellent to the pedicel, the apical part of the comb and the substrate (Kojima, 1983; pers. obs.).

When a colony of *P. indica* is disturbed, one of defensive response of the workers is to drop droplets of liquid on the supposed menace (pers. obs.).

***Parapolybia nodosa* van der Vecht, 1966.**

Tribe: Ropalidiini.

**Distribution:**

India; Nepal; Myanmar; Thailand; China; Hong Kong and Taiwan

**Dimension:**

- Workers: 11- 14mm.
- Queens: 14-15mm.
- Males: not recorded by the author.

**Diet:**

Generalist hunter and scavenger. Adults are known to feed on sap from various *Citrus* trees locally as well as extra floral nectaries of *Ricinus communis* and *Mallotus paniculatus* (Turn in the Wind tree), (pers. obs.).

**Recognition marks:**

- A small wasp, brownish in colour with conspicuous pale yellow markings on the entire body, particularly on the metasomal terga.
- Occipital carina incomplete, absent in the lower 1/3.
- Mesoscutum reddish brown with no longitudinal markings.

Can be confused with:

- *P. indica*. Size and the incomplete occipital carina of *P. varia* are conclusive identification characters
- *P. nodosa*. The two wasps are morphologically nearly identical, colours and patterns being the only clear differentiation marks, particularly the mesoscutum.

**Nest & Habitat:** Un-protected, one sided asymmetrical paper comb construction with eccentric pedicel at initiation. It gradually becomes tubular with the cell opening facing outwards. Cells unspecialized (i.e. no major difference in size for males, queens and workers). The nest material is composed of masticated plant fibre. They are commonly found in shaded areas with dense vegetation fixed to a variety of supports: underside of broad leaves, hanging from small branches, under fronds etc. The white cocoon caps; later maculated with brown are loosely woven and protrude only slightly from the cell rims.

**Colony type:** Small colonies rarely exceeding 100 workers in Hong Kong. The Queen rarely leaves the nest and monopolises the oviposition process by physically disturbing any attempt of oviposition by a sub-ordinate worker (Gadagkar, 1991)

**Note:** J. Van der Vecht (Vecht, 1966) distinguished *P. nodosa* from *P. varia* on the basis that in side view *P. nodosa* had a more strongly swollen **petiole** apically. However, from personal observation this morphological feature is not distinct in Hong Kong and both species have a similar petiole apex<sup>30</sup>. Locally, colour patterns seem to be the recognition marks and colour intensities and contrast are well marked (pers.obs).  
*P. nodosa* applies to the nest pedicel, the apical part of the comb and the substrate, a chemical ant repellent (see Plate 75). This is done alternatively by several individuals working at close intervals (every 5-10mins) rubbing their last sterna to the surface to be treated (pers.obs).

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

Tribe: Ropalidiini.

**Distribution:** India; Nepal; Myanmar; Thailand; Malay peninsula; Borneo; Sulawesi; Sumbawa; Sumba; Philippines; China; Hong Kong; Korea and Japan.

**Dimension:**

- Workers: 11-14mm.
- Queens: +/- 13mm.
- Males: 11.5-14mm.

**Diet:** Generalist hunter and scavenger. No record of adult feeding as been made by the author locally.

**Recognition marks:**

- A small/medium wasp, brownish in colour with conspicuous pale yellow markings on the entire body, particularly on the metasomal terga.
- Occipital carina incomplete, absent in the lower 1/3.
- Gradual darkening of the postscutellum from the middle.

Can be confused with:

- *P. indica*.
- *P. nodosa*.

**Nest & Habitat:** Un-protected, one sided, asymmetrical paper comb construction with eccentric pedicel. Cells unspecialized (i.e. no major difference in size for males, queens and workers). The nest material is composed of masticated plant fibre and secretions. They are commonly found in shaded areas with dense vegetation fixed to a variety of supports: underside of broad leaves, hanging from small branches, under fronds etc, generally relatively close to the ground.

**Colony type:** There is evidence that this species has a regional varying degree in nest initiation strategy: pleometrotic in Southern Taiwan, haplometrotic in North-Central Taiwan and Japan (Spradbery, 1991). There is no distinct size dimorphism between queens and workers.

**Note:** *P. varia* can be found in association with other *Parapolybia* species, particularly with *P. varia*. A rather un-usual association of the two species has been observed (X.Q.Lee, pers. comm.): a queen of *P. indica* was successfully transplanted experimentally on a nest of *P. varia* that had lost its own queen. The wasps were observed interacting and even performing **trophallaxis**.

#### 4.4.5 Genus *Ropalidia* Guérin-Méneville, 1831.

The genus *Ropalidia* comprises of nearly 180 known species worldwide, distributed from Africa to South East Asia, Australia, and the Ryukyus islands. Locally four species are recorded.

They are usually small wasps with contrasting colours. This genus displays the greatest diversity amongst all Vespidae in terms of both social organisation and nest architecture. Some species are swarm founders while others are independent founders. However, the four local species are apparently independent founders but cases of pleometrosis cannot be excluded locally as there is un-sufficient data to make a point.

Nests of *Ropalidia* are generally composed of one elongated and un-enveloped comb suspended by a short pedicel, although, sometimes several pedicles are to be found. The genus has developed likewise other Polistine wasps an ant defence mechanisms that consist in applying an ant-repellent (secreted by a gland situated on the sixth metasomal sternum) on the pedicle and its attachment to the substrate (Gadagkar, 1991).

Colonies often fall prey to larger Vespids, notably *Vespa tropica* that consumes the entire brood of larger colonies. When this happens the workers and queen are untouched by the predator and they wait until the act is over, returning to the nest where it has been observed that the remaining brood is cannibalised by the surviving workers. Ichneumon flies, Trygonalid wasps and Diptera are the most common parasites found in *Ropalidia* spp colonies.

As with *Parapolybia* spp, *Ropalidia* spp remove the meconium from the cell before pupation of the larvae through a hole made at the base of the cell which is later plugged by the workers for larvae pupation. The cells are generally re-used after emergence of new workers

Adult/larvae trophallaxis is common amongst this genus, whereby an adult by mouthing a larva solicit a droplet of fluid that is imbibed by the adult.

As opposed to most Polistinae, males of *Ropalidia* spp are often produced at any time of the colony cycle, particularly with *R. fasciata* (Gadagkar, 1991) and *R. hongkongensis* (pers. obs).



Fig.4.3.4, Distribution of the genus *Ropalidia*. Redrawn from R. Gadagkar, 1991.

#### *Ropalidia fasciata* (Fabricius, 1804).

Tribe : Ropalidiini ; Sub Genus : *Anthreneida* White

**Distribution:** India to South Eastern China; Hong Kong; Palawan; Sunda Islands; Taiwan and the Ryukyus islands.

**Dimension:**

- Worker: +/- 9-10mm.
- Queens: Not recorded by the author.
- Males: Not recorded by the author.

**Diet:** Specialist hunter, although it probably takes several species of caterpillar.



**Recognition marks:**

- A small wasp.
- 2<sup>nd</sup> metasomal segment bell-shaped.
- Yellow dot on latero-dorsal side of the 2<sup>nd</sup> metasomal segment expanded.

Can be confused with:

- *R. hongkongensis*, however the coloration, particularly the yellow marking on the 1<sup>st</sup> terga of *R. fasciata*, should be a confirming character.
- *R. mathematica*, however the incomplete or obsolete propodeal medium groove allows differentiation.
- *R. marginata*, but *R. fasciata* is much smaller and has a yellow dot on latero-dorsal side of the 2<sup>nd</sup> metasomal segment, not present in *R. marginata*.

**Nest & Habitat:**

Un-protected, elongated single paper comb with sometimes many rows of cell, attached to the substrate with a short eccentric pedicel. I have noted locally, a nest with a bifid pedicel seemingly as a structural reinforcement (see plate). Multi-combs constructions are recorded from Palawan (Starr, 1992). Cells unspecialized (i.e. no major difference in size for males, queens and workers). The nest material is composed of masticated plant fibre and secretions. The material is in this group much weaker than in other Polistinae, and the assemblage of the fibres is loose creating a kind of “laced” texture typical of the genus. The cocoon caps are densely woven forming a very depressed dome. . The pedicel, the apical part of comb and a portion of the substrate are smeared with a hard coating secretion.

**Colony size:**

Small to medium size colonies locally, however, mature colonies with more than 1000 workers seem to be quite common in Taiwan (Starr, 1992). On Okinawa Islands researchers have observed colonies founded by several queens (pleometrotic foundation) (Ito & Iwahashi 1987; Gadagkar, 1991; Kojima, 1984) and there is a possibility that in Hong Kong the same happens, although there is no records to support this. There is no distinct size dimorphism between queens and workers.

**Note:**

Although the rubbing behaviour noted for some Polistinae (see 3.3.1 above) is also observed for *Ropalidia spp* (Gadagkar, 1991; Kojima, 1984), the short pedicle with which the nest is attached to the substrate seems to be un-sufficient protection. Consequently, nests in Hong Kong are often found over water bodies fixed to water plants (pers. obs.). This could be interpreted as a mechanism that provides an additional degree of protection against ant predation. However hornets such as *V. tropica* are major predators of the nests of this genus.

The queen is the only egg layer in the colony and she maintains this reproductive dominance by direct physical attack on her sub-ordinates. Additionally, it is noted that the social relationship amongst nest mates is rather loose or less pronounced than with other Polistines (Kojima, 1984).

***Ropalidia hongkongensis* (de Saussure, 1854).**

Tribe : Ropalidiini ; Sub Genus : *Anthreneida* White

**Distribution:**

South China and Hong Kong.

**Dimension:**

- Workers: 10-12mm.
- Queens: 10.5-12mm.
- Males: +/- 10mm.

**Diet:**

Specialist hunter, although it probably takes several species of caterpillar. I have observed this species feeding on extra floral nectaries of *Ricinus communis* (Castro plant) locally.

**Recognition marks:**

- A small wasp.

Can be confused with:

- *R. fasciata*, however the coloration, particularly the yellow marking on the 1<sup>st</sup> terga of *R. fasciata*, and the general reddish/brownish ground colour of *R. hongkongensis* should be confirming characters.
- *R. mathematica*, however the incomplete or obsolete propodeal medium groove allows differentiation.

- Nest & Habitat:** Un-protected, elongated single paper comb construction with a short eccentric pedicel. Cells unspecialized (i.e. no major difference in size for males, queens and workers).
- Colony type:** Small to medium size colonies. There is no distinct size dimorphism between queens and workers.
- Note:** Very little is known about the particular biology of this species, although other *Ropalidia* spp are rather well documented.

### ***Ropalidia marginata* (Lepeletier, 1836).**

Tribe: Ropalidiini ; Sub Genus : *Anthreneida* White

**Distribution:** India, Sri Lanka, Pakistan, Hong Kong, Myanmar, Vietnam, Indonesia, Malaysia, Thailand, Philippines, Papua New Guinea, Australia, New Caledonia and the Marianna Islands.

**Dimension:**

- Workers: 13-14mm
- Queens: Not recorded by the author.
- Males: Not recorded by the author.

**Diet:** Although the specific diet of *R. marginata* has not been recorded locally, it most certainly feed its brood with larvae of small Lepidoptera as well as plant nectar, as with most Polistine wasp.

**Recognition marks:**

- Large *Ropalidia*, in fact the largest in Hong Kong.
- No yellow dot on 2<sup>nd</sup> metasomal segment.
- Clypeus same colour as head.

Can be confused with:

- *R. fasciata*, but there is a marked size difference between the two species, *R. marginata*, being conspicuously larger.

**Nest & Habitat:** Nests of this species are elongated affairs when mature, composed of 4-5 rows of cells arranged vertically without an envelope. It has a single pedicel at the beginning and when the nest grows, additional pedicels are often added. The nest is generally parallel to the substrate in a vertical orientation. Colonies can be found in sheltered places, often on the underside of roof eaves and other man made structure.

**Colony type:** In Hong Kong it seems that colonies are founded by one queen (haplometrotic). However this species is well known for its pleometrotic foundation (several queens) in places like India. There is no clear size dimorphism between queen and workers (Gadagkar, 2001).

**Note:** This species has so far only been found in a small area of the North Central New territory and does not seem common at all. There is a clear reproductive cast differentiation in this species (Gadagkar, 2001) and the queen is the only egg laying individual in the colony.

### ***Ropalidia mathematica* (Smith, 1860).**

Tribe: Ropalidiini; Sub Genus: *Anthreneida* White

**Distribution:** India; Thailand; Vietnam; most Indonesia and Hong Kong.

**Dimension:**

- Workers: 9-9.5mm.
- Queens: Not recorded by the author.
- Males: Not recorded by the author.

**Diet:** Near specialist hunter

**Recognition marks:**

- A small wasp.

- Incomplete or obsolete median propodeal groove.

Can be confused with:

- *R. fasciata*, however the general ground coloration and the extend of the propodeal groove should allow differentiation.
- *R. hongkongensis*. The ground colour is quite dissimilar and the extend of the propodeal groove permits identification.
- *R. marginata*, although *mathematica* is the smallest species of *Ropalidia*. The ground colour is also different.

**Nest & Habitat:**

Un-protected one sided paper comb with a single eccentric pedicel. The nest takes on characteristic drop shape at maturity (see plate). Nests are generally found in hidden locations. They are mainly made out of secretions and fine plant fibres assembled in a loose manner leaving numerous small “windows” on the surface. Cells unspecialized (i.e. no major difference in size for males, queens and workers). The pedicel, the apical part of comb and a portion of the substrate is smeared with a hard coating secretion.

**Colony type:**

Small to medium size colonies. There is no distinct size dimorphism between queens and workers.

**Note:**

*R. mathematica* is a common wasp in Hong Kong although often overlooked due to its minute size, often found in urban gardens and parks. It is in fact a new record for the territory and by extension for China (Barthelemy, 2006).

Females have been observed performing some kind of territorial flight, a small bush being used as hovering/landing site by up to four females (pers.obs.).

## 4.5 Stenogastrinae

### 4.5.1 General biology of the Stenogastrinae

The Stenogastrinae or hover wasps – so named for their habit of hovering in flight - comprises of approximately fifty described species divided into six genera: *Anischnogaster*, *Stenogaster*, *Metischnogaster*, *Liostenogaster*, *Parischnogaster* and *Eustenogaster*. Only the later is represented in Hong Kong with apparently only one species:

- *Eustenogaster nigra*.

It is a poorly studied sub-family - maybe as a result of their limited geographical distribution, their shy habits and cryptic nest locations - although regarded as a very important sub-family having developed behavioural traits marking the early phases of evolution of eusociability in social wasps (Turillazzi, 1991).

Habitats range from sea level to altitudes of up to 1700m (Mt Kinabalu). Nesting sites are usually found in protected, dark and humid places with more or less constant humidity and temperature. There is a considerable variability in nest architecture allowing in some instances to determine, at the genus level the identity of the builder (Turillazzi, 1991). None of the Stenogastrinae nests have a petiole, which is a distinguishing feature of this sub-family; they are directly attached to the substrate. Material range from solid or brittle mud cells to light mix of soil particles and plant matter or simply fine plant fibres.

The size of these wasps varies from 1cm in small species of *Parischnogaster* to 2 cm or above in large *Eustenogaster*. They all have a slender body with a very long petiole (1<sup>st</sup> metasomal segment), short legs, bulbous mesosoma and unfolded wings.

Colonies are generally initiated by a single inseminated queen although associative foundation of several queens has been noted for several species such as *Parischnogaster alternata*, *Liostenogaster flavolineata* or *P. jacobsoni* (Turillazzi, 1991). Division of labour, social interaction and dominance are only known for a few species in the sub-family and in general it seems that these relations vary from species to species, from simple food sharing interaction to co-operative brood care and foraging.

The larvae of Stenogastrinae are peculiar in that they are coiled around the long axis of the cell contrary to other Vespidae larvae which are always parallel to the long axis.

Another unique aspect of these wasps is the provision of a whitish, gelatinous substance (Turillazzi, 1991) placed in the cells, originally thought to be a food source, although this has been reviewed by various authors which have added additional functions:

- Serves as a tool for oviposition: before laying an egg the wasp secretes the substance which is transferred to the mandible, she then bends her metasoma and lays an egg on it and deposits the mass in the cell
- Serves as a resting substrate for the larvae
- Acts as a food and liquid storage
- Acts as an ant guard when placed on the substrate.



Fig.4.4.1, Distribution of the sub-family Stenogastrinae. Redrawn from S. Turillazzi, 1991

### 4.5.2 Genus *Eustenogaster* van der Vecht, 1969.

Species in the genus *Eustenogaster* are the largest of all the Stenogastrinae. To date twelve species are described from India in the west to Sumatra, Java and the Philippines to the East. One species is currently recorded from Hong Kong.

All *Eustenogaster* form an envelope around their nests shaped liked an upside down water flask. This external layer can be a real envelop free from the cell comb as in *E. calyptodoma* or no more than an extension of the peripheral cells as in *E. nigra* and most *Eustenogaster* species. The genus is also known for its architectural fantasies adding protuberances on the dorsal part of the nest.

In the genus, colonies are generally small not exceeding 6 workers (Turillazzi, 1996) and rarely having more than 25 cells.

The diet of these wasps is not particularly well known but *Eustenogaster spp* are known to take small insects primarily collected from spider webs (Turillazzi, 1991).

#### *Eustenogaster nigra* Saito & Nguyen, 2006.

Sub-family: Stenogastrinae.

**Distribution:** North Vietnam; Hong Kong; Thailand and South China.

**Length:**

- Workers: 19.5 - 21mm.
- Queens: +/- 21mm.
- Males: 19 – 20mm

**Diet:** Diet unknown but *Eustenogaster nigra* is probably a specialist scavenger on arthropods caught in spider webs. Experimentally, larvae readily accepted mashed up crickets and caterpillars.

