



**Taxonomy and Nesting Habits of the Ant Subgenus *Myrmatopa* Forel
of the Genus *Polyrhachis* F. Smith, 1857 (Hymenoptera: Formicidae:
Formicinae) of the Indo-Malayan Subregion**

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ชื่อวิทยานิพนธ์	อนุกรมวิธานและนิสัยการสร้างรังของมด ในสกุลย่อย <i>Myrmatopa</i> Forel สกุล <i>Polyrhachis</i> F. Smith, 1857 (อันดับ Hymenoptera: วงศ์ Formicidae: วงศ์ย่อย Formicinae) ในบริเวณเขตย่อยอินโด-มาลาเลย์ัน
ผู้เขียน	นายนาวิ หนุณอนันต์
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บทคัดย่อ

การศึกษานุกรมวิธานและนิสัยการสร้างรังของมด ในสกุลย่อย *Myrmatopa* Forel ในเขตย่อยอินโด-มาลาเลย์ัน มีวัตถุประสงค์เพื่อแก้ไขปัญหาทางด้านอนุกรมวิธานและชีวนิเวศวิทยาของมดสกุลย่อยนี้ และศึกษาบทบาทของมดที่พบในบริเวณเขตย่อยอินโด-มาลาเลย์ัน โดยใช้ลักษณะรูปร่างภายนอกและลักษณะนิเวศวิทยาของวรรณะมดงาน และวรรณะมดราชินี ในกรณีที่มีข้อมูลของวรรณะมดงานและราชินีพบอาศัยอยู่ในรังเดียวกัน

การศึกษานี้ตรวจสอบพบมดทั้งหมด 21 ชนิด และสามารถจัดแบ่งเป็น 4 กลุ่มชนิด โดยใช้ลักษณะภายนอกของวรรณะมดงาน คือ 1.) *flavicornis*-group (*Polyrhachis antedoridens* sp. nov., *P. constructor* F. Smith, *P. flavicornis* F. Smith, *P. kohouti* sp. nov. และ *P. varicolor* Viehmeyer); 2.) *schang*-group (*P. cnemidata* Emery, stat. nov., *P. dolomedes* F. Smith, *P. parvicella* Forel, stat. nov., *P. solmsi* Emery และ *P. tawauensis* sp. nov.); 3.) *simillima*-group (*P. angusticlypealis* sp. nov., *P. simillima* Emery, *P. watanasiti* sp. nov. และ *P. wiwatwitayai* sp. nov.) และ 4.) *wallacei*-group (*P. jacobsoni* Forel, *P. lilianae* Forel, *P. lombokensis* Emery, *P. subtridens* Emery, *P. vanispina* sp. nov., *P. wartburgi* Forel และ *P. yamanei* sp. nov.) และจัดทำรูปวิธานจำแนกมดในระดับกลุ่มชนิดและชนิดในวรรณะมดงาน นอกจากนี้ได้จัดทำรูปวิธานเบื้องต้นเพื่อจำแนกมดในระดับกลุ่มชนิดและชนิดในวรรณะมดราชินี ในกรณีที่มีวรรณะมดงานและราชินีพบอาศัยอยู่ในรังเดียวกัน

การศึกษานิสัยการสร้างรัง (ขนาด จำนวนรูทางเข้า และความสูงของรัง, วัสดุโครงสร้างร่างกายนอก และองค์ประกอบของอาณาจักร) ได้ดำเนินการเก็บรวบรวมข้อมูลในพื้นที่ภาคสนามใน 32 พื้นที่จุดสุ่มเก็บข้อมูล (ความสูง 0-600 เมตร จากระดับน้ำทะเลปานกลาง) ซึ่งเป็นตัวแทนของป่าดิบชื้นระดับต่ำใน 5 แนวเทือกเขา (ตะนาวศรี ภูเก็ต เขาหลวง เขาบรรทัด และสันกาลาศีรี) และเกาะตะรุเตา ในภาคใต้ของประเทศไทย ระหว่างช่วงเดือนมีนาคม 2547 ถึง มีนาคม 2551 พบว่ารังของมด 5 ชนิด (*P. cnemidata* Emery, *P. constructor* Smith, *P.*

flavicornis Smith, *P. wartburgi* Forel และ *P. varicolor* Viehmeyer) มีความคล้ายคลึงกันโดยมีการนำไปไม้มาสร้างเป็นรังในระดับไม้พื้นล่าง แต่มีความแตกต่างกันอย่างชัดเจนในด้านของความกว้าง ความหนา และความสูงของรังจากระดับพื้นดินระหว่างมด 3 ชนิด (*P. cnemidata* Emery, *P. constructor* Smith และ *P. flavicornis* Smith) อย่างไรก็ตามพบว่า ขนาดรัง (ความยาว ความกว้าง ความหนา), ความสูงของรังจากระดับพื้นดิน และจำนวนรูทางเข้าของแต่ละรัง มีช่วงขนาด ความยาว และจำนวนรู คาบเกี่ยวกันระหว่างมด 5 ชนิด ดังกล่าวข้างต้น

รังมดซึ่งสุ่มเก็บมา 17 รัง ของมด 4 ชนิด (*P. cnemidata* Emery, *P. constructor* Smith, *P. flavicornis* Smith และ *P. varicolor* Viehmeyer) นำมาตรวจสอบวัสดุโครงสร้างรังภายนอกภายใต้กล้องจุลทรรศน์แบบส่องกราดกำลังขยายสูง พบว่าชิ้นส่วนของเศษพืช ซึ่งมีทั้งขนาดหยาบและละเอียดถูกนำมาใช้เป็นส่วนประกอบของโครงสร้างรังของมดชนิดดังกล่าว ขณะที่เส้นใยไหมซึ่งสร้างจากมดในระยะตัวอ่อน ถูกนำมาใช้เป็นส่วนประกอบของโครงสร้างรังภายนอกเช่นเดียวกัน ยกเว้นในรังของมดชนิดเดียว คือ *P. cnemidata* Emery ซึ่งไม่พบเส้นใยไหมจากมดในระยะตัวอ่อนเป็นส่วนประกอบของโครงสร้างรังภายนอก

การศึกษาองค์ประกอบของอาณาจักรรังใหม่ 5 ชนิด พบว่ามด *P. cnemidata* Emery, *P. constructor* Smith, *P. flavicornis* Smith และ *P. varicolor* Viehmeyer มีลักษณะคล้ายคลึงกันคือ หนึ่งอาณาจักรรังประกอบด้วยรังย่อยมากกว่าหนึ่งรัง และโดยปกติภายในหนึ่งอาณาจักรมีวรรณะมดราชินีเพียงหนึ่งตัว ขณะที่มด *P. wartburgi* Forel ไม่สามารถระบุได้ชัดเจน เนื่องจากการศึกษาครั้งนี้พบมดชนิดนี้เพียงรังเดียว และภายในรังพบวรรณะมดราชินีเพียงตัวเดียว

การศึกษานุกรมวิธานและนิสัยการสร้างรังของมด ในสกุลย่อย *Myrmatopa* Forel ในเขตย่อยอินโด-มาลาโย เป็นการศึกษาเพิ่มเติมในด้านความสำคัญของลักษณะรูปร่างภายนอกและลักษณะนิเวศวิทยา ซึ่งช่วยขยายขอบเขตความรู้เพิ่มเติมเกี่ยวกับสัตว์ และการแพร่กระจายของมดในภูมิภาคเอเชียตะวันออกเฉียงใต้ นอกจากนี้ข้อมูลที่ได้จากการศึกษาครั้งนี้ น่าจะช่วยเพิ่มคุณค่าประโยชน์ในด้านนิเวศวิทยาพื้นฐานของสิ่งมีชีวิตที่มีพฤติกรรมอยู่ร่วมกันแบบสังคมของมดในสกุลย่อย *Myrmatopa* และสร้างเสริมความเข้าใจในด้านนิเวศวิทยาพื้นฐานของสิ่งมีชีวิตที่มีพฤติกรรมอยู่ร่วมกันแบบสังคม และสายสัมพันธ์ทางวิวัฒนาการของมดในสกุล *Polyrhachis*