**Recognition marks:**

- A medium large wasp
- Clypeus projecting ventrally, forming an acute triangle.
- Thorax globular.
- Petiole extremely long and thin, gradually swelling posteriorly.

Can be confused with:

- Species of Potter wasps (Eumeninae), however the elongated petiole, the position of the pronotal lobe and the nesting habits are distinguishing characters.

**Nest:** Non-pedicellate nest construction. The inverted flask like envelop formed by the extension of the peripheral cells, contains from 8 to over 20 cells which are unspecialized (i.e. no major difference in size for males, queens and workers). The entrance vestibule of approximate hexagonal section is perforated along its lower sides (pers. obs.). The nest material is composed of a mixture of fine plant matter and occasional small quartz grains, forming a very fragile and brittle structure. It has been observed in Hong Kong that *Eustenogaster nigra* has a gregarious behaviour when selecting nesting sites with several nests in the close vicinity of each other (pers. obs.). Colonies are found in dark, humid and sheltered habitats. On most structures observed to date, I have noted the presence of a gelatinous substance - possibly an ant guard - on the thread like substrates (pers. obs.). This substance is equally deposited at the bottom of the cells serving as an egg/larvae substrate.

**Colony type:** All colonies observed in Hong Kong have had only at maximum four individuals per nest (pers. obs.). Colonies are most probably founded by haplometrosis. Generally speaking there is no distinct size dimorphism between queens, workers and even males, only ovarian development would be a clue in determining queen status (Turillazzi, 1996)<sup>31</sup>. Females are known to overwinter in their nests (Saito et al, 2006) in Vietnam, behaviour yet to be confirmed with this species locally.

**Note:** *E. nigra* is a quiet an elusive species which tends to be difficult to spot in the wild, although it is by no means un-common and found consistently territory-wide.

These wasps tend not to defend the nesting site and leave the nest hurriedly when disturbed. Males are produced early in the colony development in Hong Kong, close after emergence of the first female(s), a rather unusual trait within the Vespidae.

*E. nigra* is a recently “discovered” species (2006), yet to be described and recorded locally.

## 5 Glossary

The definitions of this glossary are taken from “A Dictionary of Entomology”; Gordh G., Headrick D.H., Cabi Publishing, 2001 and other sources.

For morphological terms pertaining to the external structure of Apocrita Hymenoptera refer to Fig.1, 2 & 3 below.

- **Arthropod:** A member of the Class Arthropoda. A phylum of metamerically segmented metazoan organisms with jointed legs and structurally and chemically complex external skeleton composed of numerous compounds including chitin.
- **Caste:** In social insects, different groups of individuals of predictable morphological types or behaviour which perform specialised labour within the colony. Caste differences are permanent and not attributed to age.
- **Cocoon:** A covering of silk or other material that surrounds the pupae. The cocoon is spun or constructed by the larvae and composed of silk or other viscid fibres. The cocoon of many species is the products of glandular secretions.
- **Crop:** The dilated portion of the foregut positioned posterior of the oesophagus. Typically the crop forms a long, slender tube with a bladder-like swelling at the posterior end. The crop receives and holds food before its passage to the midgut. The inner wall is often convoluted to accommodate the storage of food.
- **Dimorphism:** A genetically controlled (influenced) non-pathologic condition in which individuals of a species are characterised by distinctive or discrete patterns of coloration, size or shape.
- **Eusocial:** Pertaining to insects that display social characteristics and that exhibit the following three properties: cooperative brood care, differentiation of colony member into fertile reproductive castes (queens or kings) and sterile non reproductive castes (workers) and an overlap of generations such that offspring assist their parents in brood care and other tasks involved in colony maintenance.
- **Gynes:** Noun, Social Hymenoptera: A female member of a reproductive caste; a potential or actual queen. The term is typically applied to potential queens.
- **Haplometrosis:** In social insects the foundation of a colony (nest) by a single reproductive female (queen). Haplometrotic, noun. See Pleometrosis
- **Meconium:** The pellet-like excrement of larvae or pre-pupae.
- **Metamorphosis:** Term used by entomologist to signify the morphological and physiological changes from immature to adult. Metamorphosis includes transformation in shape, form or substance during successive stages of development. It is an intricate phenomenon.
- **Monophyletic:** In taxonomic classification, a group of organisms all members of which are derived from a common ancestor and not excluding from an historical group any descendants of the ancestor of that group. See Polyphyletic.
- **Ovipositor:** An egg-laying tube of a female insect's abdomen. An extension of the common oviduct; sometimes rigid and fixed in length; sometimes flexible and telescopic. Not present in all insects, but well developed in some groups such as Thysanura, some Orthoptera, sawflies and parasitic Hymenoptera.
- **Parasitic:** Pertaining to organisms that live as parasites. Living on or in another animal in such way as to derive nourishment from the tissues of the host.
- **Parasitoid:** An organism that resembles a parasite. Parasitoids differ from parasites in: 1. they seem to be restricted taxonomically to Hymenoptera and Diptera. 2. Parasitoids are smaller than the host upon which they feed. 3. Typically, parasitoids only attack on stage of the host. 4. Parasitoid larvae kill their hosts near the end of the parasitoid's larval development.
- **Pedicel:** In Hymenoptera the stalk supporting the nest on the substratum.

- **Petiole:** In Apocrita Hymenoptera the slender or narrow tubular segment between the Thorax and the Abdomen.
- **Phylogeny:** The development of taxonomic groupings through evolutionary studies, comparative anatomy and related phenomenon.
- **Pleometrosis:** In social insects, foundation of a colony (nest) by more than one reproductive female (queen). Pleometrotic, noun. See Haplometrosis.
- **Polyethism:** In social insects, a division of labour among members of a colony. Division than relates to age and casts.
- **Polyphyletic :** A natural or genetically cohesive lineage of Taxa whose most recent common ancestor has given rise to excluded Taxa of which at least one of the sister group is only partly included in the group. See Monophyletic.
- **Trophallaxis:** In social hymenoptera, a mutual exchange of food between adults and their larvae. Adults provide proteins to larvae; larvae provide carbohydrates to adults. Regurgitation of a droplet of liquid by a larva and taken by an adult worker. Data on vespids suggest larval salivary secretions are essential for the colony survival because they are the only source of compounds necessary for nitrogen metabolism and egg production.



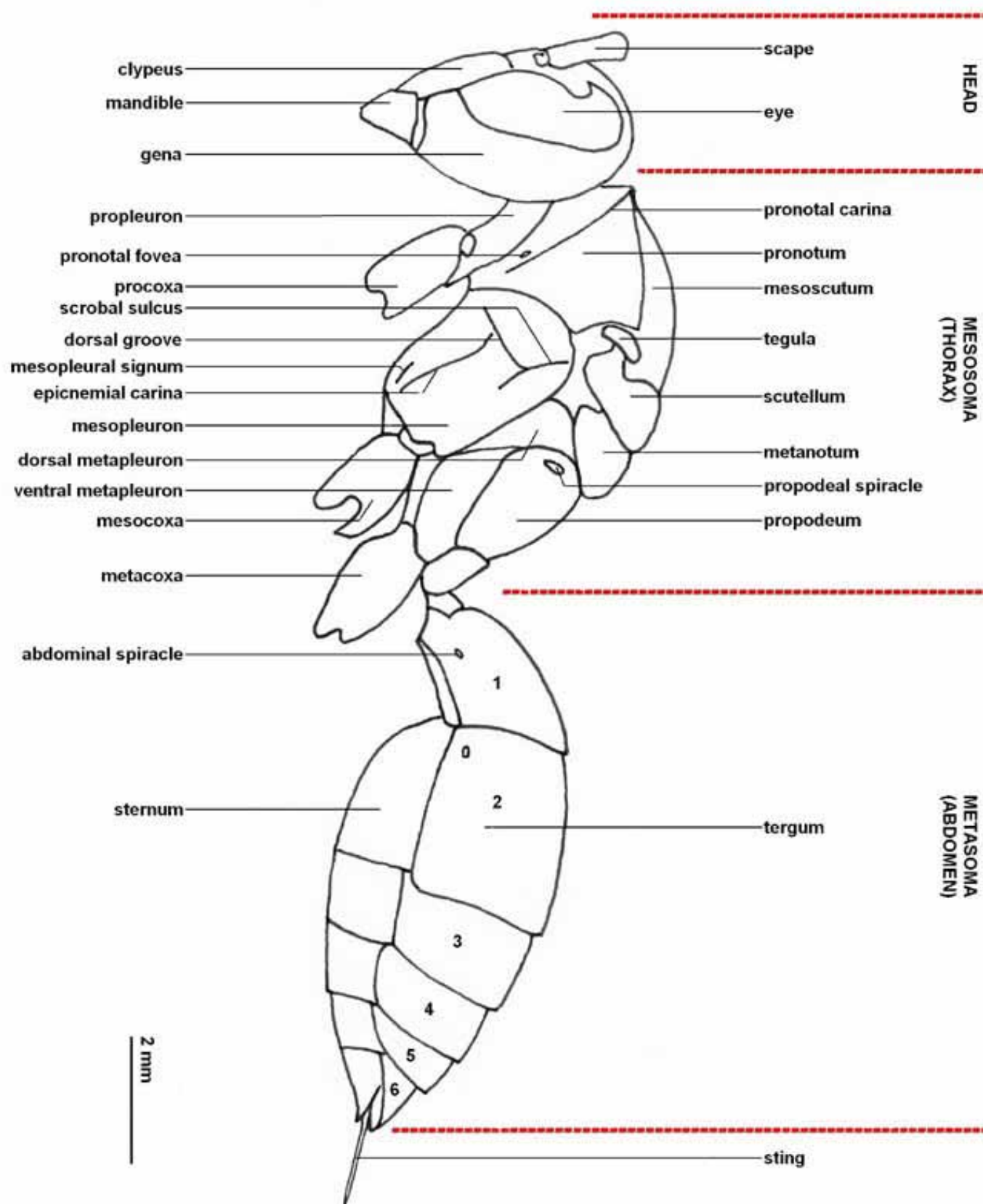


Fig.1. Main morphological divisions and structures of a species of female Vespidae, *Polistes olivaceus*: lateral view. (drawing Author.)

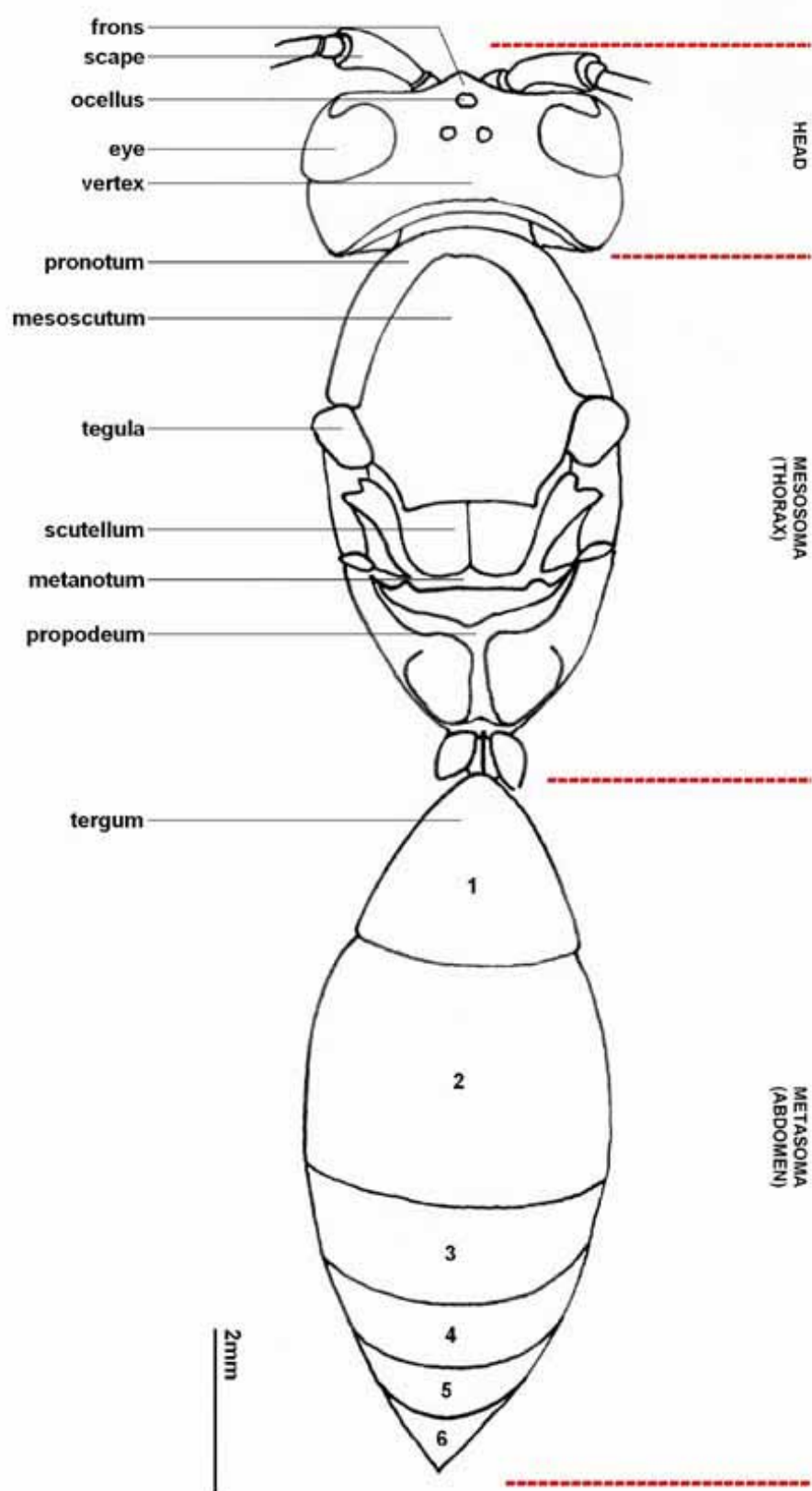


Fig.2. Main morphological divisions and structures of a species of Vespidae, *Polistes olivaceus*: dorsal view. (drawing Author.)

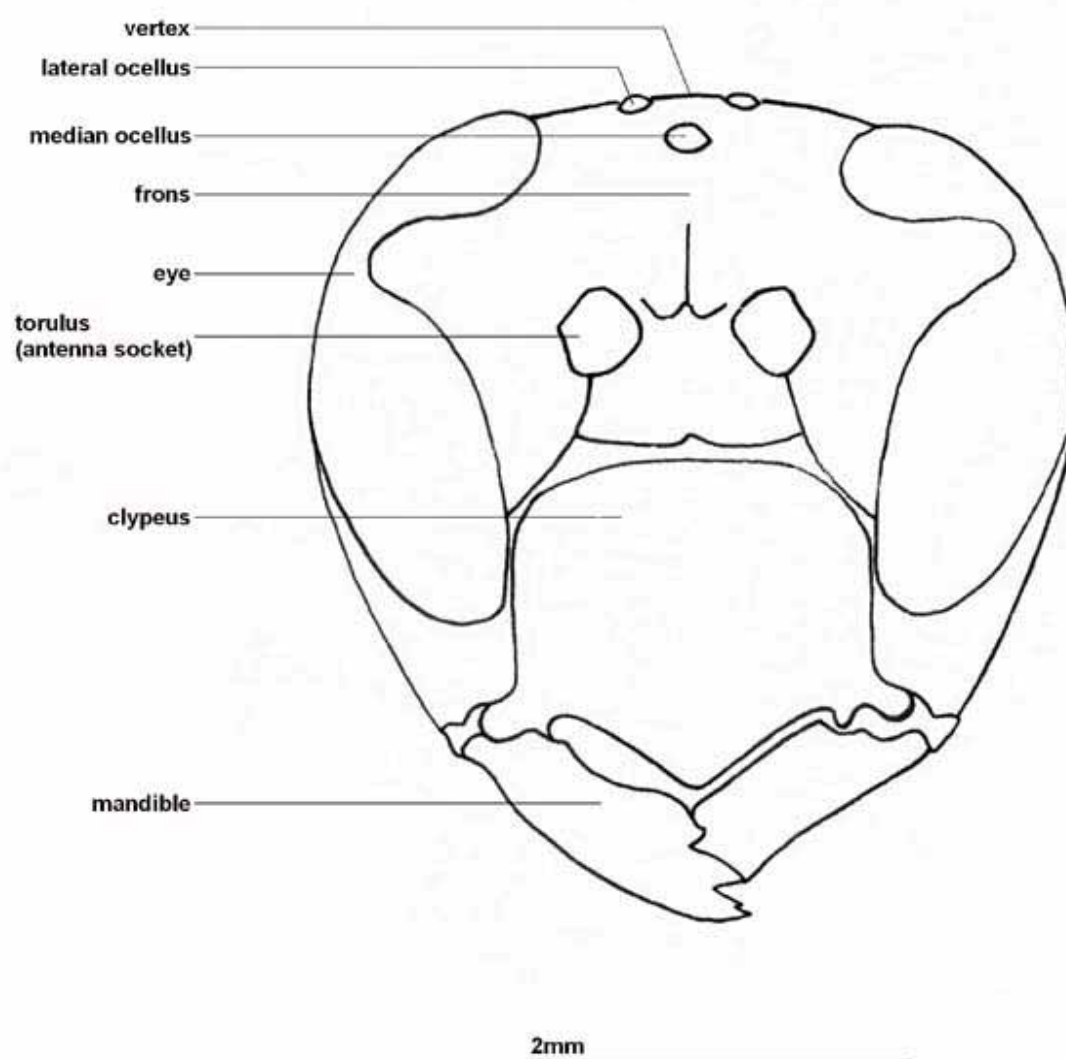
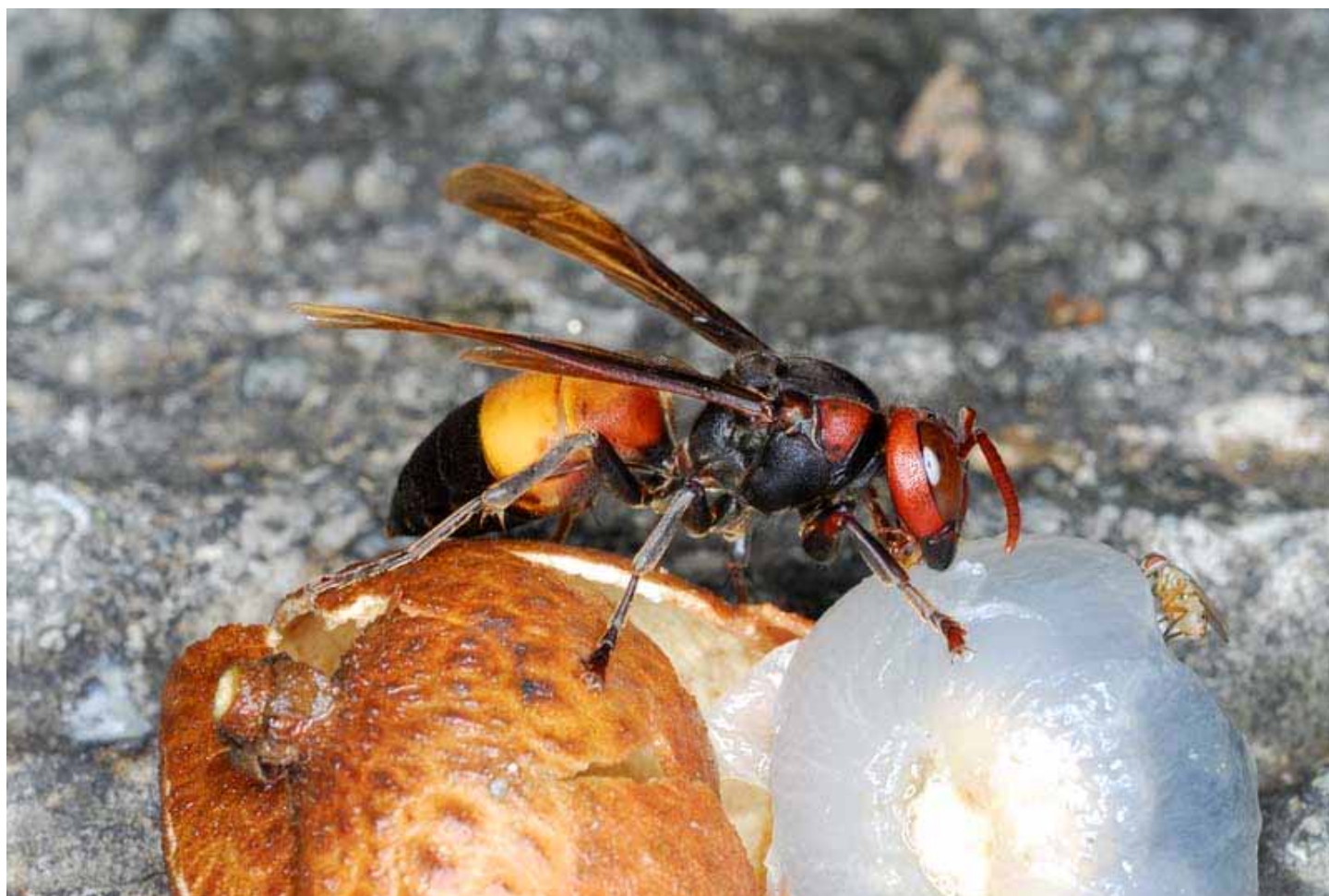


Fig.3. Main morphological divisions and structures of a species of Vespidae, *Polistes olivaceus*: head view. (drawing Author.)

## 6 Plates.

Plate 1. *Vespa affinis*. Worker foraging on fruits of *Euphoria longan*. (Photo. Author).





**Plate 2. *Vespa affinis*.** Mature nest found in low bushes and destroyed by EPD. It contained over 150 individuals and a complete brood. (Photo. Author).



**Plate 3. *Vespa affinis*.** Same nest: vertical section showing the stack combs held by a central column and the multi-layered envelop. (Photo. Author).



**Plate 4. *Vespa affinis*.** A nest affixed to the side of a tin shed at approximately 100cm from the ground. (Photo. Author).



**Plate 5. *Vespa affinis*.** An small nest at early stage on a roof edge. (Photo. Author).





Plate 5a. *Vespa analis*. Dorsal view of a worker. (Photo. Author).

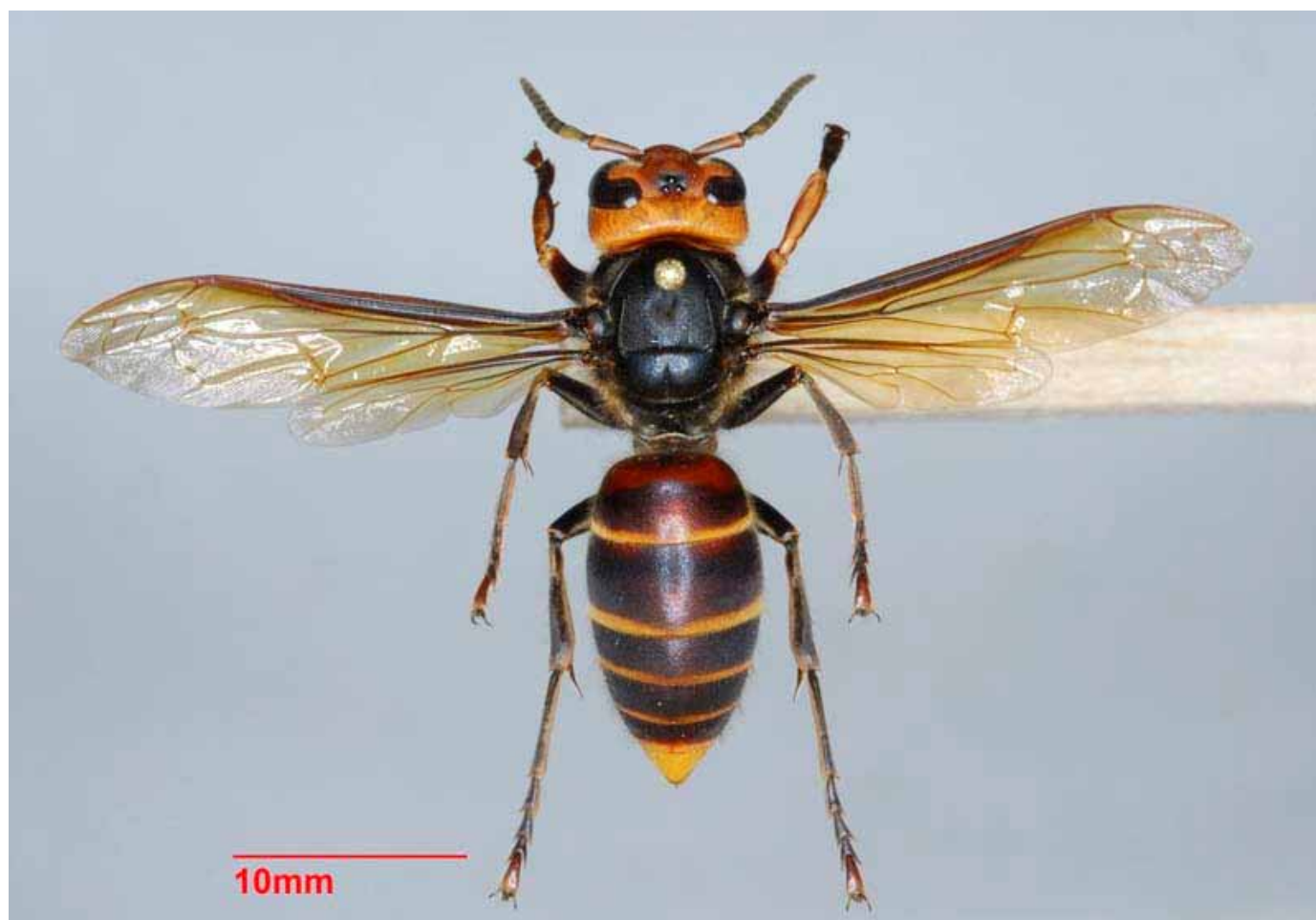


Plate 5b. *Vespa analis*. Head view of a worker. (Photo. Author).



**Plate 5c.** *Vespa analis*. Lateral view of a worker. (Photo. Author).



Plate 6. *Vespa bicolor*. (Photo. Author).





Plate 7. *Vespa bicolor*. Worker scavenging on the remains of a caterpillar possibly left over by a *Polistes* species. (Photo. Author).





**Plate 8. *Vespa bicolor*.** A mature colony fixed to the tiles of a temple roof. The nest had a diameter in the order of 20cm, and contained approximately fifty workers. (Photo. Author).



**Plate 9. *Vespa bicolor*.** The same nest with the external envelope removed showing white pupal caps and larvae. Nearly all cells were furnished with either eggs or larvae and pupae. A few cells contained two eggs. (Photo. Author).



**Plate 10.** *Vespa bicolor*. A nest at initiation stage. Note the umbrella like cover over the structure, this will remain as such for a couple of days . (Photo. Author).



**Plate 11.** *Vespa bicolor*. the same nest 3 days later the envelop is starting to take shape. (Photo. Author).





**Plate 12. *Vespa ducalis*.** A worker foraging for tree sap (*Citrus reticulata*). Note the yellow band on the 3<sup>rd</sup> tergum and the non enlarged gena (Photo. Author).



**Plate 13. *Vespa ducalis*.** An exposed nest located on the soffit of vehicular bridge in town. Note the umbrella like cover and the protruding pupal caps typical of this species. (Photo. Author).



**Plate 14. *Vespa ducalis*.** The same nest month later. Note the second comb and the extension of the envelope.. (Photo. Author).





**Plate 15. *Vespa soror*.** Worker foraging tree sap of *Citrus reticulata* (Tangerine). (Photo. Author).



**Plate 16. *Vespa soror*.** Head close up. (Photo. Author).





**Plate 17. *Vespa soror*.** Female eating out a pupa from the exposed nest of Plate 2. (Photo. Author).



**Plate 18. *Vespa soror*.** A collective raid on a mature colony of *P. indica*. Note the few paper wasp workers atop the structure watching but helpless. Later they will cannibalise their own remaining brood and abandon the nest (Photo. Author).



Plate 19. *Vespa tropica*. (Photo. Author).



Plate 20. *Vespa tropica*. Worker foraging tree sap from a *Citrus grandis* (Tangerine) (Photo. Author).



**Plate 21. *Vespa tropica*.** Queen on her nest. Colony at early worker stage. This species is normally fossorial but here it nested inside. Note the reduced envelop. (Photo. Author).



**Plate 22. *Vespa tropica*.** Photo of the same nest showing the brood (Photo. Author).





Plate 23. *Vespa velutina*. Lateral view of worker (Photo. Author).



Plate 24. *Vespa velutina*. Dorsal view of worker (Photo. Author).



Plate 25. *Vespa velutina*. Head view of worker (Photo. Author).



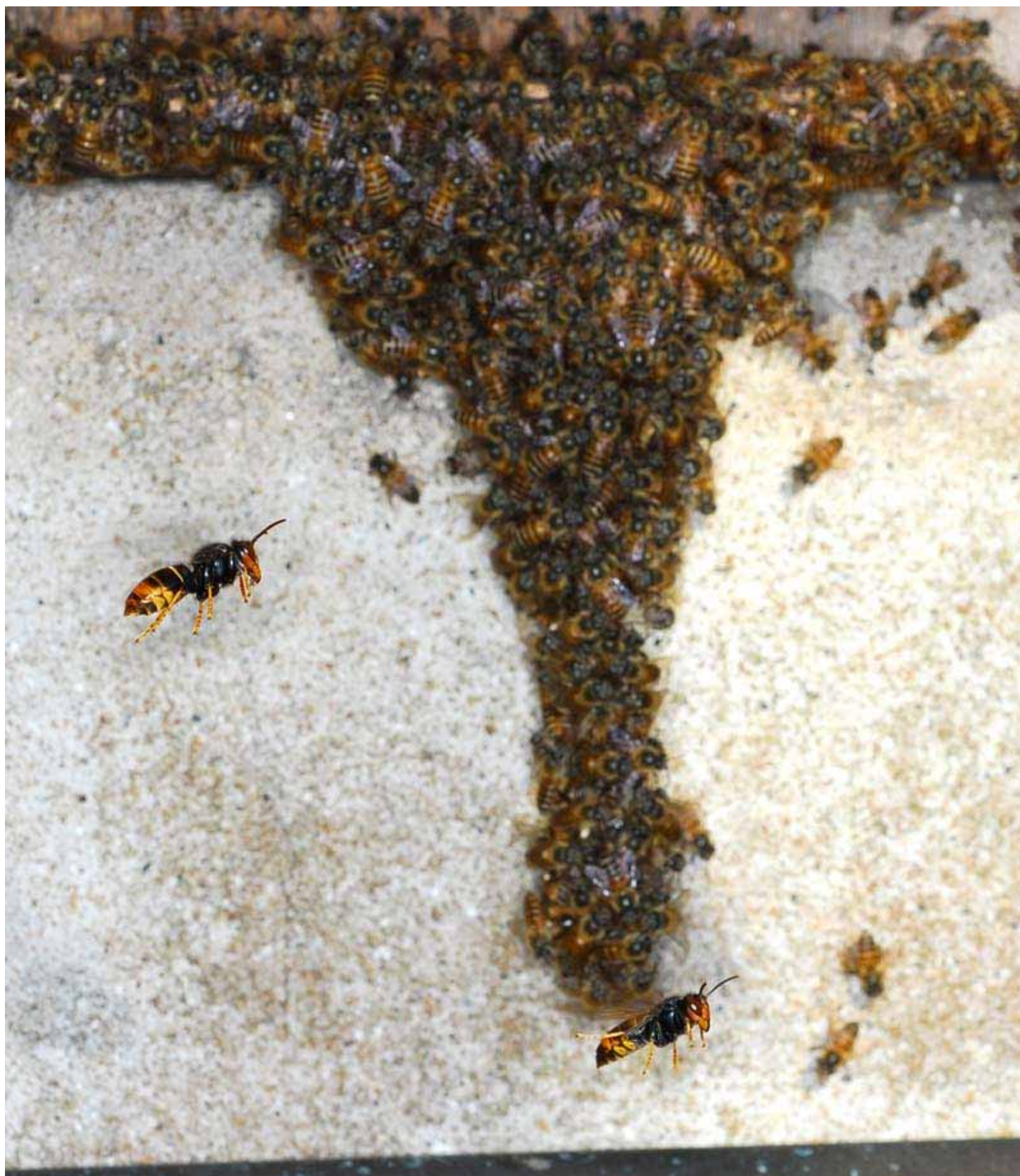


Plate 26. *Vespa velutina*. Worker foraging of fruit of *Euphoria longan* (Photo. Author).





**Plate 27. *Vespa velutina*.** Two workers hovering at the entrance of a bee hive (*Apis cerana*) and ambushing incoming and outgoing bees (Photo. Author).





**Plate 28.** *Vespa velutina*. A mature nest showing the disposition of the combs. Sample kept at the AFCD's Tai Lung experimental farm (Photo. Author).



**Plate 29.** *Vespula flaviceps*. A worker scavenging on a dead arthropod. January 2005. (Photo. Fang Hong Jian).





Plate 30. *Vespula flaviceps* . Dorsal view of worker (Photo. Author).



Plate 31. *Vespula flaviceps* . Lateral view of worker (Photo. Author).



Plate 32. *Vespula flaviceps* . Head view of worker (Photo. Author).





**Plate 33. *Polistes gigas*** . Worker foraging for tree sap from a *Citrus reticulata* (Tangerine) (Photo. Author).





**Plate 34. *Polistes gigas*** . View of a nest at initiation stage, note the very large and protruding pupal caps typical of this species. (Photo. Author).





**Plate 35. *Polistes gigas*** . Same nest looking up into the cells, showing, pupal caps, mature larvae and eggs.  
(Photo. Author).



**Plate 36. *Polistes gigas*** . Worker foraging for construction material, in this case dry bamboo fibers. Note on how the pulp pellet is held at the back of the mandibles with the aid of the palpi. (Photo. Author).



**Plate 37. *Polistes gigas*.** This small nest was photographed on the 23<sup>rd</sup> of August 2006, and surprisingly contained only two individuals and a few larvae. This colony is possibly a relocation after the initial nest was abandoned. (Photo. Author).





**Plate 38. *Polistes gigas*.** A mature nest showing some enlarged male cells. Nest held at the AFCD, Tai lung Experimental farm. (Photo. Author).



Plate 40. *Polistes japonicus*. Worker foraging for bamboo fibers as construction material. (Photo. Author).





**Plate 41. *Polistes japonicus*.** A nest at initiation stage with its young queen. (Photo. Author).



**Plate 42. *Polistes japonicus*.** View down the cells of a nest at initiation stage, showing pupal cells, and mature larvae. Note the bright yellowish color of the pupal caps, a distinguishing feature of this species (Photo. Author).





Plate 43. *Polistes olivaceus*. Lateral view of a worker (Photo. Author).