Thesis Title Taxonomy and Nesting Habits of the Ant Subgenus *Myrmatopa* Forel of the Genus *Polyrhachis* F. Smith, 1857 (Hymenoptera: Formicidae: Formicinae) of the Indo-Malayan Subregion

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ABSTRACT

A study of the taxonomy and nesting habits of the ant subgenus *Myrmatopa* Forel in the Indo-Malayan subregion aimed to resolve the taxonomic and bionomic problems of the subgenus *Myrmatopa*, to revise the Indo-Malayan species of this group based on the morphological and ecological characteristics of the workers, and queen when information on the worker-queen association was available.

In this study, a total of 21 species were recognized on the basis of their external morphological characteristics into four species-groups: 1.) *flavicornis*-group (*Polyrhachis*) *antedoridens* sp. nov., *P. constructor* F. Smith, *P. flavicornis* F. Smith, *P. kohouti* sp. nov. and *P. varicolor* Viehmeyer); 2.) *schang*-group (*P. cnemidata* Emery, stat. nov., *P. dolomedes* F. Smith, *P. parvicella* Forel, stat. nov., *P. solmsi* Emery and *P. tawauensis* sp. nov.); 3.) *simillima*-group (*P. angusticlypealis* sp. nov., *P. simillima* Emery, *P. watanasiti* sp. nov. and *P. wiwatwitayai* sp. nov.) and 4.) *wallacei*-group (*P. jacobsoni* Forel, *P. lilianae* Forel, *P. lombokensis* Emery, *P. subtridens* Emery, *P. vanispina* sp. nov., *P. wartburgi* Forel and *P. yamanei* sp. nov.). Keys to species-groups and species are provided for identification of workers. In addition, a provisional key is proposed for species-groups and species for which the worker-queen association was available.

The nesting habits (nesting sites, nest materials and colony composition) was examined in the field at thirty-two sampling sites (0-600 msl.) as representatives of lowland forest in five mountain ranges (Tenasserim, Phuket, Khao Luang, Khao Banthat and Sankalakhiri) and Tarutao island of Peninsular Thailand during March 2004 to March 2008. This study indicated that five species (*P.*

cnemidata Emery, *P. constructor* Smith, *P. flavicornis* Smith, *P. wartburgi* Forel and *P. varicolor* Viehmeyer) were similar in nesting on the lower vegetation using plant leaves but there was a remarkable difference in nest width, nest depth and nest location above the ground among three species (*P. cnemidata* Emery, *P. constructor* Smith and *P. flavicornis* Smith). However, the size of nest (height, width, depth), nest location above ground and the number of entrances per nest, were overlapping among these five species in their range.

Seventeen sampled nests of the four species (*P. cnemidata* Emery, *P. constructor* Smith, *P. flavicornis* Smith and *P. varicolor* Viehmeyer), were examined with a scanning electron microscope to help identify the nest materials. They showed ‘carton’ material composed of both coarse and finely particulate material, while silk sheets were incorporated into the nest wall structures, with the exception of the single species, *P. cnemidata* Emery.

The colony composition of the five species indicated that *P. cnemidata* Emery, *P. constructor* Smith, *P. flavicornis* Smith and *P. varicolor* Viehmeyer are polydomous and generally monogynous. For *P. wartburgi* Forel it was not possible to be specific because only one nest with a dealate queen was found.

This study of the taxonomy and nesting habits of the ant subgenus *Myrmatopa* Forel in the Indo-Malayan subregion adds important morphological and ecological defining characteristic, that contributes to the faunistic and distributional knowledge of ants in general from Southeast Asia. In addition, the information given in this study provides useful knowledge on the socioecology of the subgenus *Myrmatopa*, and facilitates an understanding of the socioecology and phylogeny of the genus *Polyrhachis*.

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CONTENTS

	Page
Contents	viii
List of Tables	ix
List of Figures	xii
List of Abbreviations and Symbols	xixii
Chapter 1. Introduction	1
An overview of the ants	1
Historical review and biology of the ant genus <i>Polyrhachis</i> F. Smith	3
Historical review and biology of the subgenus <i>Myrmatopa</i> Forel	4
Taxonomic problems	4
Objectives	5
Summary of chapters	5
Chapter 2. Revision based on material from Indo-Malayan subregion	6
Introduction	6
Materials and methods	6
Results	11
Discussion	123
Chapter 3. Nesting habits	126
Introduction	126
Materials and methods	127
Results	131
Discussion	156
Chapter 4. Conclusions and further perspectives	161
References	163
Appendix	172
Vitae	199

LIST OF TABLES

Table	Page
1 Size of the nests and the number of entrances per nest for <i>P. cnemidata</i> Emery In Peninsular Thailand	133
2 Location of the nests above ground for <i>P. cnemidata</i> Emery in Peninsular Thailand	133
3 Size and location of the nests, and the number of entrances per nest for <i>P. constructor</i> Smith in Peninsular Thailand	135
4 Size, location of the nests, and the number of entrances per nest for <i>P. flavicornis</i> Smith in Peninsular Thailand	137
5 The frequency of <i>P. flavicornis</i> Smith nests and colonies on different plant categories in Peninsular Thailand	138
6 The frequency of <i>P. flavicornis</i> Smith nests and colonies on different plant families in Peninsular Thailand	139
7 Location of the nests above ground for <i>P. flavicornis</i> Smith in Peninsular Thailand and West Sumatra, Indonesia	140
8 Size, location of the nests, and the number of entrances per nest for <i>P. varicolor</i> Viehmeyer in Peninsular Thailand	142
9 Size, location of the nests, the number of entrances per nest and multiple (A-B) comparisons tests among the different species of <i>Myrmatopa</i> in Peninsular Thailand	144
10 Nest material among the different <i>species</i> -groups and species of <i>Myrmatopa</i> in Peninsular Thailand	146
11 Colony composition of <i>P. cnemidata</i> Emery from Peninsular Thailand	151
12 Colony composition of <i>P. constructor</i> Smith from Peninsular Thailand	152
13 Colony composition of <i>P. flavicornis</i> Smith from Peninsular Thailand and West Sumatra, Indonesia	153
14 Colony composition of <i>P. varicolor</i> Viehmeyer from Peninsular Thailand	154
15 Colony composition of <i>P. wartburgi</i> Forel from Peninsular Thailand	155
16 Colony composition among the different species of <i>Myrmatopa</i> from Peninsular Thailand	156

LIST OF TABLES (Continued)