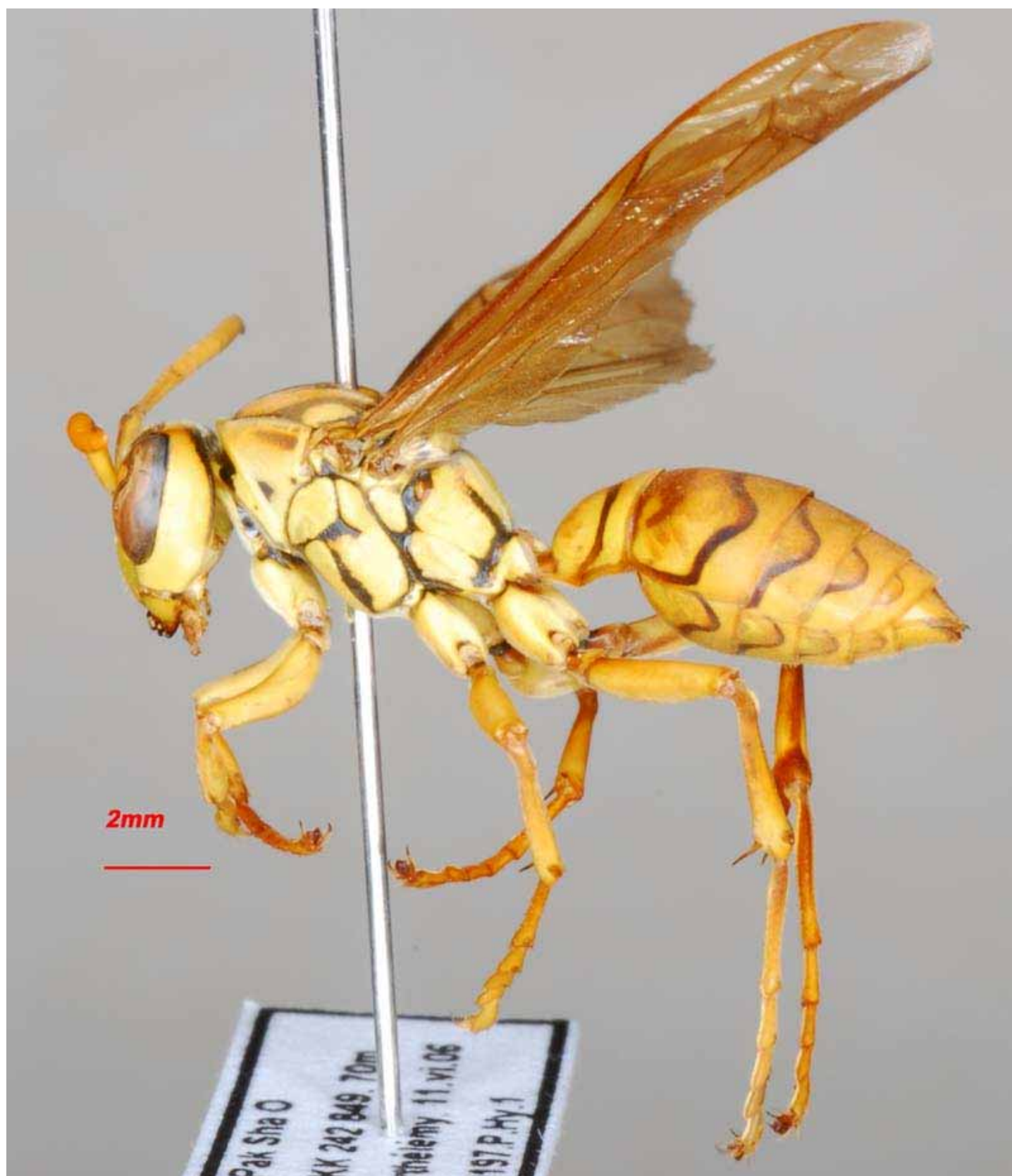
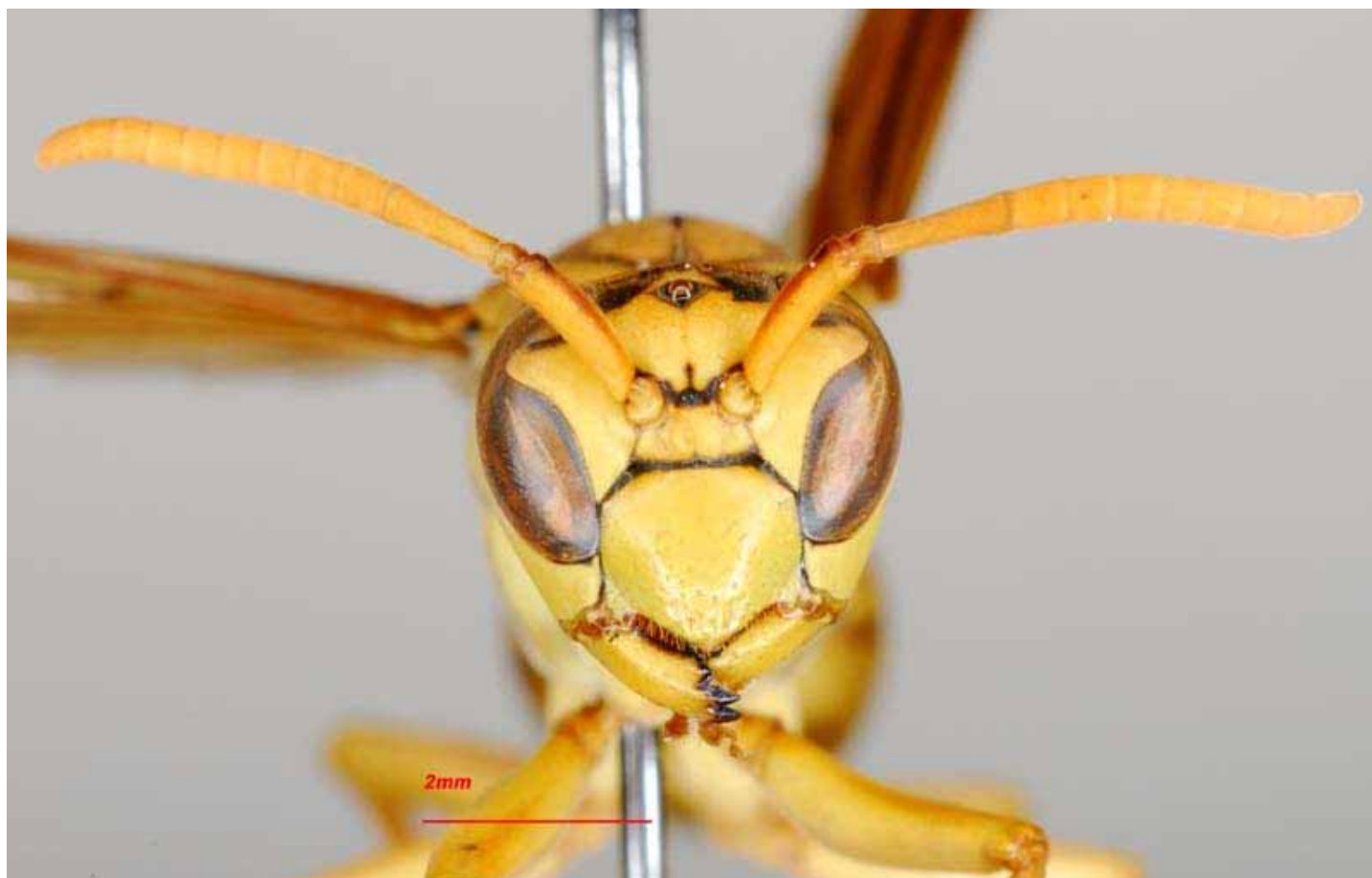


Plate 44. *Polistes olivaceus*. Dorsal view of a worker (Photo. Author).

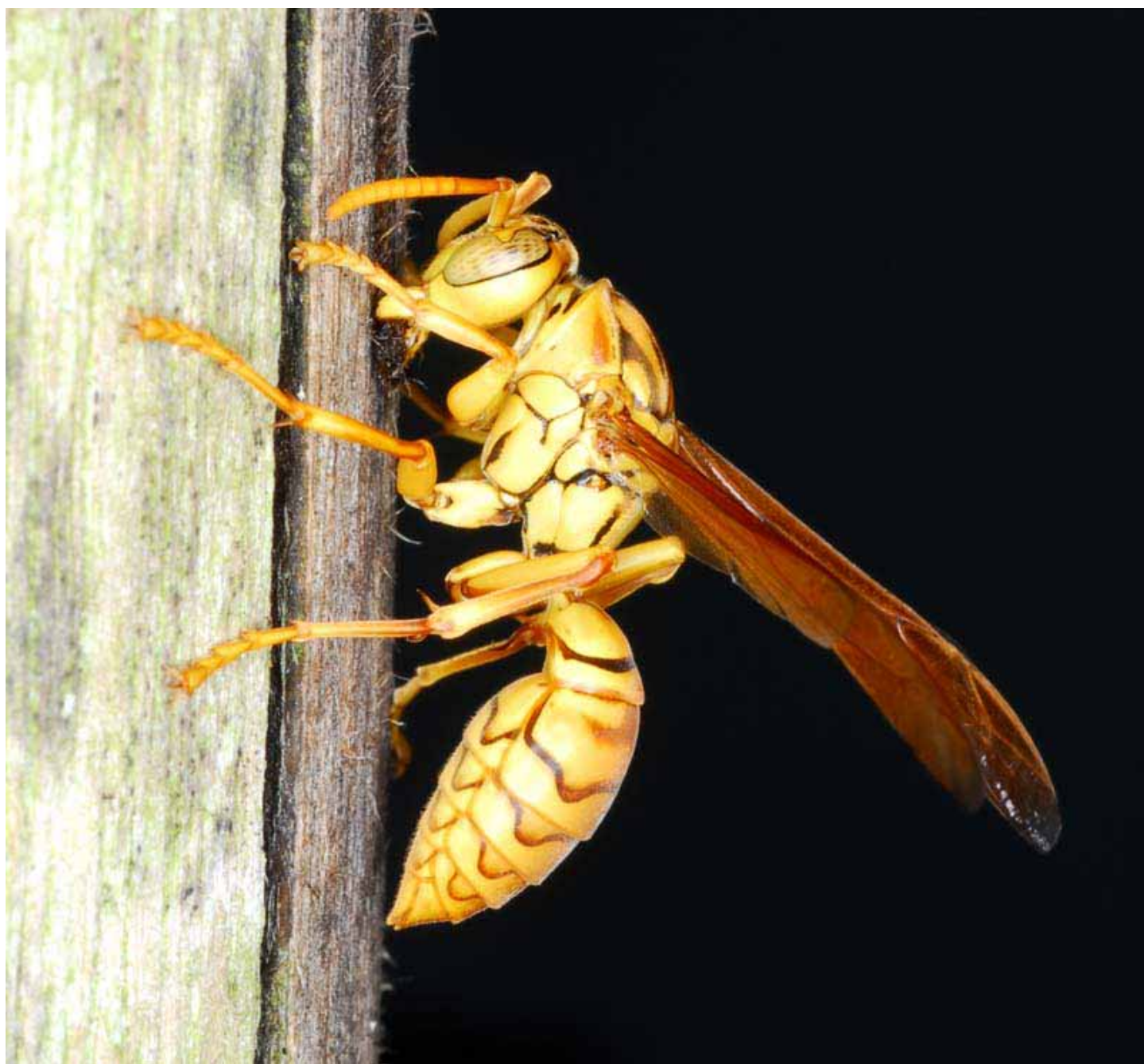


**Plate 45.** *Polistes olivaceus*. Head view of a worker (Photo. Author).





**Plate 46.** *Polistes olivaceus*. Worker foraging for construction material (soft wood). (Photo. Author).





**Plate 47.** *Polistes olivaceus*. A thriving colony inside a tin shed (Photo. Author).



Plate 48. *Polistes rothneyi*. A lone male. (Photo. Yip Chui Ha.).





Plate 49. *Polistes yokahamae*. Lateral view of a worker. (Photo. Author.).

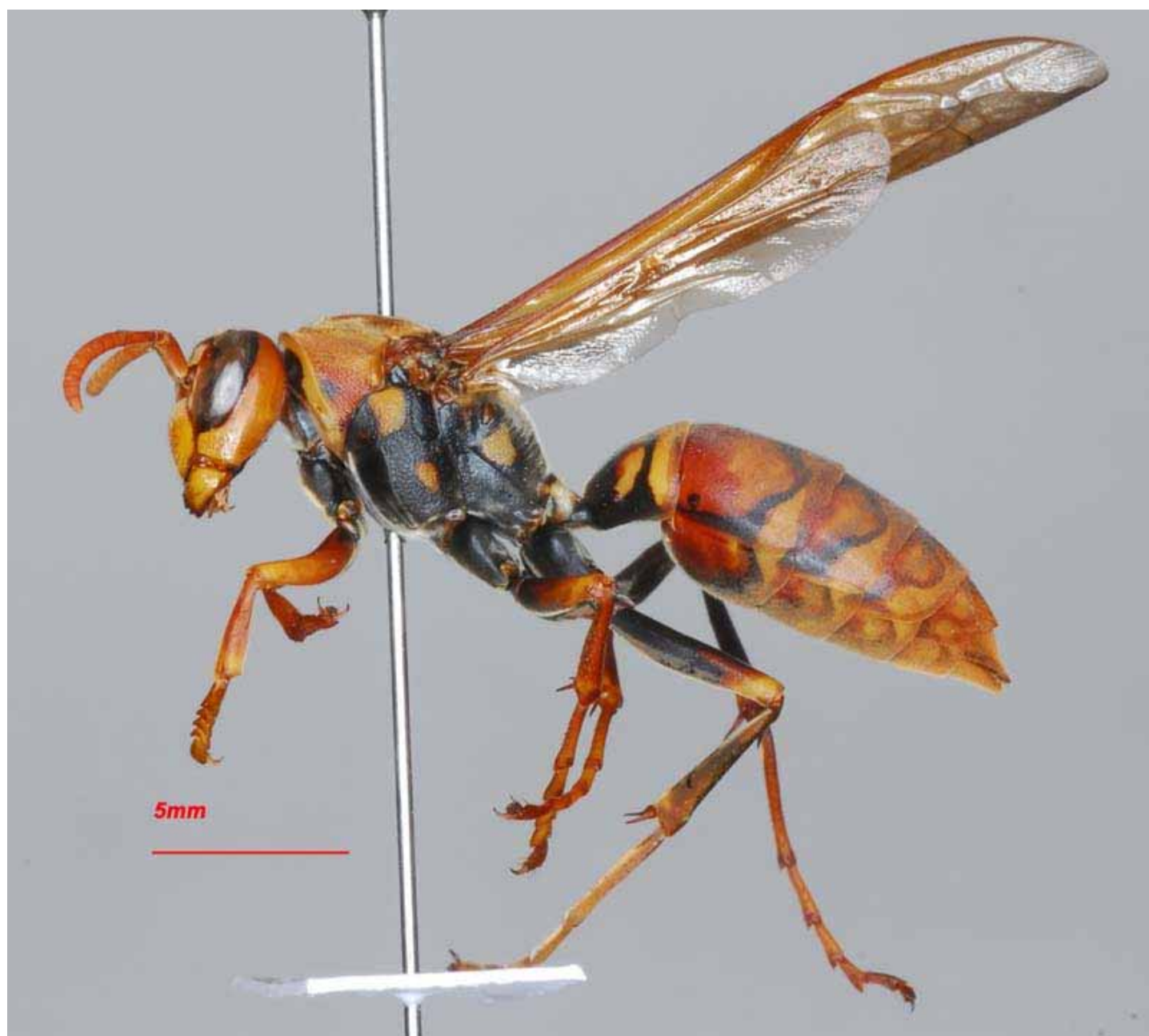


Plate 50. *Polistes yokahamae*. Dorsal view of a worker. (Photo. Author.).





Plate 51. *Polistes yokahamae*. Head view of a worker (Photo. Author.).



Plate 52. *Polistes yokahamae*. Worker foraging on fruit of *Euphoria longan* (Photo. Author.).





**Plate 53. *Polistes yokahamae*.** A declining colony. This nest had no brood and many males. In fact it seemed that the cells had not been occupied for a while, most had obvious traces of micro mites infestation (Photo. Author.).



**Plate 54. *Polistes yokahamae*** The same nest detached from the substrate. Note the single, though reinforced centered pedicel (Photo. Author.).





**Plate 55. *Polistes yokahamae*** View of the empty cells of this colony. Note the near hexagonal shape that the comb adopts. (Photo. Author.).

**Plate 56.** *Polistes sagittarius*. Worker foraging for bamboo fibers as construction material. (Photo. Author).

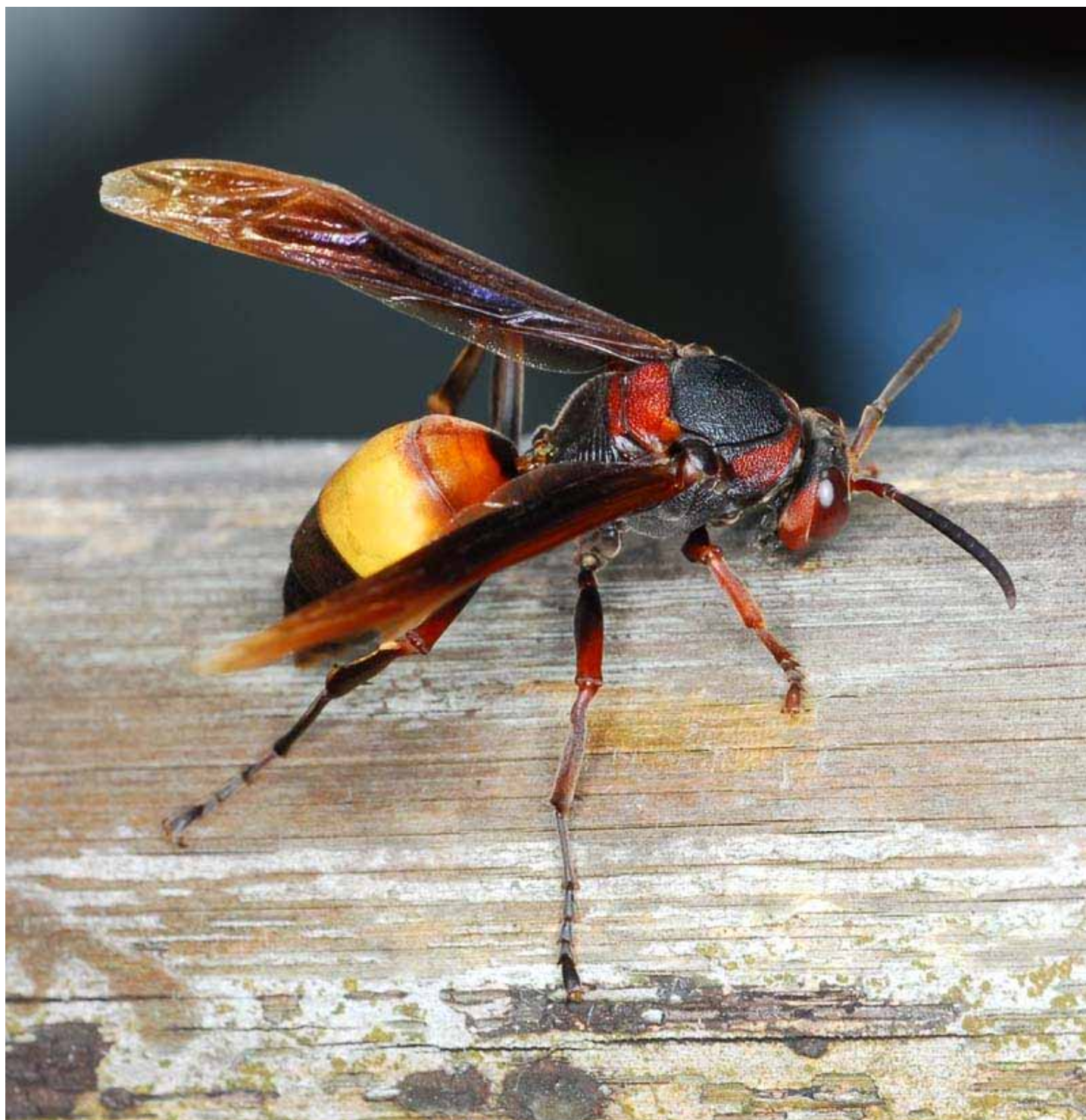




Plate 57. *Polistes sagittarius*. Worker masticating a caterpillar. (Photo. Author).

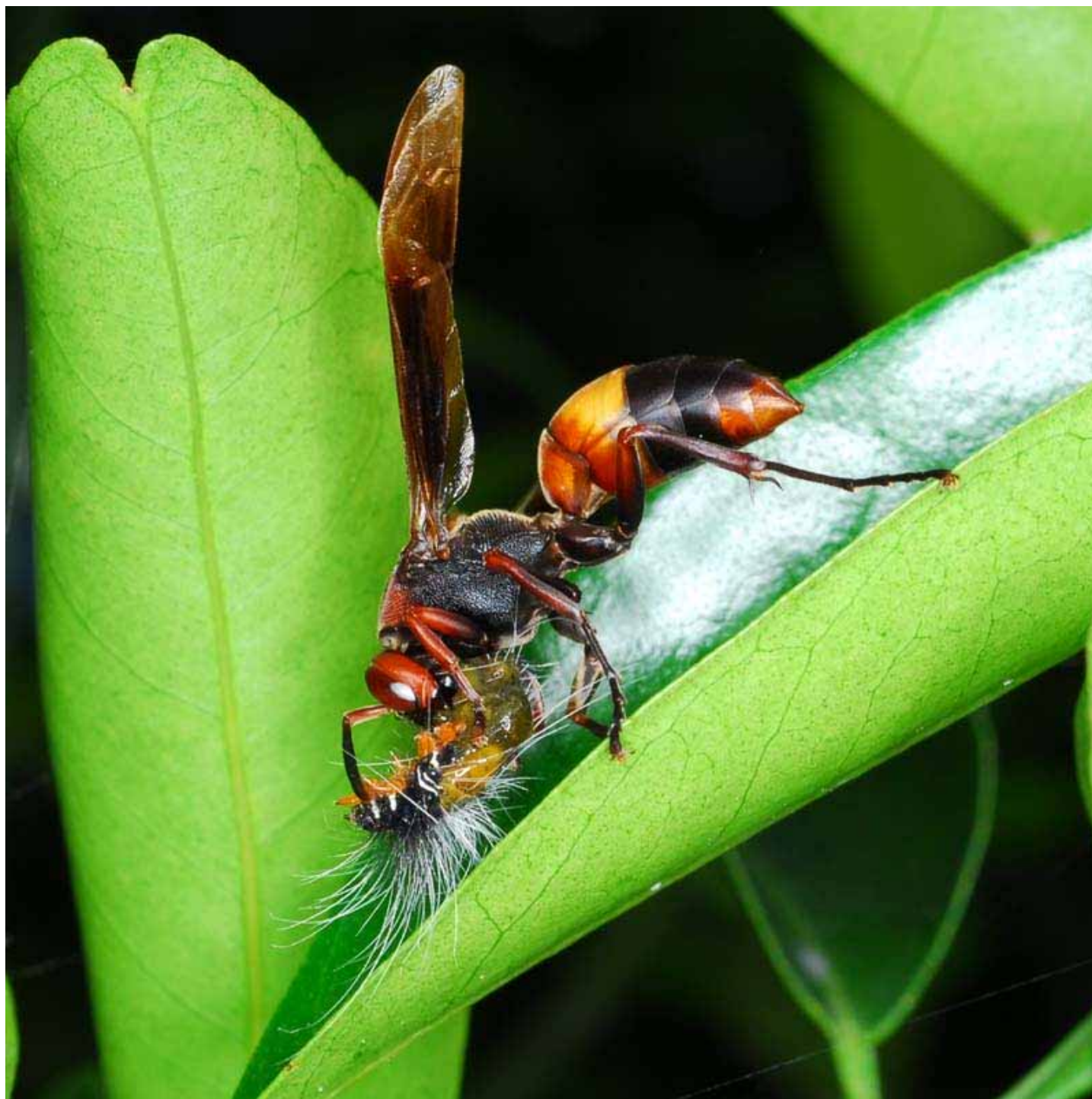


Plate 58. *Polistes sagittarius*. A mature nest. (Photo. Author).







**Plate 59. *Polistes sagittarius*.**  
The same nest showing the complete brood.. (Photo. Author).



**Plate 60. *Polistes sagittarius*.**  
The same nest, dorsal view. (Photo. Author).



**Plate 61. *Polistes stigma*.** Lateral view of a worker. (Photo. Author).

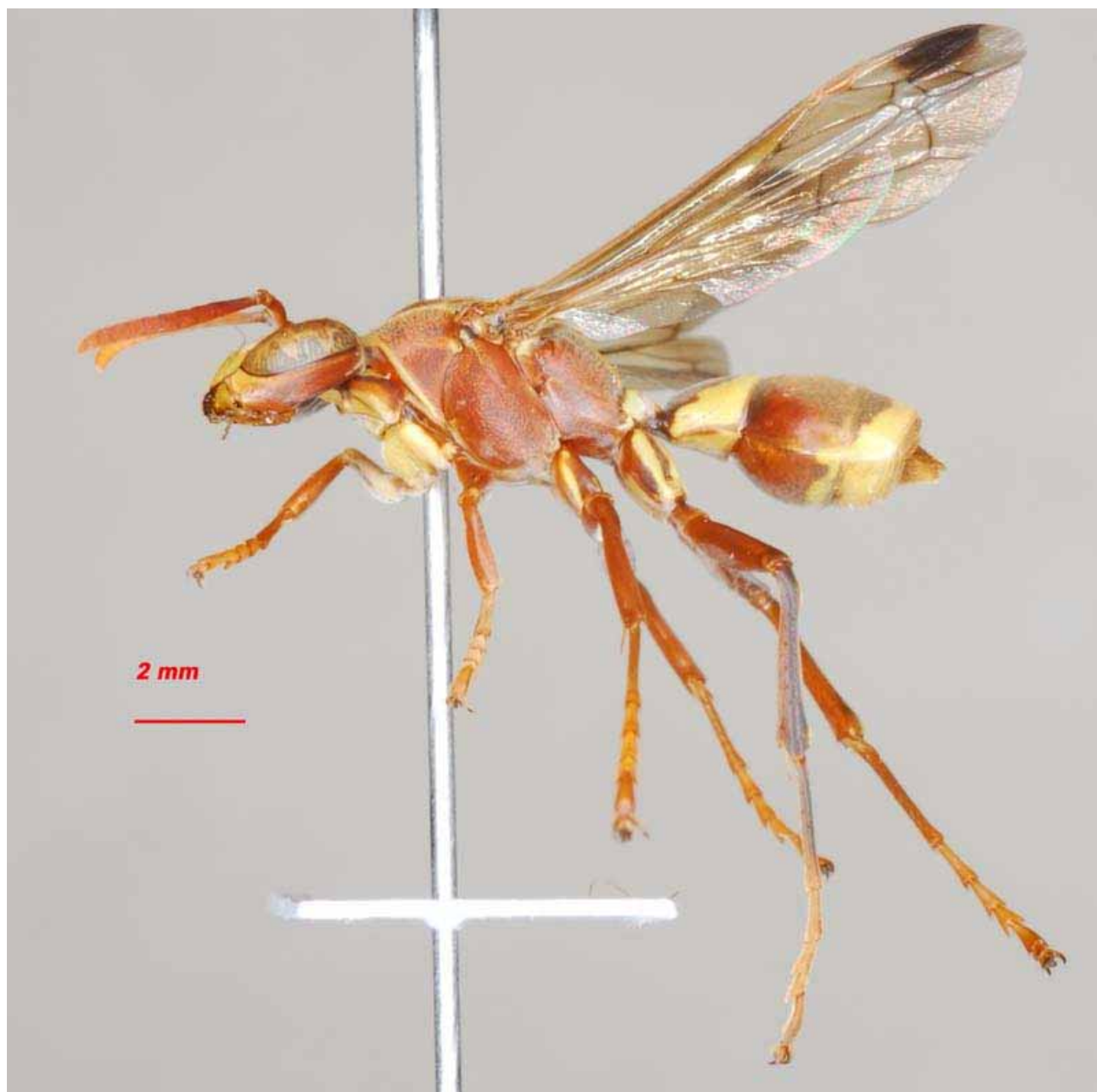


Plate 62. *Polistes stigma*. Dorsal view of a worker. (Photo. Author).

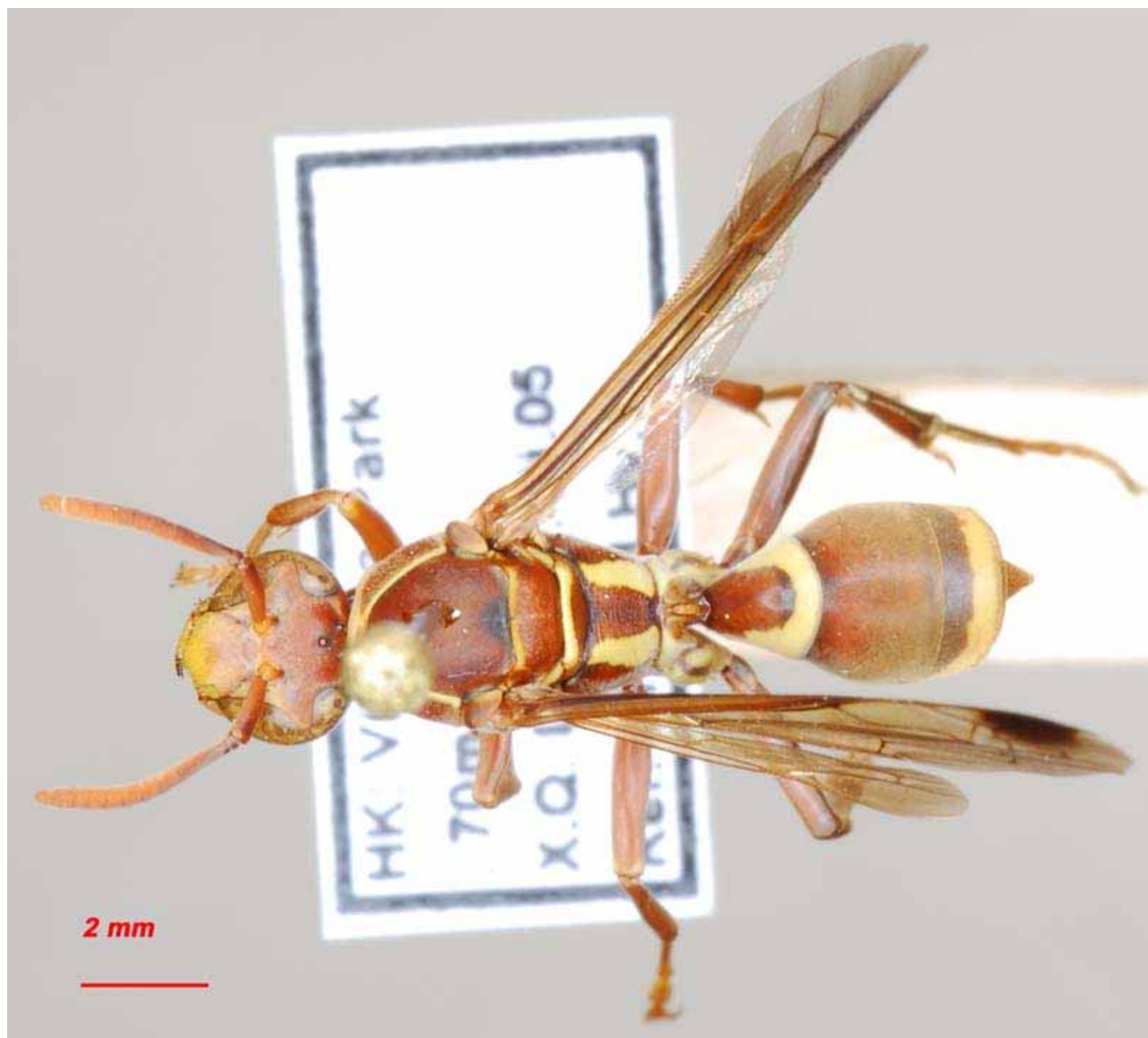
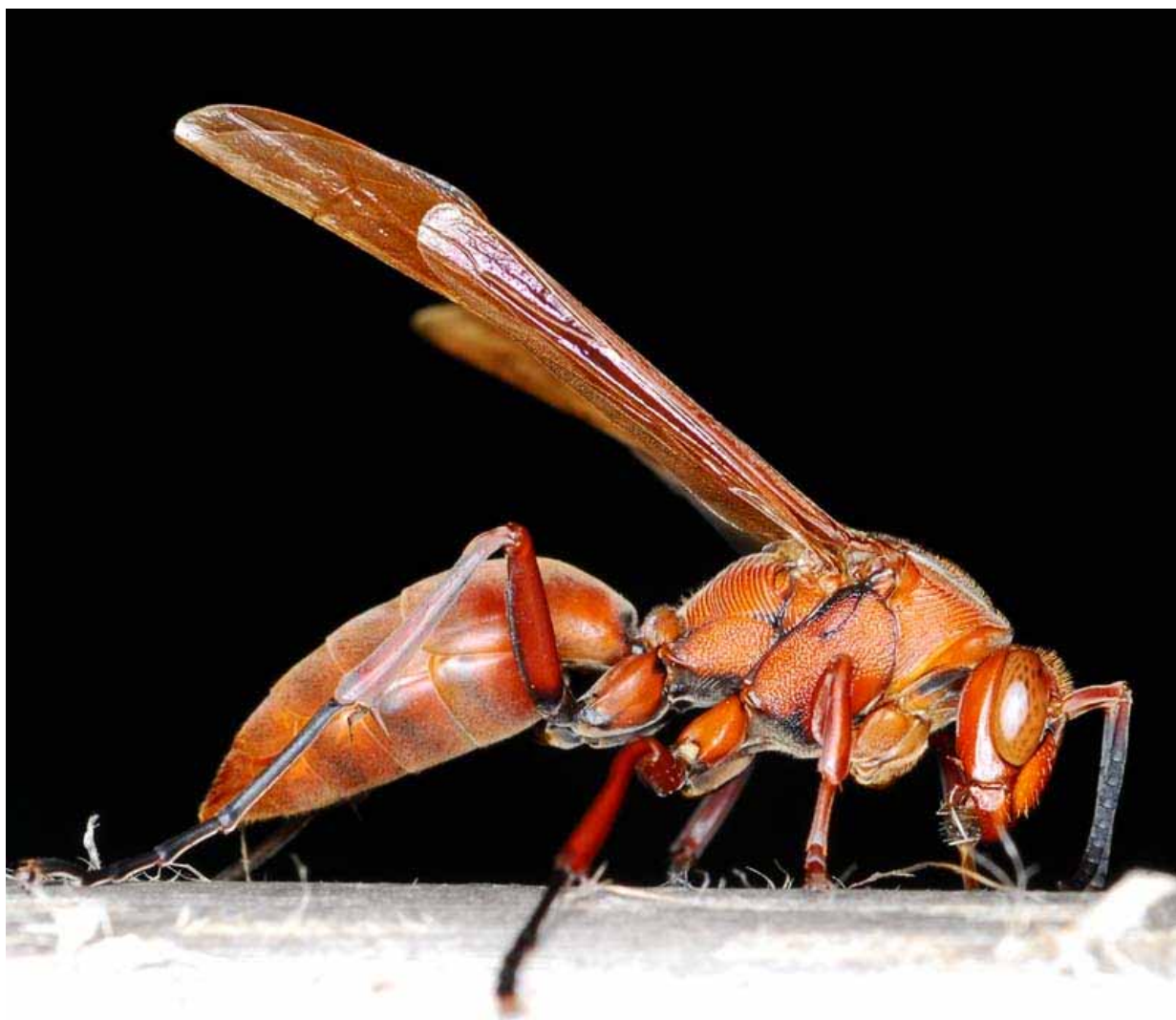


Plate 63. *Polistes stigma*. Head view of a worker. (Photo. Author).