Table		Page
17	Nest structure and location of the nests for <i>P. cnemidata</i> Emery in the Tenasserim mountain range	174
18	Nest structure and location of the nests for <i>P. cnemidata</i> Emery in the Phuket mountain range	175
19	Nest structure and location of the nests for <i>P. cnemidata</i> Emery in the Khao Luang mountain range	176
20	Nest structure and location of the nests for <i>P. cnemidata</i> Emery in the Khao Banthat mountain range	177
21	Nest structure and location of the nests for <i>P. cnemidata</i> Emery in the Sunkalakhiri mountain range	178
22	Nest structure and location of the nests for <i>P. cnemidata</i> Emery in the Tarutao island	179
23	Nest structure and location of the nests for <i>P. constructor</i> Smith in the Tenasserim mountain range	180
24	Nest structure and location of the nests for <i>P. constructor</i> Smith in the Phuket mountain range	181
25	Nest structure and location of the nests for <i>P. constructor</i> Smith in the Khao Banthat mountain range	182
26	Nest structure and location of the nests for <i>P. flavicornis</i> Smith in the Tenasserim mountain range	183
27	Nest structure and location of the nests for <i>P. flavicornis</i> Smith in the Phuket mountain range	185
28	Nest structure and location of the nests for <i>P. flavicornis</i> Smith in the Khao Luang mountain range	186
29	Nest structure and location of the nests for <i>P. flavicornis</i> Smith in the Khao Banthat mountain range	188

LIST OF TABLES (Continued)

Table		Page
30	Nest structure and location of the nests for <i>P. flavicornis</i> Smith in West Sumatra, Indonesia	193
31	Nest structure and location of the nests for <i>P. varicolor</i> Viehmeyer in the Tenasserim mountain range	194
32	Nest structure and location of the nests for <i>P. varicolor</i> Viehmeyer in the Khao Luang and Khao Banthat mountain range	195
33	The Pearson Chi-square test showed the proportion of <i>P. flavicornis</i> Smith nests on different plant categories in Peninsular Thailand	196
34	The Pearson Chi-square test showed the proportion of <i>P. flavicornis</i> Smith colonies on different plant categories in Peninsular Thailand	196
35	The Pearson Chi-square test showed the proportion of <i>P. flavicornis</i> Smith nests on different host plant families in Peninsular Thailand	197
36	The Pearson Chi-square test showed the proportion of <i>P. flavicornis</i> Smith colonies on different host plant families in Peninsular Thailand	198

LIST OF FIGURES

Figure		Page
1	Worker of <i>Polyrhachis</i> F. Smith in lateral view	2
2	Map of study area	8
3	Measuring points and some morphological terms of the worker	10
4	Distribution of <i>P. antedoridens</i> sp. nov.	22
5	Distribution of <i>P. constructor</i> F. Smith	26
6	Distribution of <i>P. flavicornis</i> F. Smith	30
7	Distribution of <i>P. kohouti</i> sp. nov.	33
8	Distribution of <i>P. varicolor</i> Viehmeyer	37
9	<i>P. antedoridens</i> sp. nov. worker in lateral view of hole body	38
10	<i>P. constructor</i> F. Smith worker in lateral view of hole body	38
11	<i>P. elii</i> Emery worker (syntype) in lateral view of hole body	38
12	<i>P. flavicornis</i> F. Smith worker in lateral view of hole body	38
13	<i>P. kohouti</i> sp. nov. worker in lateral view of hole body	38
14	<i>P. varicolor</i> Viehmeyer worker in lateral view of hole body	38
15	<i>P. constructor</i> F. Smith queen (syntype) in lateral view of hole body	39
16	<i>P. constructor</i> F. Smith queen in lateral view of hole body	39
17	<i>P. piliventris</i> F. Smith queen (syntype) in lateral view of hole body	39
18	<i>P. ruficornis</i> F. Smith queen (syntype) in lateral view of hole body	39
19	<i>P. flavicornis</i> F. Smith queen in lateral view of hole body	39
20	<i>P. varicolor</i> Viehmeyer queen in lateral view of hole body	39
21	<i>P. antedoridens</i> sp. nov. worker, head in full face view	40
22	<i>P. constructor</i> F. Smith worker, head in full face view	40
23	<i>P. elii</i> Emery worker (syntype), head in full face view	40
24	<i>P. flavicornis</i> F. Smith worker, head in full face view	40
25	<i>P. kohouti</i> sp. nov. worker, head in full face view	40
26	<i>P. varicolor</i> Viehmeyer worker, head in full face view	40
27	<i>P. constructor</i> F. Smith queen (syntype), head in full face view	41
28	<i>P. constructor</i> F. Smith queen, head in full face view	41

LIST OF FIGURES (Continued)

Figure		Page
29	<i>P. piliventris</i> F. Smith queen (syntype), head in full face view	41
30	<i>P. ruficornis</i> F. Smith queen (syntype), head in full face view	41
31	<i>P. flavicornis</i> F. Smith queen, head in full face view	41
32	<i>P. varicolor</i> Viehmeyer queen, head in full face view	41
33	<i>P. antedoridens</i> sp. nov. worker in lateral view of mesosoma and petiole	42
34	<i>P. constructor</i> F. Smith worker in lateral view of mesosoma and petiole	42
35	<i>P. elii</i> Emery worker (syntype) in lateral view of mesosoma and petiole	42
36	<i>P. flavicornis</i> F. Smith worker in lateral view of mesosoma and petiole	42
37	<i>P. kohouti</i> sp. nov. worker in lateral view of mesosoma and petiole	42
38	<i>P. varicolor</i> Viehmeyer worker in lateral view of mesosoma and petiole	42
39	<i>P. constructor</i> F. Smith queen (syntype) in lateral view of mesosoma and petiole	43
40	<i>P. constructor</i> F. Smith queen in lateral view of mesosoma and petiole	43
41	<i>P. piliventris</i> F. Smith queen (syntype) in lateral view of mesosoma and petiole	43
42	<i>P. ruficornis</i> F. Smith queen (syntype) in lateral view of mesosoma and petiole	43
43	<i>P. flavicornis</i> F. Smith queen in lateral view of mesosoma and petiole	43
44	<i>P. varicolor</i> Viehmeyer queen in lateral view of mesosoma and petiole	43
45	<i>P. antedoridens</i> sp. nov. worker in dorsal view of mesosoma and petiole	44
46	<i>P. constructor</i> F. Smith worker in dorsal view of mesosoma and petiole	44
47	<i>P. elii</i> Emery worker (syntype) in dorsal view of mesosoma and petiole	44
48	<i>P. flavicornis</i> F. Smith worker in dorsal view of mesosoma and petiole	44
49	<i>P. kohouti</i> sp. nov. worker in dorsal view of mesosoma and petiole	44
50	<i>P. varicolor</i> Viehmeyer worker in dorsal view of mesosoma and petiole	44
51	<i>P. constructor</i> F. Smith queen (syntype) in dorsal view of mesosoma and petiole	45
52	<i>P. constructor</i> F. Smith queen in dorsal view of mesosoma and petiole	45

LIST OF FIGURES (Continued)

Figure		Page
53	<i>P. piliventris</i> F. Smith queen (syntype) in dorsal view of mesosoma and petiole	45
54	<i>P. ruficornis</i> F. Smith queen (syntype) in dorsal view of mesosoma and petiole	45
55	<i>P. flavicornis</i> F. Smith queen in dorsal view of mesosoma and petiole	45
56	<i>P. varicolor</i> Viehmeyer queen in dorsal view of mesosoma and petiole	45
57	Distribution of <i>P. cnemidata</i> Emery	50
58	Distribution of <i>P. dolomedes</i> F. Smith	53
59	Distribution of <i>P. parvicella</i> Forel	56
60	Distribution of <i>P. solmsi</i> Emery queen	60
61	Distribution of <i>P. tawauensis</i> sp. nov.	63
62	<i>P. cnemidata</i> Emery worker (syntype) in lateral view of hole body	64
63	<i>P. cnemidata</i> Emery worker in lateral view of hole body	64
64	<i>P. dolomedes</i> F. Smith worker (syntype) in lateral view of hole body	64
65	<i>P. parvicella</i> Forel worker (syntype) in lateral view of hole body	64
66	<i>P. solmsi</i> Emery worker (syntype) in lateral view of hole body	65
67	<i>P. solmsi</i> Emery worker in lateral view of hole body	65
68	<i>P. tawauensis</i> sp. nov. worker in lateral view of head and mesosoma	65
69	<i>P. tawauensis</i> sp. nov. worker in lateral view of head and mesosoma	65
70	<i>P. cnemidata</i> Emery queen (syntype) in lateral view of hole body	66
71	<i>P. cnemidata</i> Emery queen in lateral view of hole body	66
72	<i>P. dolomedes</i> F. Smith queen (syntype) in lateral view of hole body	66
73	<i>P. parvicella</i> Forel queen (syntype) in lateral view of hole body	66
74	<i>P. solmsi</i> Emery queen (syntype) in lateral view of hole	67
75	<i>P. solmsi</i> Emery queen in lateral view of head and mesosoma	67
76	<i>P. solmsi</i> Emery queen in lateral view of petiole and gaster	67
77	<i>P. cnemidata</i> Emery worker (syntype), head in full face view	68
78	<i>P. cnemidata</i> Emery worker, head in full face view	68

LIST OF FIGURES (Continued)

Figure		Page
79	<i>P. dolomedes</i> F. Smith worker (syntype), head in full face view	68
80	<i>P. parvicella</i> Forel worker (syntype), head in full face view	68
81	<i>P. solmsi</i> Emery worker, head in full face view	68
82	<i>P. tawauensis</i> sp. nov. worker, head in full face view	68
83	<i>P. cnemidata</i> Emery queen (syntype), head in full face view	69
84	<i>P. cnemidata</i> Emery queen, head in full face view	69
85	<i>P. dolomedes</i> F. Smith queen (syntype), head in full face view	69
86	<i>P. parvicella</i> Forel queen (syntype), head in full face view	69
87	<i>P. solmsi</i> Emery queen, head in full face view	69
88	<i>P. cnemidata</i> Emery worker (syntype) in lateral view of mesosoma and petiole	70
89	<i>P. cnemidata</i> Emery worker in lateral view of mesosoma and petiole	70
90	<i>P. dolomedes</i> F. Smith worker (syntype) in lateral view of mesosoma and petiole	70
91	<i>P. parvicella</i> Forel worker (syntype) in lateral view of mesosoma and petiole	70
92	<i>P. solmsi</i> Emery worker in lateral view of mesosoma and petiole	70
93	<i>P. cnemidata</i> Emery queen (syntype) in lateral view of mesosoma and petiole	71
94	<i>P. cnemidata</i> Emery queen, in lateral view of mesosoma and petiole	71
95	<i>P. dolomedes</i> F. Smith queen (syntype) in lateral view of mesosoma and petiole	71
96	<i>P. parvicella</i> Forel queen (syntype) in lateral view of mesosoma and petiole	71
97	<i>P. cnemidata</i> Emery worker (syntype) in dorsal view of mesosoma and petiole	72
98	<i>P. dolomedes</i> F. Smith worker (syntype) in dorsal view of mesosoma and petiole	72

LIST OF FIGURES (Continued)

Figure		Page
99	<i>P. cnemidata</i> Emery worker in dorsal view of mesosoma and petiole	72
100	<i>P. parvicella</i> Forel worker (syntype) in dorsal view of mesosoma and petiole	72
101	<i>P. solmsi</i> Emery worker in dorsal view of mesosoma and petiole	72
102	<i>P. tawauensis</i> sp. nov. worker in dorsal view of mesosoma and petiole	72
103	<i>P. cnemidata</i> Emery queen (syntype) in dorsal view of mesosoma and petiole	73
104	<i>P. cnemidata</i> Emery queen, in dorsal view of mesosoma and petiole	73
105	<i>P. dolomedes</i> F. Smith queen (syntype) in dorsal view of mesosoma and petiole	73
106	<i>P. parvicella</i> Forel queen (syntype) in dorsal view of mesosoma and petiole	73
107	Distribution of <i>P. angusticlypealis</i> sp. nov.	76
108	Distribution of <i>P. simillima</i> Emery	79
109	Distribution of <i>P. watanasiti</i> sp. nov.	82
110	Distribution of <i>P. wiwatwitayai</i> sp. nov.	84
111	<i>P. angusticlypealis</i> sp. nov. worker in lateral view of hole body	85
112	<i>P. simillima</i> Emery worker (syntype) in lateral view of hole body	85
113	<i>P. watanasiti</i> sp. nov. worker in lateral view of hole body	85
114	<i>P. wiwatwitayai</i> sp. nov. worker in lateral view of hole body	85
115	<i>P. angusticlypealis</i> sp. nov. worker, head in full face view	86
116	<i>P. simillima</i> Emery worker (syntype), head in full face view	86
117	<i>P. watanasiti</i> sp. nov. worker, head in full face view	86
118	<i>P. wiwatwitayai</i> sp. nov. worker, head in full face view	86
119	<i>P. angusticlypealis</i> sp. nov. worker in lateral view of mesosoma and petiole	87
120	<i>P. simillima</i> Emery worker (syntype) in lateral view of mesosoma and petiole	87

LIST OF FIGURES (Continued)

Figure		Page
121	<i>P. watanasiti</i> sp. nov. worker in lateral view of mesosoma and petiole	87
122	<i>P. wiwatwitayai</i> sp. nov. worker in lateral view of mesosoma and petiole	87
123	<i>P. angusticlypealis</i> sp. nov. worker in dorsal view of mesosoma and petiole	88
124	<i>P. simillima</i> Emery worker (syntype) in dorsal face view of mesosoma and petiole	88
125	<i>P. watanasiti</i> sp. nov. worker in dorsal view of mesosoma and petiole	88
126	<i>P. wiwatwitayai</i> sp. nov. worker in dorsal view of mesosoma and petiole	88
127	Distribution of <i>P. jacobsoni</i> Forel	92
128	Distribution of <i>P. lilianae</i> Forel	95
129	Distribution of <i>P. lombokensis</i> Emery	98
130	Distribution of <i>P. subtridens</i> Emery	101
131	Distribution of <i>P. vanispina</i> sp. nov.	103
132	Distribution of <i>P. wartburgi</i> Forel	107
133	Distribution of <i>P. yamanei</i> sp. nov.	110
134	<i>P. jacobsoni</i> Forel worker (syntype) in lateral view of hole body	111
135	<i>P. lilianae</i> Forel worker (syntype) in lateral view of hole body	111
136	<i>P. lombokensis</i> Emery worker (syntype) in lateral view of hole body	111
137	<i>P. subtridens</i> Emery worker (syntype) in lateral view of hole body	111
138	<i>P. vanispina</i> sp. nov. worker in lateral view of hole body	112
139	<i>P. wartburgi</i> Forel worker in lateral view of hole body	112
140	<i>P. yamanei</i> sp. nov. worker in lateral view of hole body	112
141	<i>P. jacobsoni</i> Forel queen (syntype) in lateral view of hole body	113
142	<i>P. lilianae</i> Forel queen (syntype) in lateral view of hole body	113
143	<i>P. lombokensis</i> Emery queen (syntype) in lateral view of hole body	113
144	<i>P. wartburgi</i> Forel queen in lateral view of hole body	113
145	<i>P. jacobsoni</i> Forel worker (syntype), head in full face view	114
146	<i>P. lilianae</i> Forel worker (syntype), head in full face view	114

LIST OF FIGURES (Continued)