**Plate 64.** *Polistes strigosus*. Worker foraging for bamboo fibers as construction material. (Photo. Author).



**Plate 64a.** *Polistes strigosus*. Young queen on nest at initiation stage. Note the pedicel at near perpendicular with the long axis of the cells. (Photo. Author).

**Plate 65. *Parapolybia indica*.** A young worker resting. Note the contrasting patterns on the Mesoscutum and terga typical of young individuals (Photo. Author).





**Plate 66.** *Parapolybia indica*. Worker scavenging food from a prey (*Melolonthinae* sp, Coleoptera) caught in a spider web. (Photo. Author).





**Plate 67.** *Parapolybia indica*. A thriving colony at early worker stage, fixed on fronds of *Pandanus austrosinensis*. (Photo. Author).



**Plate 68. *Parapolybia indica*.** Clusters of this kind are commonly found towards the end of the colony cycle, from August to September locally. They are generally initiated after the colony experiences a *Vespa* spp attack. (Photo. Author).



**Plate 69. *Parapolybia indica*.** A cluster of males on an abandoned nest. Note the very long antennae typical of nearly all males in the family Vespidae. (Photo. Author).





**Plate 70.** *Parapolybia varia*. Lateral view of a worker. (Photo. Author).



**Plate 71.** *Parapolybia varia*. Head view of a worker. (Photo. Author).

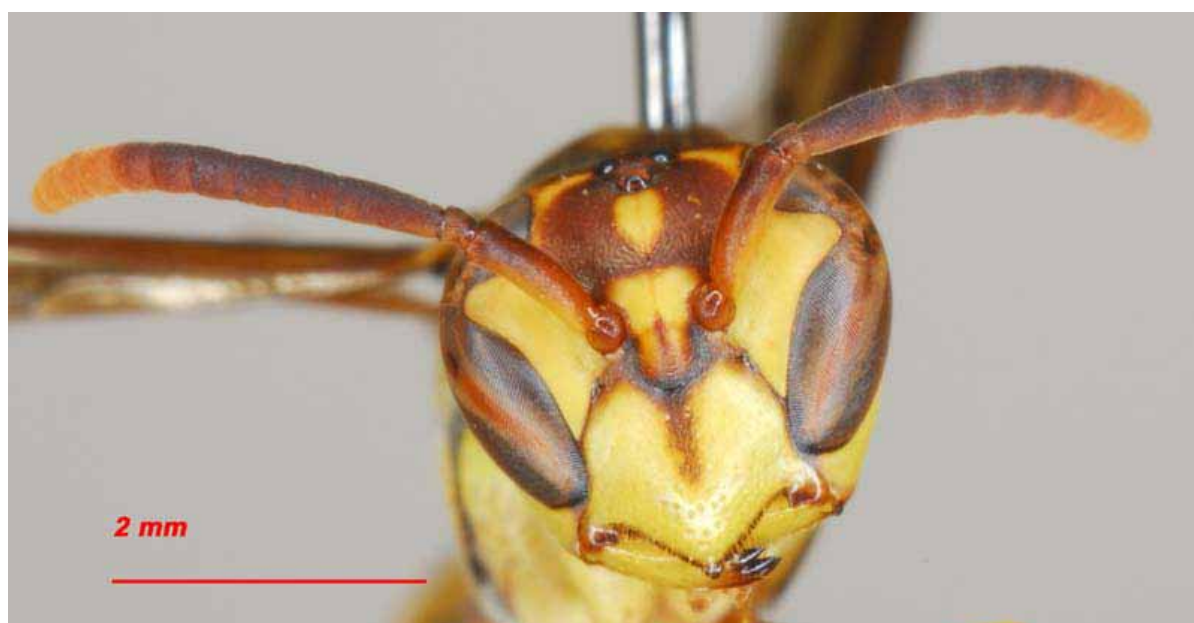




Plate 72. *Parapolybia varia*. Dorsal view of a worker. (Photo. Author).



**Plate 73. *Parapolybia varia*.** A healthy colony in its worker phase, June 2006. The nest contained over 50 workers and was sheltered in a low edge in an estate playground. (Photo. Author).



**Plate 74. *Parapolybia varia*.** Close up on the nest. (Photo. Author).





**Plate 75. *Parapolybia nodosa*.** Lateral view of a worker. (Photo. Author).

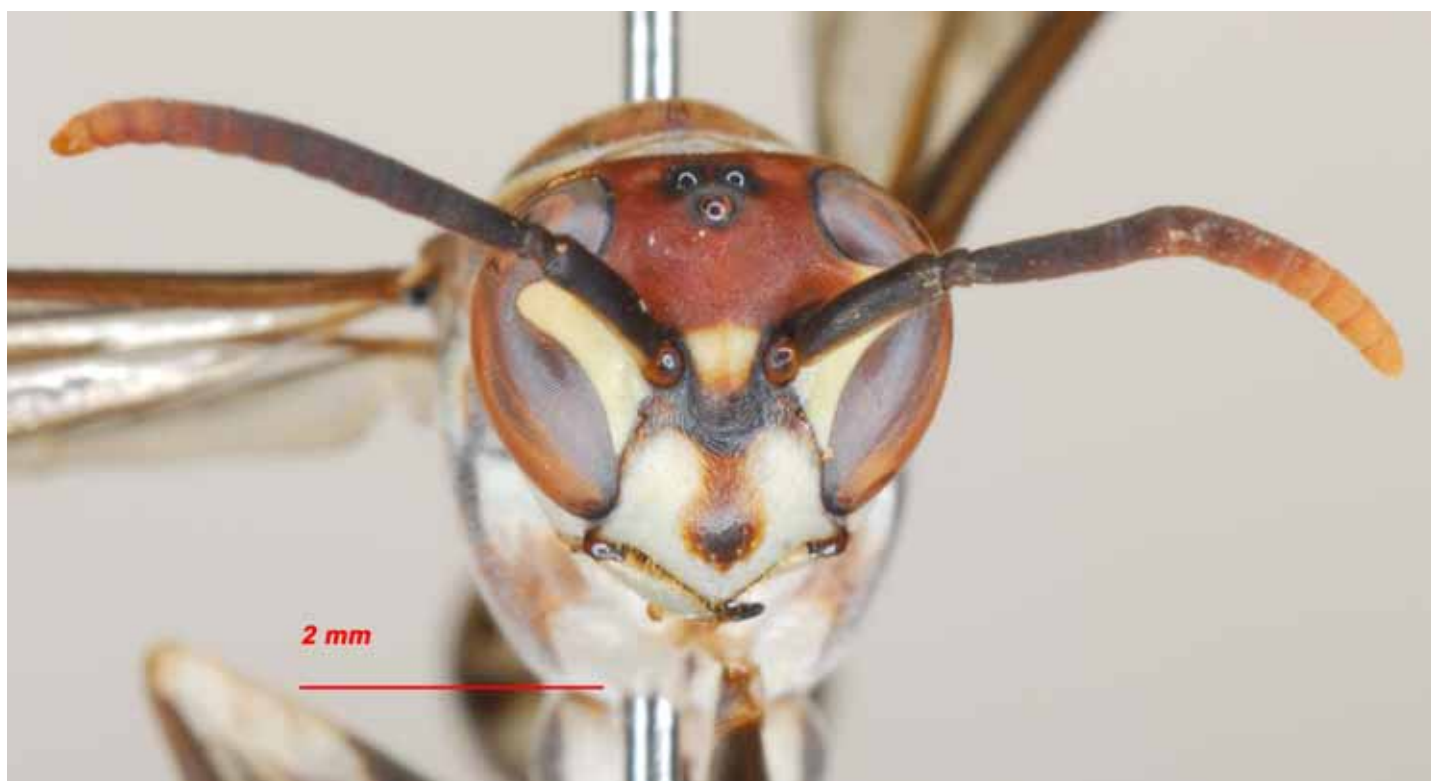




Plate 76. *Parapolybia nodosa*. Dorsal view of a worker. (Photo. Author).



**Plate 77. *Parapolybia nodosa*.** Head view of a worker. (Photo. Author).



**Plate 78. *Parapolybia nodosa*.** A large colony at early worker stage. This nest shows a peculiar morphology with its ventral side forming a near-perfect cylinder. This was a successful colony with over 80 individuals and when the picture was taken. Several females were observed ovipositing. (Photo. Author).



**Plate 79. *Parapolybia nodosa*.** A worker is applying "ant repellent" to the pedicel. (Photo. Author).





Plate 80. *Ropalidia fasciata*. Lateral view of a worker. (Photo. Author).



Plate 81. *Ropalidia fasciata*. Dorsal view of a worker. (Photo. Author).



Plate 82. *Ropalidia fasciata*. Head view of a worker. (Photo. Author).





**Plate 83. *Ropalidia fasciata*.** A mature colony with approximately twenty individuals. It is affixed to the stem of a grass growing in water. (Photo. Author).





**Plate 84.** *Ropalidia fasciata*. The same colony showing the cell arrangement. (Photo. Author).



**Plate 85. *Ropalidia fasciata*.** A newly initiated nest, with a single individual. There were two similar nests located next to this one although the picture was taken on the 25<sup>th</sup> of August, late in the seasonal cycle of this wasp. This may suggest that these three colonies were formed by the remnants of a bigger colony that has been destroyed. (Photo. Author).





Plate 86. *Ropalidia hongkongensis*. Lateral view of a worker. (Photo. Author).

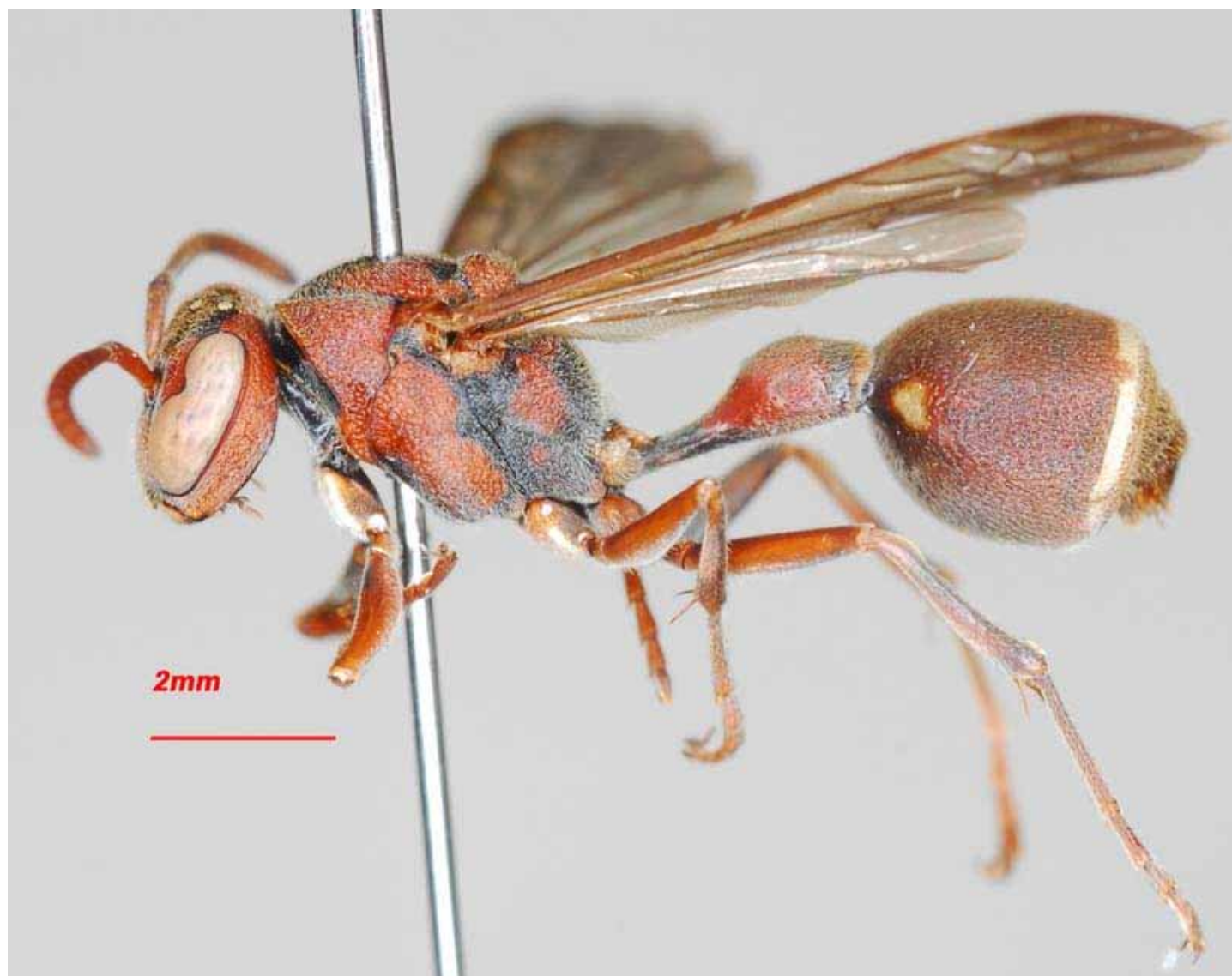
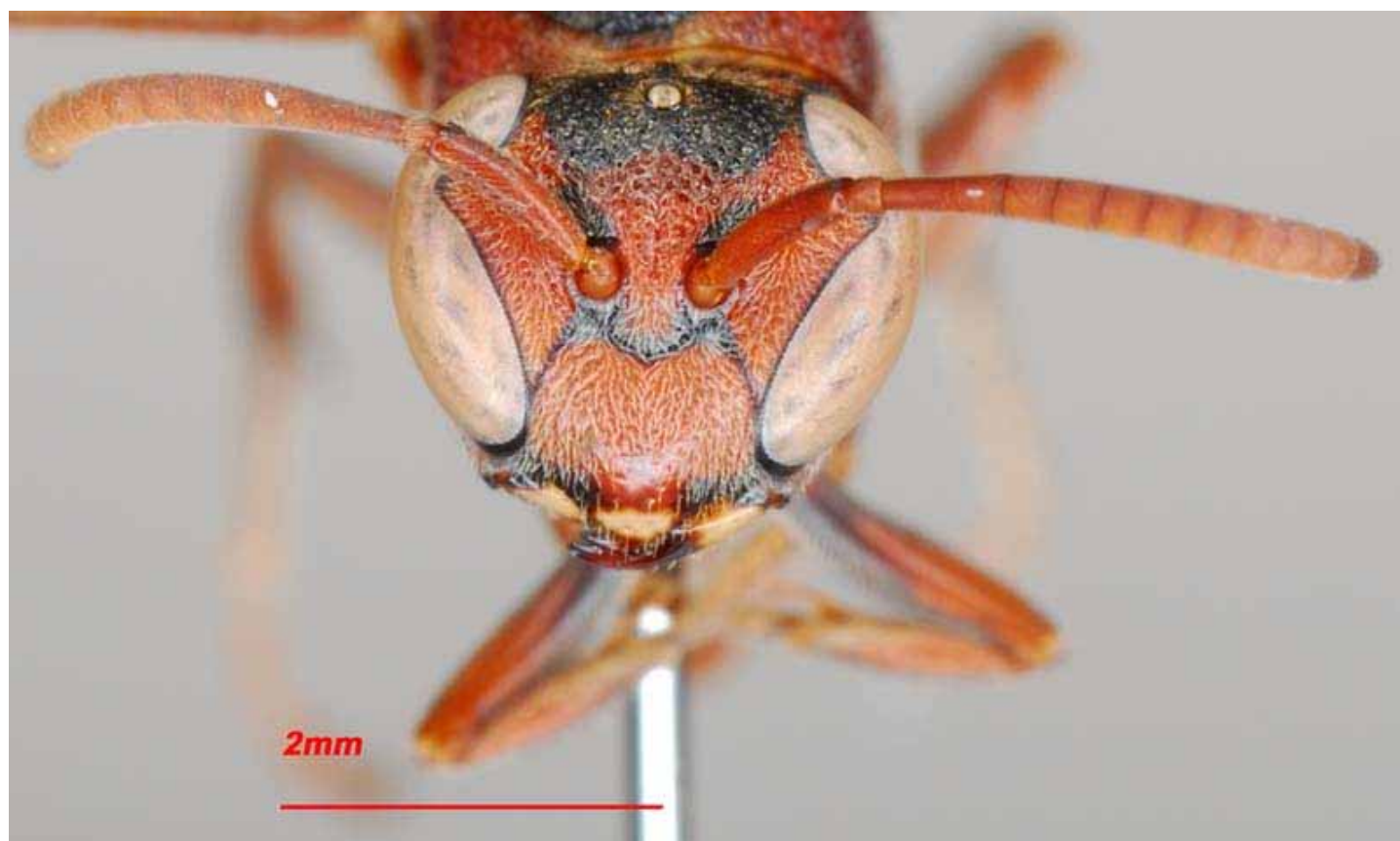