Figure		Page
147	<i>P. lombokensis</i> Emery worker (syntype), head in full face view	114
148	<i>P. subtridens</i> Emery worker (syntype), head in full face view	114
149	<i>P. vanispina</i> sp. nov. worker, head in full face view	115
150	<i>P. wartburgi</i> Forel worker, head in full face view	115
151	<i>P. yamanei</i> sp. nov. worker, head in full face view	115
152	<i>P. lilianae</i> Forel queen (syntype), head in full face view	116
153	<i>P. lombokensis</i> Emery queen (syntype), head in full face view	116
154	<i>P. wartburgi</i> Forel queen, head in full face view	116
155	<i>P. jacobsoni</i> Forel worker (syntype) in lateral view of mesosoma and petiole	117
156	<i>P. lilianae</i> Forel worker (syntype) in lateral view of mesosoma and petiole	117
157	<i>P. lombokensisi</i> Emery worker (syntype) in lateral view of mesosoma and petiole	117
158	<i>P. subtridens</i> Emery worker (syntype) in lateral view of mesosoma and petiole	117
159	<i>P. vanispinai</i> sp. nov. worker in lateral view of mesosoma and petiole	118
160	<i>P. wartburgi</i> Forel worker in lateral view of mesosoma and petiole	118
161	<i>P. yamanei</i> sp. nov. worker in lateral view of mesosoma and petiole	118
162	<i>P. jacobsoni</i> Forel queen (syntype) in lateral view of mesosoma and petiole	119
163	<i>P. lilianae</i> Forel queen (syntype) in lateral view of mesosoma and petiole	119
164	<i>P. lombokensis</i> Emery queen (syntype) in lateral view of mesosoma and petiole	119
165	<i>P. wartburgi</i> Forel queen in lateral view of mesosoma and petiole	119

LIST OF FIGURES (Continued)

Figure		Page
166	<i>P. jacobsoni</i> Forel worker (syntype) in dorsal view of mesosoma and petiole	120
167	<i>P. lilianae</i> Forel worker (syntype) in dorsal view of mesosoma and petiole	120
168	<i>P. lombokensis</i> Emery worker (syntype) in dorsal view of mesosoma and petiole	120
169	<i>P. subtridens</i> Emery worker (syntype) in dorsal view of mesosoma and petiole	120
170	<i>P. vanispina</i> sp. nov. worker in dorsal view of mesosoma and petiole	121
171	<i>P. wartburgi</i> Forel worker in dorsal view of mesosoma and petiole	121
172	<i>P. yamanei</i> sp. nov. worker in dorsal view of mesosoma and petiole	121
173	<i>P. jacobsoni</i> Forel queen (syntype) in dorsal view of mesosoma and petiole	122
174	<i>P. lilianae</i> Forel queen (syntype) in dorsal view of mesosoma and petiole	122
175	<i>P. lombokensis</i> Emery queen (syntype) in dorsal view of mesosoma and petiole	122
176	<i>P. wartburgi</i> Forel queen in dorsal view of mesosoma and petiole	122
177	Map of Peninsular Thailand and its thirty-two sampling sites	129
178	Measurements in the maximum height and width of nest	130
179	The nest wall structure of <i>P. cnemidata</i> Emery	147
180	The nest wall structure of <i>P. constructor</i> Smith	148
181	The nest wall structure of <i>P. flavicornis</i> Smith	149
182	The nest wall structure of <i>P. varicolor</i> Viehmeyer	150

LIST OF FIGURES (Continued)

Figure		Page
183	Nest of <i>P. cnemidata</i> Emery from Tarutao I., Tarutao N.P., Peninsular Thailand	173
184	Nest of <i>P. flavicornis</i> F. Smith from Ka Oon Waterfall, Peninsular Thailand	173
185	Nest of <i>P. varicolor</i> Viehmeyer from Ka Oon Waterfall, Peninsular Thailand	173
186	Nest of <i>P. varicolor</i> Viehmeyer from Khiriwong Village, Peninsular Thailand	173

LIST OF ABBREVIATIONS AND SYMBOLS

cm	=	centimeter
C. Thailand	=	Central Thailand
E. Malaysia	=	Eastern Malaysia
E. Thailand	=	Eastern Thailand
Fig.	=	Figure
I.	=	Island
km	=	kilometer
loc.	=	location, locality
m	=	meter
NAW	=	Nawee Noon-anant
N.P.	=	National Park;
nr.	=	near
Prov.	=	Province
SE	=	Standard Error
S. Thailand	=	Southern Thailand
SKY	=	Seiki Yamane
sp. nov.	=	new species
stat. nov.	=	taxon altered in rank, but retains specific name for former rank
syn. nov.	=	new synonym
vs	=	versus
W.S.	=	Wildlife Sanctuary

CHAPTER 1

INTRODUCTION

1.1 An overview of the ants

Ants (Formicidae, Hymenoptera) are eusocial insects which have been evolving successfully since the Cretaceous Period. Around 11,000 species have been described belonging to 284 genera and 21 extant subfamilies (Bolton, 1995a, 1995b, 2003; Ward *et al.*, 2005). However, the number of species still remaining to be discovered and described is many times higher (Bolton, 2003; Hölldobler & Wilson, 1990).

Ants are important ecologically because they serve at many levels in an ecosystem, as predators, preys, and scavengers. They also have diverse associations with plants such as defenders, seed dispersers, pollinators and are symbionts with other animals, particularly arthropods (Beattie & Hughes, 2002; Bronstein, 1998; Hölldobler & Wilson, 1990; Schultz & McGlynn, 2000). Many ant species are highly sensitive to microclimate and habitat structure. Thus they respond rapidly to environmental change (Alonso *et al.*, 2000; Anderson, 1990, 2000; King *et al.*, 1998). For example, in Australia, ants have been used extensively as bioindicators in relation to minesite restoration (Majer *et al.*, 1984) and other disturbances such as fire, grazing, and logging (Anderson, 1991; York, 1994).

The body parts of the ants are divided into four main sections (Fig. 1) (Bolton, 1994; Lattke, 2000; Shattuck, 1997). The first section is head, followed by the mesosoma or alitrunk, the petiole and sometimes the postpetiole, and the gaster is the last section. There are several characters which will separate them from other insects (Bolton, 1994; Lattke, 2000; Shattuck, 1997). Firstly, the antenna geniculate between the long basal segment (the scape) and the remaining funicular segments. Secondly, all ants have either a second abdominal segment reduced, forming a single distinct segment (the petiole), or the third abdominal segment reduced and isolated (the postpetiole), between the mesosoma and gaster. Lastly, the metapleural gland which found only in ants, and this gland is found on the side of the propodeum just

above the hind leg and has a small opening to the outside of the body. However, not all ants have a metapleural gland and a few genera in the subfamily Formicinae, such as *Camponotus* Mayr (except for two species), *Oecophylla* F. Smith and *Polyrhachis* F. Smith have lost this gland and its associated opening (Bolton, 2003).

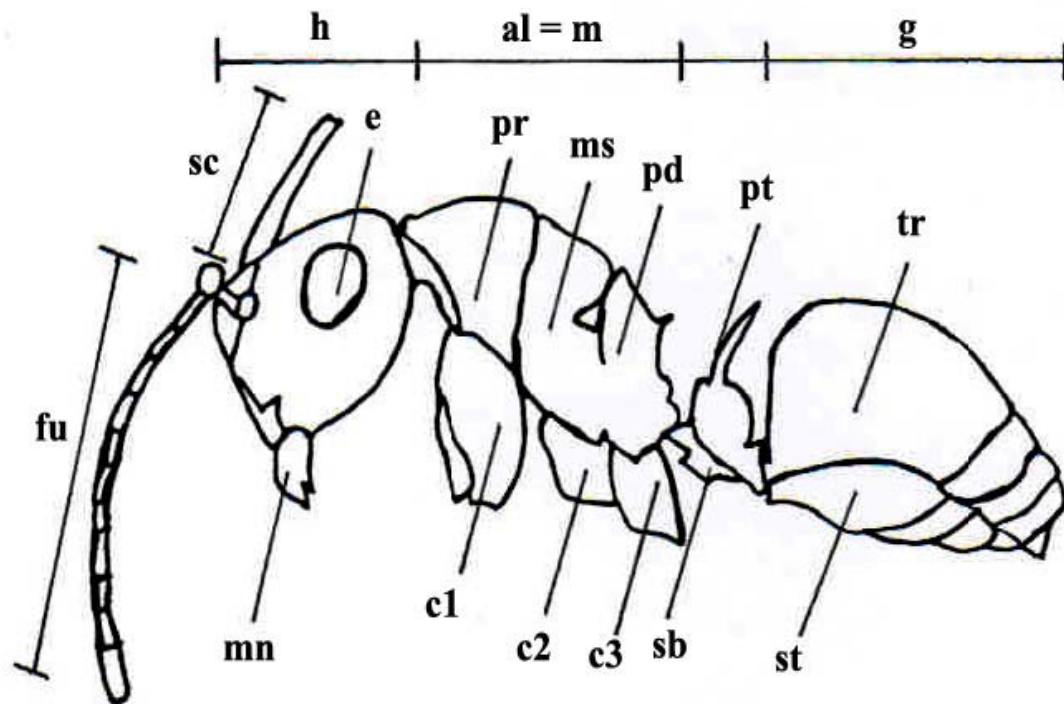


Figure 1. Worker of *Polyrhachis* F. Smith in lateral view, legs below coxae omitted:

a = alitrunk, c1 = coxa of prothoracic leg, c2 = coxa of mesothoracic leg, c3 = coxa of metathoracic leg, e = eye, fu = funiculus of antenna, g = gaster, h = head, m = mesosoma, mn = mandible, ms = mesonotum, pd = propodeum, pr = pronotum, pt = petiole, sb = subpetiolar process, sc = scape of antenna, st = sternite and tr = tergite.

1.2 Historical review and biology of the ant genus *Polyrhachis* F. Smith

Polyrhachis is one of the largest genera of ant, distributed mostly in the tropics and subtropics of the Old World (Bolton, 1995a; Dorow, 1995). The genus was first established by Billberg in 1820 under the name *Myrma* without further descriptions, for the African species *Formica carinata* and *F. militaris*, but the current generic name *Polyrhachis* was introduced and the genus was redefined by F. Smith in 1857 (Dorow, 1995). Although *Myrma* is the oldest name for this taxon, for the stable use of the frequently used name *Polyrhachis*, *Myrma* was reduced to a subgeneric name (Bolton, 1995b, 2003). Currently, the genus contains over 500 described species and is divided into 12 subgenera: *Aulacomyrma*, *Campomyrma*, *Chariomyrma*, *Cyrtomyrma*, *Hagiomyrma*, *Hedomyrma*, *Hemioptica*, *Myrma*, *Myrmatopa*, *Myrmhopla*, *Myrmotherinax* and *Polyrhachis* (Bolton, 1995b, 2003; Dorow, 1995; Kohout, 2003).

The dominant characteristics of the genus *Polyrhachis* are the thorax and petiole usually armed with spines or teeth, the metapleural gland lacking and the capability to construct nests with larval silk (Bolton, 2003; Dorow, 1995). Moreover, many different ecological strategies occur in this genus, ranging from construction of small to very large colonies, from monodomy to polydomy, and from monogyny to polygyny (Dorow, 1995; Dorow & Maschwitz, 1990; Dorow *et al.*, 1990; Liefke *et al.*, 1998; Schellerich-Kaaden *et al.*, 1997).

The nesting habits of *Polyrhachis* ants are highly diverse, ranging from subterranean to arboreal in nesting site. They often construct nests on vegetation; nest walls are composed of silk produced by their own larvae or carton (plant fibre), or a combination of both (Dorow, *et al.*, 1990; Hung, 1967; Liefke *et al.*, 1998; Kohout, 1999, 2000; Robson & Kohout, 2005, 2007). Some *Polyrhachis* species are able to incorporate spider silk in addition to their larval silk (Dwyer & Ebert, 1994; Robson & Kohout, 2004) into their nests. Nesting habits might have diversified along with the use of various nesting sites and materials not only in *Polyrhachis*, but also in other ants (Hölldobler & Wilson, 1990; Hung, 1967; Liefke *et al.*, 1998).

1.3 Historical review and biology of the subgenus *Myrmatopa* Forel

The subgenus *Myrmatopa* comprises arboreal weaver ants with 41 described species which are found throughout the tropics of Asia and the Australian region (Dorow, 1995; Kohout, 2008). In 1915, Forel created this subgenus but the first description was given by Emery (1925), and later it was divided into the *schang*-group and *wallacei*-group (Bolton, 1995a; Dorow, 1995). However, the new arrangement was subdividing the *wallacei*-group and placing several of its species into a new *flavicornis*-group (Kohout, 2008).

All species within this subgenus construct arboreal nests and the larvae appear to pupate without cocoons, many species can incorporate silk into their nests with the exception of *Polyrhachis schang* Forel (Robson & Kohout, 2007). Their nests are constructed on leaves (usually on the underside of a leaf) (Hung, 1967), but in an Australian species, the nest is made by joining together leaves of various trees and shrubs (Kohout, 1999).

1.4 Taxonomic problems

Although a large number of new *Polyrhachis* species have been described by many myrmecologists (Bolton, 1975; Dorow, 1995; Dorow & Kohout, 1995; Hung, 1967, 1970; Kohout, 1988a, b, c, 1989, 1990, 1994a, b, 2000, 2006a, b, 2007a, b, c, 2008; Kohout & Taylor, 1990), taxonomic review has been done for some subgenera and species groups mostly from particular geographical regions, such as *Campomyrma* from Borneo (Kohout 2007a); *Cyrtomyrma* of Australia, Borneo, New Guinea and the Solomon islands (Kohout 2006a); and the *P. cryptoceroides* species group from Thailand (Kohout, 2006b). Keys to species do exist only for the African *Polyrhachis* (Bolton, 1973) and a few Australian, and Asian species groups (Hung, 1970; Anderson, 2000b; Kohout, 1987, 1988a, b, c, 1989, 1990, 2006a, b, 2007a, c, 2008). Thus, many taxonomic and bionomic problems still remain in other subgenera and regions (Bolton, 1973; Dorow, 1995; Kohout, 1989); especially most species of *Myrmatopa* are known only from the original descriptions, or only from the queen, leaving many unsolved taxonomic and bionomic problems. For a more comprehensive understanding of biological diversity, behavior, ecology, and

conservation of this interesting group, more information on taxonomy and bionomics is required.

1.5 Objectives

The present study is aimed to resolve the taxonomic and bionomic problems of the subgenus *Myrmatopa*, and revise the Indo-Malayan species of this group based on the morphological and ecological characteristics of the workers, and queen when information on worker-queen association is available. It would add important morphological and ecological characteristics, and eventually contribute much to the faunistic and distributional knowledge of ants in general from Southeast Asia.