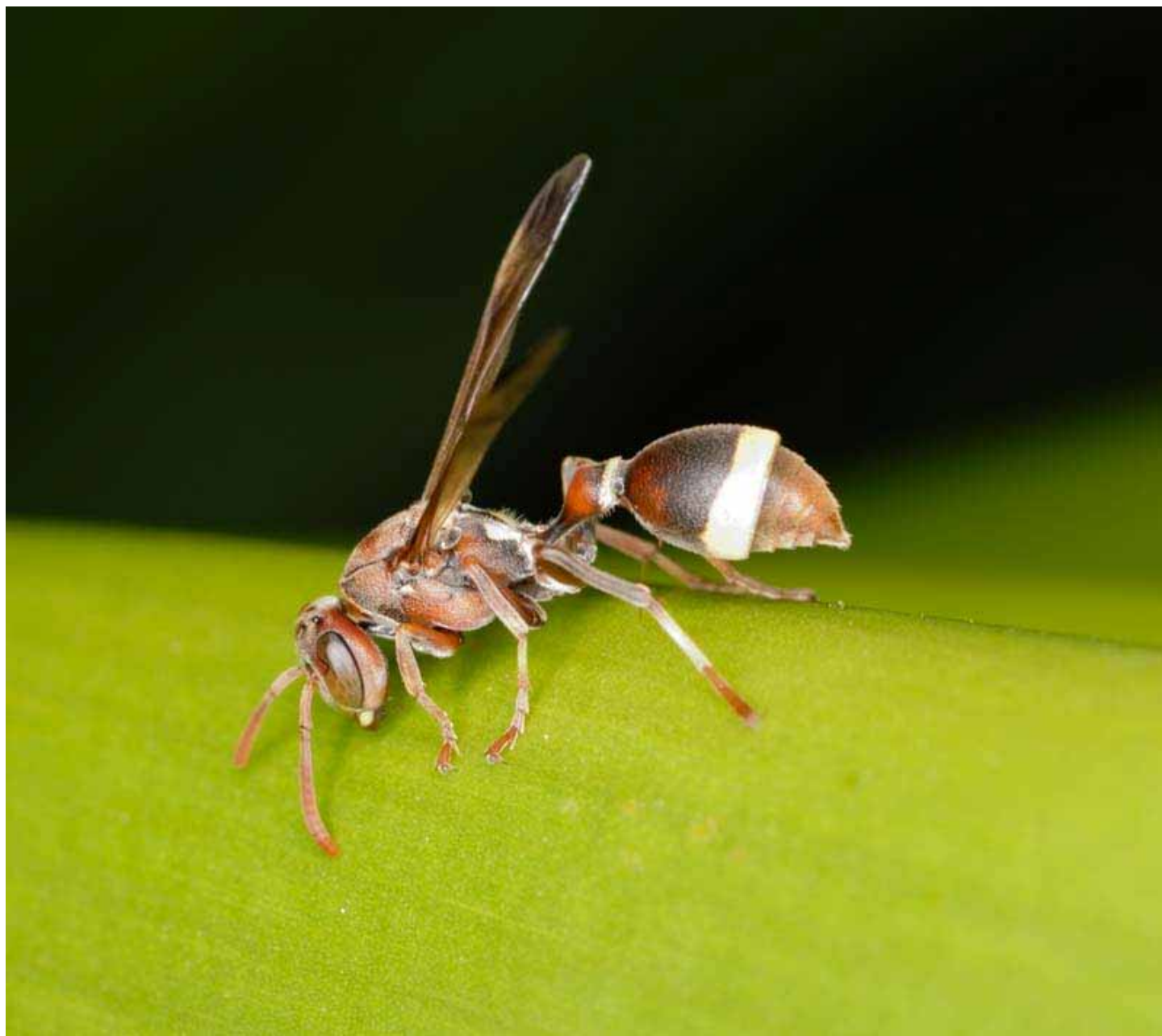
Plate 87. *Ropalidia hongkongensis*. Dorsal view of a worker. (Photo. Author).



Plate 88. *Ropalidia hongkongensis*. Head view of a worker. (Photo. Author).



**Plate 89.** *Ropalidia marginata*. Lateral view of a lone worker. (Photo. Author).





**Plate 90.** *Ropalidia marginata*. Dorsal view of a lone worker. (Photo. Author).



Plate 91. *Ropalidia mathematica*. Lateral view of a worker. (Photo. Author).



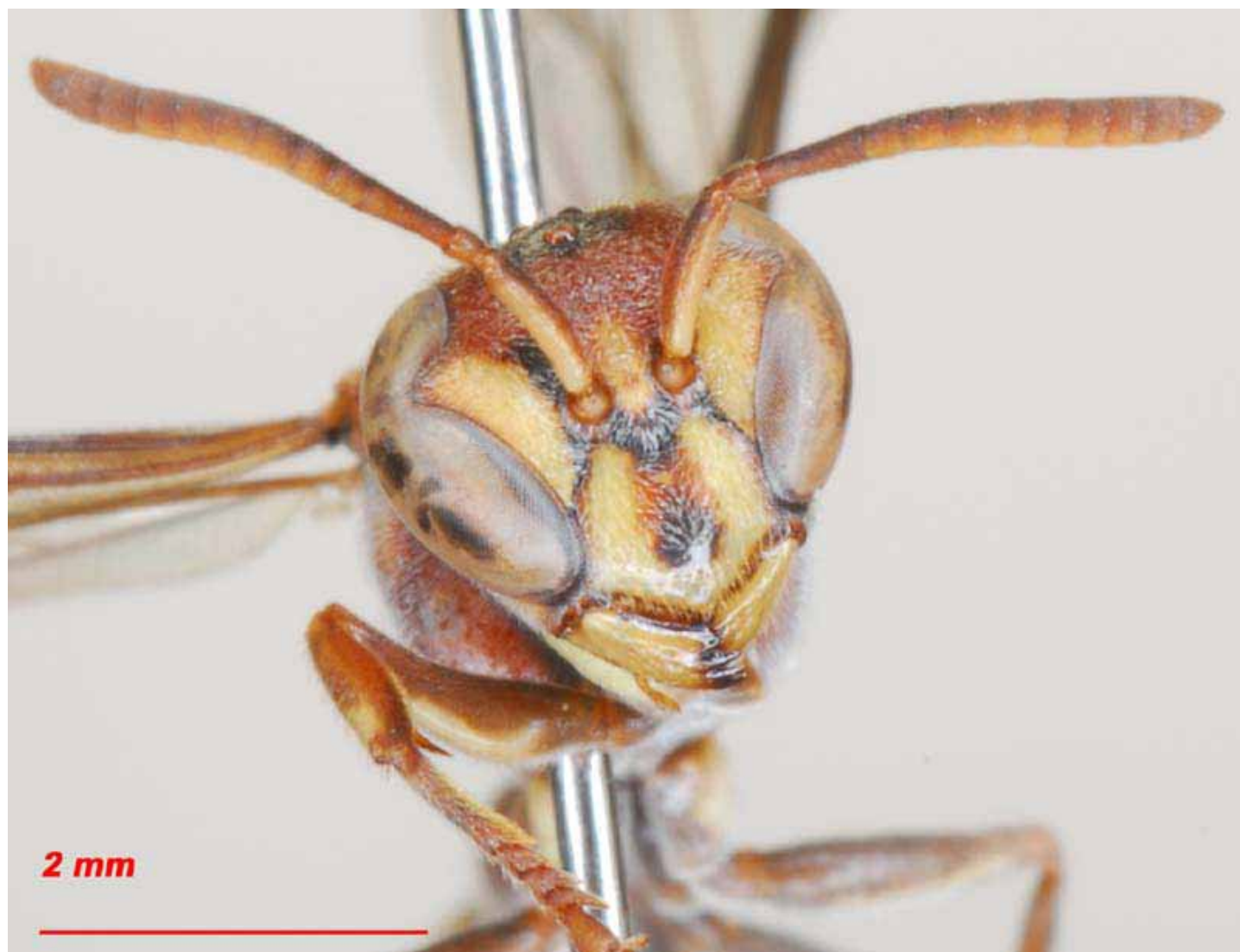


**Plate 92.** *Ropalidia mathematica*. Dorsal view of a worker. (Photo. Author).





Plate 93. *Ropalidia mathematica*. Head view of a worker. (Photo. Author).



**Plate 94. *Ropalidia mathematica*.** Lateral view of a nest at initiation stage. No worker has yet emerged. Note the single pedicel (Photo. Author).



**Plate 95. *Ropalidia mathematica*.** Same nest, frontal view. Note the large larvae at the top of the nest. (Photo. Author).





**Plate 96. *Eustenogaster nigra*.** Lateral view of a male. Note the extremely slender 1<sup>st</sup> abdominal segment. (Photo. Author).

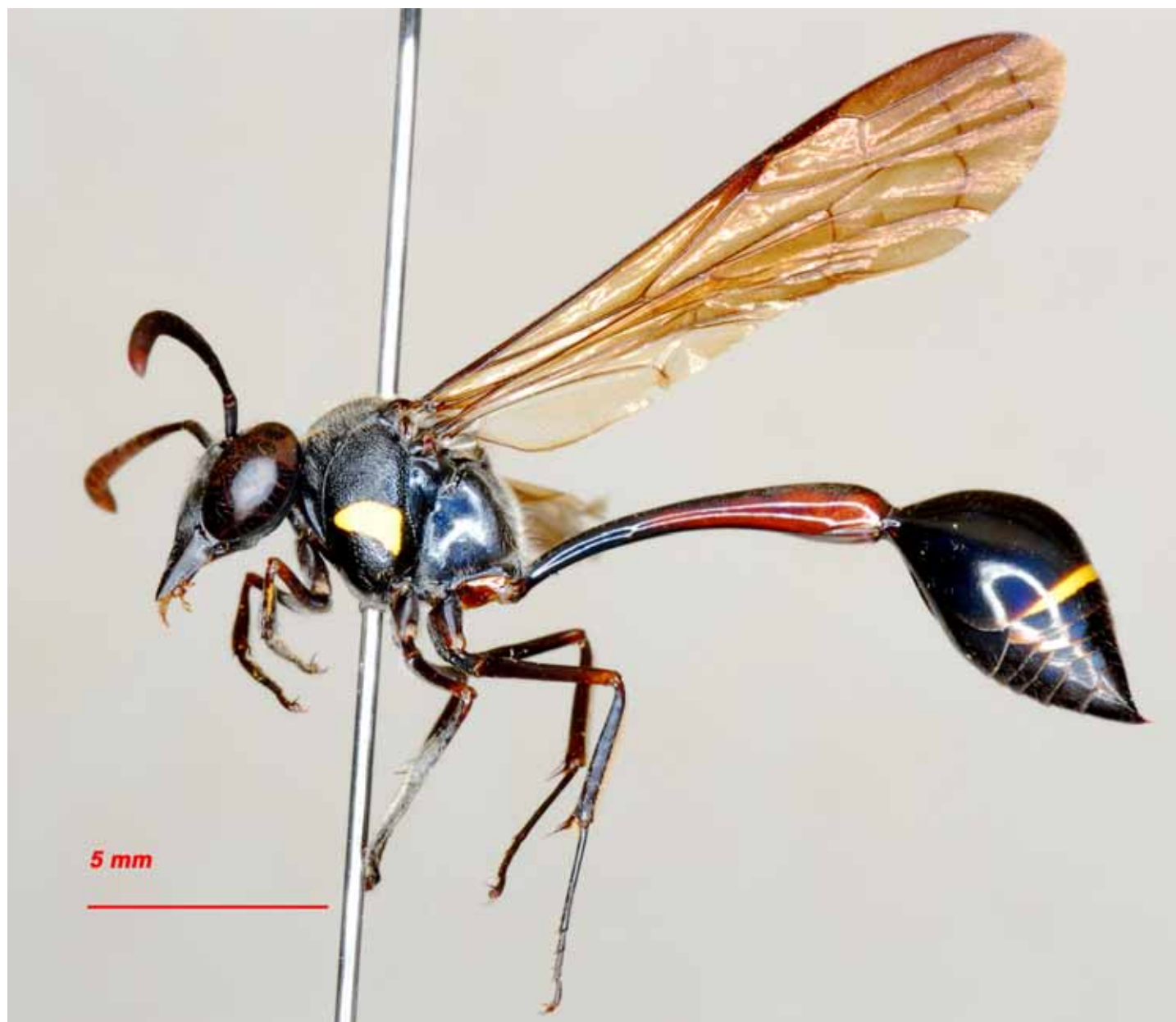




Plate 97. *Eustenogaster nigra*. Dorsal view of a male. (Photo. Author).



**Plate 98.** *Eustenogaster nigra*. Head view of a male. (Photo. Author).



**Plate 99. *Eustenogaster nigra*.** A nest. Note the perforated entrance vestibule. (Photo. Author).



**Plate 100. *Eustenogaster nigra*.** A nest in-situ fixed to a loose wire. Note the gelatinous substance (ant guard) on the substrate above the nest. (Photo. Author).



**Plate 101. *Eustenogaster nigra*.** A open nest revealing larvae at various development stage. Note the way the larvae are coiled around the long axis of the cells. (Photo. Author).





**Plate 102. *Eustenogaster nigra*.** The individual is checking the nest envelop after I had disturbed it. Note the peculiar horn like extension that this species builds at the top of the nest. (Photo. Author).



## Check List of the Social Vespidae Species of Hong Kong

Sub family	Tribe	Genus	Sub-genus	Species
Vespinae		<i>Vespa</i>		<i>affinis</i>
		<i>V.</i>		<i> analis</i>
		<i>V.</i>		<i> bicolor</i>
		<i>V.</i>		<i> ducalis</i>
		<i>V.</i>		<i> soror</i>
		<i>V.</i>		<i> tropica</i>
		<i>V.</i>		<i> velutina</i>
		<i>Vespula</i>	<i>Paravespula</i>	<i> flaviceps</i>
Stenogastrinae		<i>Eustenogaster</i>		<i> nigra</i>
Polistinae	Polistini	<i>Polistes</i>	<i>Gyrostoma</i>	<i> gigas</i>
	Polistini	<i>P.</i>	<i>Megapolistes</i>	<i> oliveaceous</i>
	Polistini	<i>P.</i>	<i>Megapolistes</i>	<i> rothneyi</i>
	Polistini	<i>P.</i>	<i>Megapolistes</i>	<i> jokahamae</i>
	Polistini	<i>P.</i>	<i>Polistella</i>	<i> japonicus</i>
	Polistini	<i>P.</i>	<i>Polistella</i>	<i> sagittarius</i>
	Polistini	<i>P.</i>	<i>Polistella</i>	<i> stigma</i>
	Polistini	<i>P.</i>	<i>Polistella</i>	<i> strigosus</i>
	Ropalidiini	<i>Parapolybia</i>		<i> indica</i>
	Ropalidiini	<i>P.</i>		<i> nodosa</i>
	Ropalidiini	<i>P.</i>		<i> varia</i>
	Ropalidiini	<i>Ropalidia</i>	<i>Anthreneida</i>	<i> fasciata</i>
	Ropalidiini	<i>R.</i>	<i>Anthreneida</i>	<i> hongkongensis</i>
	Ropalidiini	<i>R.</i>	<i>Anthreneida</i>	<i> marginata</i>
	Ropalidiini	<i>R.</i>	<i>Anthreneida</i>	<i> mathematica</i>

## 7 Bibliography

- Archer, M.E. 1989; "A Key to the World Species of the Vespinae (Hymenoptera), College of Ripon & York St John, The Academic Board research Committee.
- Barthélemy, C; 2006; A New Record for Hong Kong and China of a Polistine Wasp of the Genus *Ropalidia*: *Ropalidia mathematica* (Vespidae; Polistinae: Ropalidiini); *Porcupine*, No 34; The University of Hong Kong.
- Carpenter, J.M. 1991; Phylogenetic Relationships and the Origin of Social Behavior in the Vespidae, "The Social Biology of Wasps"; Ed, K.G. Ross & R.W. Matthews; Cornell University Press.
- Carpenter, J.M. 1996; Distributional Checklist of Species of the Genus *Polistes* (Hymenoptera: Vespidae; Polistinae; Polistini); *American Museum Novitates*, No 3188, New York.
- Downing, H.A.; 1991; The Function and Evolution of Exocrine Glands; "The Social Biology of Wasps"; Ed, K.G. Ross & R.W. Matthews; Cornell University Press.
- Evans, H.E & West Eberhard, M.J. 1970; "The Wasps"; The University of Michigan Press.
- Fabre, J.H., 1925 ; "Souvenirs Entomologiques : Etudes sur l'Instinct et les Mœurs des Insectes" ; R. Laffont, Paris 1996, (Librairie Delgrave, Paris, 1925)
- Gadagkar, R. 1991, *Belonogaster*, *Mischocyttarus*, *Parapolybia* and Independent-founding *Ropalidia*; "The Social Biology of Wasps"; Ed, K.G. Ross & R.W. Matthews; Cornell University Press.
- Gadagkar, R. 2001, "The Social Biology of *Ropalidia marginata*: Towards Understanding the Evolution of Eusociality"; Harvard University Press.
- Gauld, I. & Bolton, B.; 1996; "The Hymenoptera"; Oxford University Press.
- Goulet, H. & Huber, J.T., 1993; "Hymenoptera of the World: An identification guide to families"; Centre for Land and Biological Resources Research, Agriculture Canada.
- Gordh G., Headrick D.H., 2001, "A Dictionary of Entomology", CABI Publishing.
- Greene, A. 1991, *Dolichovespula* and *Vespula*, "The Social Biology of Wasps"; Ed, K.G. Ross & R.W. Matthews; Cornell University Press.
- Haxaire, J., Bouget, J.P., Tamisier, J.P.; 2006; *Vespa velutina*, une redoutable nouveauté pour la faune de France; *Bulletins de la Société Entomologique de France*; Vol.111 (2), p194.
- Hunt, J.H., 1991; Nourishment and the Evolution of the Social Vespidae, "The Social Biology of Wasps"; Ed, K.G. Ross & R.W. Matthews; Cornell University Press.
- Ito, Y. & Iwahashi, O.; 1987; An analysis of Foundress Group Size in *Ropalidia fasciata*, with Zero-Truncated distributions, *Researches on Population Ecology*, Vol.29, pp180-194.
- Jeanne, R.L., 1991; Polyethism, "The Social Biology of Wasps"; Ed, K.G. Ross & R.W. Matthews; Cornell University Press.
- Kasuya E, Hibino, Y & Ito, Y. 1980; On Intercolonial Cannibalism in Japanese Paper Wasps, *Polistes chinensis antennalis* Perez and *P. jadvigae* Dalla Torre (Hymenoptera: Vespidae; *Researches on Population Ecology*; Vol.22, No 2.
- Kojima, J.; 1983; Occurrence of the Rubbing Behavior in a Paper Wasp, *Parapolybia indica* (Hymenoptera, Vespidae; *Kontyu*, Tokyo, Vol. 51(1), pp158-159.
- Kojima, J., 1984; Division of Labor and Dominance Interaction among Co-foundresses on Pre-emergence Colonies of *Ropalidia fasciata* (Hymenoptera, Vespidae; *Biological Magazine of Okinawa*, Vol.22, pp27-35.