1.6 Summary of chapters

This dissertation is divided into five parts. Chapter 1 is Introduction, explaining the taxonomic history and biology of the genus *Polyrhachis* F. Smith and its subgenus *Myrmatopa* Forel. A taxonomic revision of the subgenus *Myrmatopa* Forel based on material from Indo-Malayan subregion is presented in Chapter 2. Morphological description and other information will be given for each species, followed by a key to the species occurring in this subregion. The nesting habits of the subgenus *Myrmatopa* Forel is elaborated in Chapter 4. Finally, conclusions and future perspectives are presented in Chapter 5.

CHAPTER 2

REVISION BASED ON MATERIAL FROM INDO-MALAYAN SUBREGION

2.1 Introduction

The original description of the subgenus *Myrmatopa* Forel was given by Emery (1925), and the subgenus was later divided into the *schang*-group and *wallacei*-group (Bolton, 1995a; Dorrow, 1995). At present, this subgenus was divided by Kohout (2008) into three species-groups: *flavicornis*-group, *schang*-group and *wallacei*-group, and 41 species have been described based on material from tropical Asia, Sulawesi and Australia (Dorrow, 1995; Kohout, 2008). However, most species are known only from the type materials, or only from the queen caste, leaving many taxonomic problems, and worker-queen association being available only for a few species. Moreover, the Indo-Malayan subregion is one of the biodiversity hotspots with high concentrations of endemic species and undergoing immense habitat loss (Myers *et al.*, 2000; Sodhi *et al.*, 2004). Under the circumstances the present study aims to revise the Indo-Malayan species of the subgenus *Myrmatopa* based on the morphological characteristics of the workers, and queen when information on the worker-queen association is available.

2.2 Materials and Methods

2.2.1 Study area

Indo-Malayan subregion is defined as the area consisting of Borneo, southern Malay Peninsula, Sumatra, Java, Bali, Philippines, and small islets surrounding these main islands (Lincoln *et al.*, 1998). This study focuses on the forms from Borneo, Peninsular Thailand, Peninsular Malaysia, Sumatra and Java (Fig. 2), but materials from other areas such as Bali, Philippines and Sulawesi were also used for comparison.

2.2.2 Sources of material

Specimens examined were loaned from the following museums, institutions, and private collections listed below. For their abbreviations I follow Brandão (2000).

- AMK Ant Museum, Kasetsart University, Bangkok, Thailand.
BMNH The Natural History Museum, London, U.K.
MCSN Museo Civico di Storia Naturale “Giacomo Doria”, Genova, Italy.
MHNG Muséum d’Histoire Naturelle, Geneva, Switzerland.
NHMB Naturhistorisches Museum, Basel, Switzerland.
MNHU Meseum für Naturkunde der Humboldt Universität, Berlin, Germany.
OXUM Hope Entomological Collections, Oxford University Museum of Natural History, Oxford, U.K.
PSNH Princess Maha Chakri Sirindhorn Natural History Museum, Prince of Songkla University, Songkhla, Thailand.
QMBA Queensland Museum, Brisbane, Australia.
SKYC Seiki Yamane Collection, Kagoshima University, Kagoshima, Japan.
TNHM Thailand Natural History Museum, Pathum Thani, Thailand.

2.2.3 Sampling methods

The specimens from different sources, not only those loaned from public and private collections but also those collected in the field by myself, were used for the present study. Hand collecting, including colony-based collection, was conducted to cover the lower vegetation below 4 m above the ground. Some specimens derived from canopy knockdown. The samplings were carried out in Peninsular Thailand during September 2004 to December 2007.

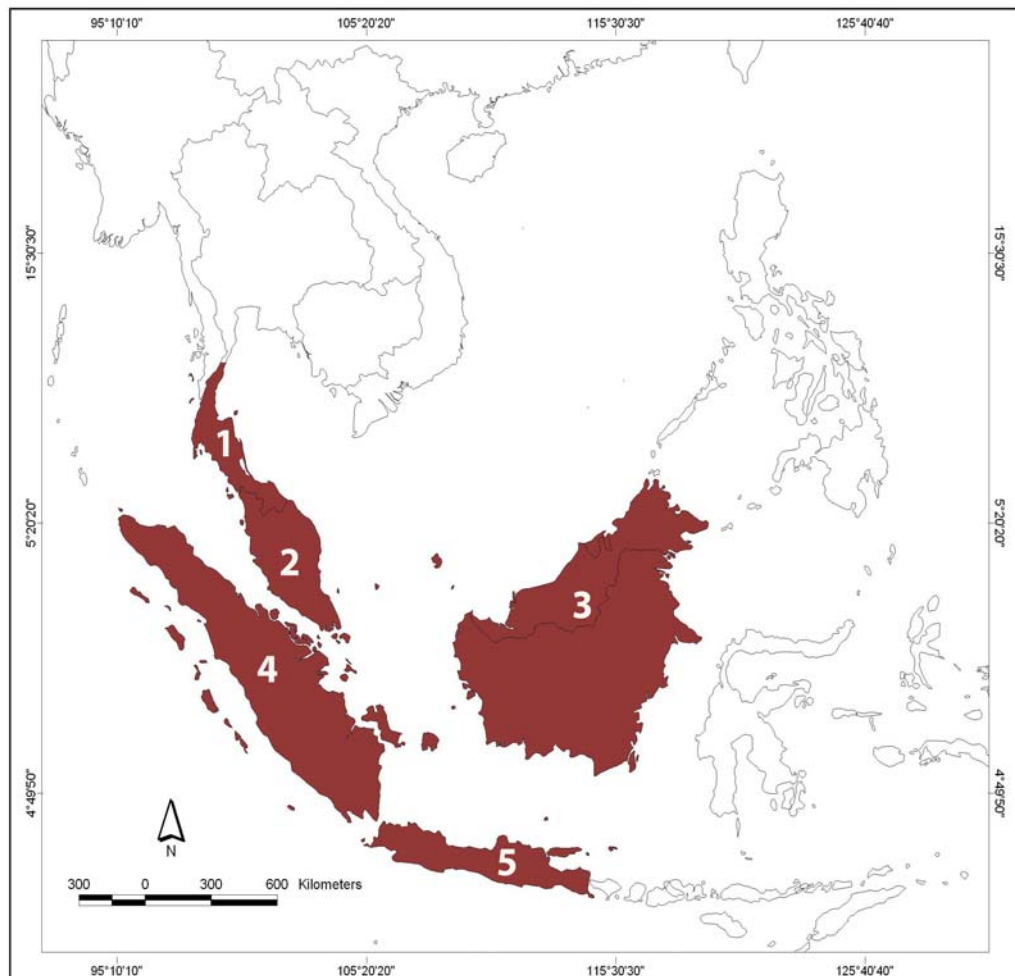


Figure 2. Map of study area: 1, Peninsular Thailand; 2, Peninsular Malaysia; 3, Borneo; 4, Sumatra; 5, Java (modified from the Southern Remote Sensing GIS Center, Prince of Songkla University, 2008).

2.2.4 Measuring methods and terminology

The following abbreviations and definitions of the indices used follow Hung (1967, 1970), Kohout (1988c) and Ward (1999, 2001) with some modification.

HW Head width: maximum width of head, excluding the eyes, measured in full-face view (Fig. 3A).

HL Head length: maximum length of head from the posterior margin of head to the anterior extremity (including teeth) of clypeus, measured in full-face view (Fig. 3A).