- Kojima, J., 2001; "Check list of Species of Social Wasps (Vespidae: Stenogastrinae, Vespinae and tribe Ropalidiini)". Natural History Laboratory, Ibaraki University, Japan.
- Lee, J.X.Q & Starr, C.K.; 2007; Violent Combat Among Polistes gigas Males (Hymenoptera: Vespidae); *Sociobiology*, Vol 50, No 2, pp337-342.
- Matsuura, M. 1991; Vespa and Provespa, "The Social Biology of Wasps"; Ed, K.G. Ross & R.W. Matthews; Cornell University Press.
- Ngyuen, L.T.P., Saito, F., Kojima, J., Carpenter, M.; 2006; Vespidae of Vietnam (2). Taxonomic notes on Vespinae; *Zoological Science*, vol.23, pp 95-104. Zoological Society of Japan.
- Ngyuen, L.T.P., Kojima, J., Saito, F., Carpenter, M.; 2006; Vespidae of Vietnam (3): Synoptic key to Vietnamese species of the polistine genus Ropalidia, with notes on taxonomy and distribution; *Entomological Science*, vol.9, pp 93-107. The Entomological Society of Japan.
- O'Donnell, S., 1998; Reproductive Caste Determination in Eusocial Wasps; *Annual Review of Entomology*; 43: 323-346.
- Saito, Fuki; Nguyen, Lien P.T; Carpenter, J.M ; Kojima, J ; 2006 ; A new Eustenogaster Species (Hymenoptera: Vespidae: Stenogastrinae), the First Hover Wasp known to Over-winter on the Nest; *American Museum Novitates*, No 3534; New York
- Spradbery, J.P., 1991; Evolution of Queen Number and Queen Control; "The Social Biology of Wasps"; Ed, K.G. Ross & R.W. Matthews; Cornell University Press.
- Reeve, H.K. 1991, Polistes, "The Social Biology of Wasps"; Ed, K.G. Ross & R.W. Matthews; Cornell University Press.
- Ross, K.G. & Carpenter, J.M., 1991, Population Genetic Structure, Relatedness, and Breeding Systems; Ed, K.G. Ross & R.W. Matthews; Cornell University Press.
- Starr, C.K. 1992, The Social Wasps of Taiwan, *Bulletin of the National Museum of Natural Science*, No 3.
- Turillazzi, S. 1991, The Stenogastrinae; "The Social Biology of Wasps"; Ed, K.G. Ross & R.W. Matthews; Cornell University Press.
- Turillazzi, S. 1996; Polistes in perspective; "Natural History and evolution of Paper-wasps", Ed. S. Turillazzi & M.J. West-Eberhard, Oxford University Press.
- Vecht, J. van der 1957; "The Indo-Australian Species of the Genus *Ropalidia* (*Icaria*) (Hymenoptera, Vespidae)"; E.J. Brill, Leiden.
- Vecht, J. van der 1962; "The Vespinae of the Indo-Malayan and Papuan Areas (Hymenoptera, Vespidae)"; E.J. Brill, Leiden.
- Vecht, J. van der 1963, "Studies on Indo-Australian and East-Asiatic Eumenidae (Hymenoptera, Vespoidea), E.J. Brill, Leiden.
- Vecht, J. van der 1966, "The East-Asiatic and Indo-Australian Species of *Polybioides* Buysson and *Parapolybia* Saussure (Hym. Vespidae)", E.J. Brill, Leiden.
- Vecht, J. van der & Carpenter, J.M; 1990; "A Catalogue of the genera of the Vespidae (Hymenoptera)"; Zoologische Verhandelingen, Leiden, Netherland.
- Yamane, Seiki. & Wang, H.Y., 1; " Guide Book to Insects of Taiwan (16), Hornets, Paper wasps and Potter wasps";
- Yamane, Seiki, Ikudome, S & Terayama, M, 1999; "Identification guide to the Aculeata of the Nansei Islands, Japan", Hokkaido University Press, Sapporo.

- Yamane, Soichi. 1996; Ecological factors influencing the colony cycle of *Polistes* wasps, "Natural History and evolution of Paper-wasps", Ed. S. Turillazzi & M.J. West-Eberhard, Oxford University Press.
- Wenzel, John W. 1991, Evolution of Nest Architecture; "The Social Biology of Wasps"; Ed, K.G. Ross & R.W. Matthews; Cornell University Press.

## 8 Index of families, sub-families, tribes, genera and species

### E

<i>E. nigra</i> .....	41, 42
Eumeninae.....	4, 5, 8, 41, 131
Euparagiinae.....	5
<i>Eustenogaster</i> .....	4, 7, 40, 41, 126, 131
<i>Eustenogaster nigra</i> .....	4, 40, 41, 131
<i>Eustenogaster nigra</i> .....	41

### H

hornet.....	15, 16, 17
hornets.....	3, 8, 13, 15, 18, 22, 37
hover-wasps.....	3

### M

Masarinae.....	5
----------------	---

### P

<i>P. indica</i> .....	33, 34, 35
<i>P. nodosa</i> .....	33, 34, 35
<i>P. varia</i> .....	33, 34, 35
<i>P.indica</i> .....	34
paper wasps.....	3, 21
<i>Parapolybia</i> ...	15, 16, 17, 21, 25, 33, 34, 35, 36, 126, 127, 128, 131
<i>Parapolybia indica</i> .....	15, 16, 21, 25, 33
<i>Parapolybia nodosa</i> .....	21, 25, 34
<i>Parapolybia varia</i> .....	21, 25, 35
<i>Polistes</i> .....	24, 26
<i>Polistes gigas</i> .....	21, 24, 27
<i>Polistes japonicus</i> .....	6, 21, 24, 29
<i>Polistes jokahamae</i> .....	21, 24, 29
<i>Polistes olivaceus</i> .....	21, 24, 27, 28
<i>Polistes olivaceus</i> .....	24
<i>Polistes rothneyi</i> .....	21, 25, 28
<i>Polistes sagittarius</i> .....	21, 24, 30
<i>Polistes stigma</i> .....	21, 24, 31
<i>Polistes strigosus</i> .....	21, 24, 31, 32
Polistinae.....	4, 5, 6, 8, 9, 21, 22, 23, 33, 36, 37, 126, 127, 131
Polistine wasps.....	22, 36

### R

<i>R. fasciata</i> .....	36, 37, 39
<i>R. fasciata</i> ,.....	39
<i>R. hongkongensis</i> .....	36, 37, 39
<i>R. marginata</i> .....	37, 39
<i>R. mathematica</i> .....	37, 39
<i>Ropalidia</i> .....	21, 22, 25, 36, 37, 38, 126, 127, 128, 131
<i>Ropalidia fasciata</i> .....	21, 25, 36, 127
<i>Ropalidia hongkongensis</i> .....	21, 25, 37
<i>Ropalidia marginata</i> .....	21, 25, 38
<i>Ropalidia mathematica</i> .....	21, 25, 38

### S

Stenogastrinae.....	4, 5, 6, 7, 22, 40, 41, 126, 128, 131
---------------------	---------------------------------------

### V

<i>V. affinis</i> .....	16
<i>V. bicolor</i> .....	12
<i>V. ducalis</i> .....	11, 16
<i>V. soror</i> .....	11, 16
<i>V. tropica</i> .....	11
<i>V. velutina</i> .....	12
<i>Vespa</i> ...	8, 9, 11, 13, 14, 15, 16, 17, 18, 31, 34, 36, 62, 63, 64, 126, 128, 131
<i>Vespa affinis</i> .....	8, 11, 13, 17, 31
<i>Vespa analis</i> .....	9, 14
<i>Vespa bicolor</i> .....	9, 15
<i>Vespa ducalis</i> .....	9, 15
<i>Vespa soror</i> .....	9, 16
<i>Vespa tropica</i> .....	9, 14, 17, 31, 36
<i>Vespa velutina</i> .....	9, 17
Vespidae.....	3, 4, 5, 6, 7, 15, 18, 33, 36, 40, 126, 127, 128
Vespids.....	5, 7, 31, 34, 36
Vespinae ...	4, 5, 6, 8, 9, 10, 13, 14, 15, 16, 17, 19, 22, 26, 126, 127, 128, 131
<i>Vespula</i> .....	6, 8, 9, 11, 18, 19, 20, 66, 126, 127
<i>Vespula flaviceps</i> .....	6, 9, 11, 18, 19, 66

### Y

yellow-jacket.....	3
yellow-jackets.....	8



## 9 Notes

- <sup>1</sup> However, humans have a varying degree of reaction to the venom that is injected when attacked. In extreme cases, when the individual is allergic to hymenoptera venom, a sting could cause an anaphylactic choc that can lead to death. In most cases (for social wasps) one will suffer a localized swelling accompanied by a loss of feeling, that is regained in a few hours maybe a day or two.
- <sup>2</sup> In fact wasps are mainly tropical and if they are well distributed world-wide they are generally not found over 2500m in elevation and are not present in Antarctica or Greenland.
- <sup>3</sup> It is understood from fossil record that all wasps originally descend from a common group of plant feeding ancestors.
- <sup>4</sup> A few groups, however, have larvae that are largely eyeless and legless, borers of plant tissue, including wood.
- <sup>5</sup> While the Aculeata group forms a **monophyletic** assemblage, Parasitica is **polyphyletic** and therefore the group is invalid in terms of pure **phylogeny**. It can be said that some species in the Parasitica group are able to sting and that species of the Aculeata group have developed a Parasitic behaviour (some Vespinae, some Eumeninae).
- <sup>6</sup> The Sphecidae family: a few species of Sphecids wasps display true eusocial behaviour, whilst others in the same family have also a pre-social behaviour. (Ross & Carpenter, 1991).
- <sup>7</sup> A few publications treat partially of social wasps in Hong Kong, much of it either outdated in terms of nomenclature, with erroneous species identifications or too badly illustrated or without proper biological analysis to make any sense and therefore of little use for the serious entomologist.
- <sup>8</sup> Dimensions of species where taken from various sources:
- Personal collection.
  - Tai Lung Experimental Farm holdings.
  - X.Q. Lee personal collection.
- <sup>9</sup> It has to be noted that this classification is rather loose and based on local colonies thus far observed. Some nests collected by local amateurs suggest that in various species of *Vespa* (*V. bicolor*, *V. velutina*, *V. affinis*) colonies in Hong Kong can reach well over 1000 individuals.
- <sup>10</sup> James Hunt argues (Hunt; 1991) that particular anatomic traits of wasps such as the abdominal constriction and the anatomy of the digestive tract constrains wasps to a liquid diet and as such are not strictly carnivorous.
- <sup>11</sup> Both aspects are important facets of the mechanisms of colony control and social cohesion (Hunt, 1991).
- <sup>12</sup> Workers are generally sterile females, but they possess ovaries and in some species any female has the potential of reproducing (some Stenogastrinae and *Ropalidia rufoplagiata*). However, strong evidence suggests that reproductive differentiation occurs before the adult emergence (pre-imaginal stage). (O'Donnell S. 1998).
- <sup>13</sup> The reproductive queen stores sperm in a special organ called spermatheca and release it accordingly to the planned sex of the offspring.
- <sup>14</sup> *Parapolybia indica*, *Ropalidia spp* colonies and *Eustenogaster nigra* produce males as early as July in Hong Kong.
- <sup>15</sup> Multiple foundation (Pleometrosis) is observed for many Polistinae world wide. Various species in the genera *Polistes*, *Paraschnogaster*, *Ropalidia*, *Belonogaster*, *Parapolybia* and *Mischocyttarus* are known to have multiple foundresses (Spradbery, 1991). A sub-species of *V. tropica* (*V. tropica leefmansii*) is recorded to have a pleometrotic foundation in Sumatra (Spradbery, 1991). Therefore, it could be possible that in Hong Kong a few species (*Ropalidia spp*, *Polistes spp* and *Parapolybia spp*) may have colonies that are pleometrotic, but there is a lack of record to prove or disprove this.
- <sup>16</sup> The sub-tropical weather of Hong Kong with a relatively cold period in winter seems to be the leading factor in regulating intraspecific colony initiation and all species have a more or less synchronous colony development, i.e. all colonies are initiated in spring. However, under tropical latitudes in Southeast Asia, species of *Vespa* (Matsuura, 1991; Starr, 1989), *Polistes*, *Ropalidia*, *Stenogastrinae* form colonies that have an asynchronous development, i.e. nests of varying level of development can be found at the same time during any period of the year.

<sup>17</sup> No foundation by swarming is recorded for Hong Kong. However when that happens in more tropical latitudes, it is the workers that select the nesting site, initiate the construction of the first cells and forage food for the larvae. *Vespa affinis* is known to form colonies by swarming (Starr 1992).

<sup>18</sup> These phases have been adapted from those derived by Robert L. Jeanne (Jeanne 1991), with regards to temperate zones. However Hong Kong despite its sub-tropical climate and because of its marked cold season, colonies generally disintegrate between November and March.

<sup>19</sup> In fact, in the case of most single un-protected comb construction, the geometry of the surface becomes rather complex. In deed cells taper towards their base, being more or less conical in longitudinal section, therefore when peripheral cell additions are made the surface develops into a complex toroid, with single or multiple curvatures, it folds on itself.

<sup>20</sup> In fact for many Polistinae it has been observed that workers have varying level of ovarian development, correlated to a finer cast differentiation: The queen is the  $\alpha$ -female which is dominant over all other individuals in the colony, then comes the  $\beta$ -female which is dominant over all except the  $\alpha$ -female and so on (Spradbery, op.cit.). However, the definition of "cast" is not completely fixed and some researchers consider that only the reproductive potential of individuals defines casts within the eusocial Vespidae (O'Donnell, op.cit.).

<sup>21</sup> *Vespa soror* and *Vespa tropica*, and to a lesser extent *Vespa ducalis*, form nests that have an incomplete envelop. It has to be noted that these species are often fossorial.

<sup>22</sup> The envelop is composed of overlapping pockets of air enclosed in wood pulp. The enclosed still air forms a perfect insulation matting allowing the colony inside, to be protected from over-heating and to a lesser extend, in Hong Kong from over-cooling. This particular function of the envelop was first described by the French naturalist J.H. Fabre (Fabre, 1925).

<sup>23</sup> If *V. mandarinia* is confirmed in Hong Kong then *V.soror* will loose its title as the largest hornet locally.

<sup>24</sup> Field observations in South-west of France between 2005 and 2006 have revealed the existence of colonies that have successfully colonized the area. The source and how the species got there in the first place remains un-explained (Haxaire et al, 2006).

<sup>25</sup> Much work remains to be done in understanding the nature and the role of pheromones in Vespidae.

<sup>26</sup> It is Leo Pardi (1915-1990) an Italian biologist that 1<sup>st</sup> conceptualized in 1942 - through the analysis of *Polistes* wasps colonies- the notion of dominance/ sub-ordinance in animal societies.

<sup>27</sup> In fact I have observed many species of Polistinae using dry bamboo: *P. gigas*, *P. strigosus*, *P. olivaceus*, *P. jadvigae* and *P. Sagittarius*. (pers. obs.).

<sup>28</sup> This sequence is adapted from that given for sub-tropical climates by Soichi Yamane (Yamane, 1996) and adapted according to personal observations of nests of *P.gigas* and *P. japonicus* in Hong Kong.

<sup>29</sup> Van der Vecht who revised the genus in 1966, recognised five regionally different forms from color patterns in species of *P. varia*. (Vecht, 1966).

<sup>30</sup> In fact I have noted that many a time *P. varia* presents a more swollen petiole at the apex.

<sup>31</sup> There is little evidence of queen/worker dominance hierarchy in the genus *Eustenogaster* as most nests studied to date have had one only female (Turillazzi, 1996).