- SL Scape length: length of first antennal segment, excluding radicle (condyle) (Fig. 3A).
- CI Cephalic index: $HW \times 100/HL$.
- SI Scape index: $SL \times 100/HW$.
- PrW Pronotal width: maximum width of pronotum, between the bases of pronotal spines, or across humeri, measured in dorsal view (Fig. 3B).
- MPL Mesonoto-propodeal length: diagonal distance from anterior mesonotal margin to maximum extension of posterolateral propodeal lobe, measured in lateral view (Fig. 3C).
- MTL Metatibial length: maximum length of metatibia, excluding basal condyla (Fig. 3D).
- MTI Metatibial index: $MTL \times 100/HW$.
- PL Petiolar length: horizontal distance from the anterior margin (excluding short peduncle) to the posterior margin of petiole, measured in lateral view (Fig. 3C) (not measurable in some subgenera of *Polyrhachis*).
- PH Petiolar height: maximum height of petiole, seen from back, excluding any spines and denticles (Fig. 3E) (not measurable in some subgenera).
- PW Petiolar width: maximum width of petiole, seen from back, excluding any spines and denticles (Fig. 3E) (not measurable in some subgenera).
- PI Petiolar index: $PH \times 100/PW$ (not measurable in some subgenera).
- PLI Petiolar length index: $PL \times 100/PH$ (not measurable in some subgenera).

The linear measurements are in millimeters and all measurements were made using a Nikon SMZ 800 stereomicroscope with an eyepiece graticule calibrated against a stage micrometer.

All images were taken with Nikon Coolpix 990 digital camera attached to a Nikon SMZ 1000 stereomicroscope and multi-focused montage images were produced using Helicon Focus 4.47 Pro (MP) from a series of photographs. Artifacts and unnecessary parts surrounding the objects were erased and cleaned up using the retouching function of Helicon Focus. Finally, the sharpness, brightness and contrast were adjusted using Adobe Photoshop 7.0.

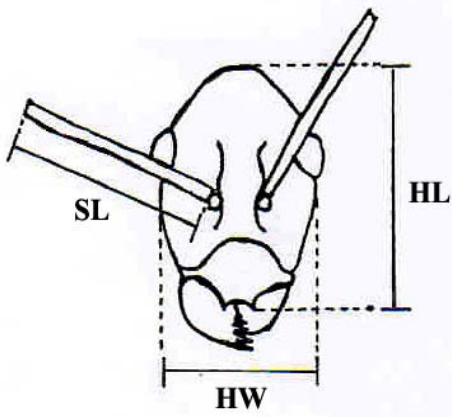


Figure 3A, head in full-face view.

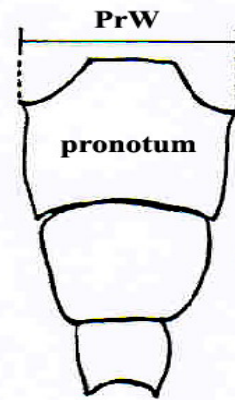


Figure 3B, mesosoma in dorsal view.

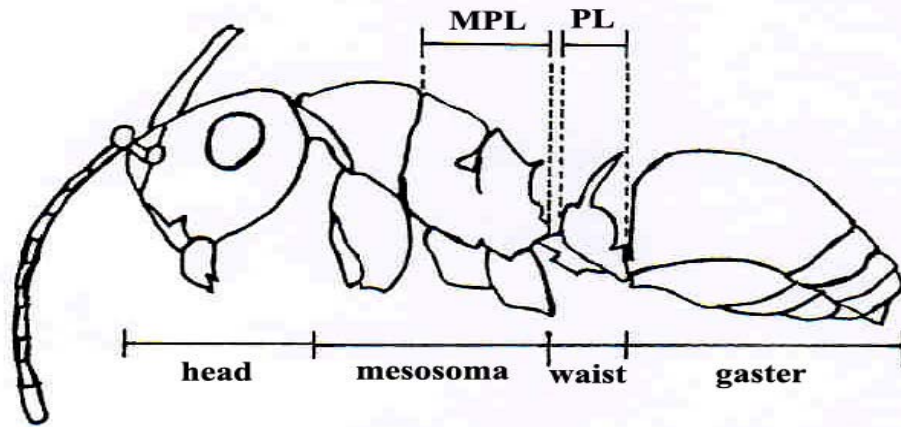


Figure 3C, whole body in lateral view.

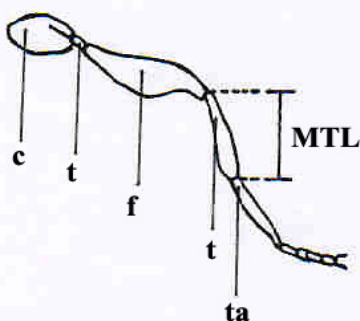


Figure 3D, leg in full-face view, c = coxa, t = trochanter, f = femur, t = tibia, ta = tarsus.

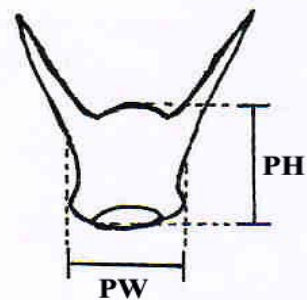


Figure 3E, petiole in back view.

Figure 3(A-E). Measuring points and some morphological terms of the worker.

2.3 Results

2.3.1 Systematics

Genus *Polyrhachis* F. Smith, 1857

Myrma Billberg, 1820: 104. Type species: *Formica militaris* W.M. Wheeler, 1911: 860, worker; by subsequent designation. Although *Myrma* is an older name, for the stable use of the historically frequently used name *Polyrhachis* is applied.

Polyrhachis F. Smith, 1857: 58. Type species: *Formica bihamata* Drury, 1773: 73, pl. 38, figs 7 & 8, worker; by original designation.

Subgenus *Myrmatopa* Forel, 1915

Myrmatopa Forel, 1915: 107 (as subgenus of *Polyrhachis* F. Smith). Type species: *Polyrhachis schang* Forel, 1879: 123, queen; by original designation.

Myrmatopa Forel; Emery, 1925: 180; Dorow, 1995: 42; Bolton, 1995: 36; Bolton, 2003: 124; Kohout, 2008: 282. As subgenus of *Polyrhachis* F. Smith.

Irenea Donisthorpe, 1938: 502; Chapman & Capco, 1951: 186. Type species: *Dolichoderus omyrmex* Donisthorpe, 1938: 502, worker; by original designation (synonymy by Brown, 1973: 181 with *Polyrhachis*).

2.3.2 Diagnosis of the subgenus *Myrmatopa*

2.3.2.1 Worker (Fig. 9-14, 21-26, 33-38, 45-50, 62-69, 77-82, 88-92, 97-102, 111-126, 134-140, 145-151, 155-161, 166-172)

The workers have the following characteristics (21 species examined):

1. Anterior extremity of clypeus with a pair of teeth, or only in one species, *P. tawauensis* sp. nov., with a median tooth that is apically bifid (in *P. lombokensis*; anterior extremity of clypeus without a pair of short teeth).
2. Pronotum laterally not marginate or weakly marginate.
3. Pronotum anterolaterally unarmed or armed with a pair of small teeth (not long spines).

4. Promesonotal furrow generally distinct.
5. Mesonotum weakly to distinctly marginate laterally.
6. Propodeal dorsum in lateral view sloping posteriorly.
7. Propodeum laterally not marginate or weakly to distinctly marginate.
8. Propodeum usually with short to medium-sized spines (only in one species the spines entirely absent).
9. Petiole with two spines, which are usually medium in length and not close to each other, or rarely short; spines can be diverging, curved or straight, and sometimes with two denticles between spines.
10. First gastral tergite covering no more than half the gaster.

2.3.2.2 Queen (Fig. 15-20, 27-32, 39-44, 51-56, 70-76, 83-87, 93-96, 103-106, 141-144, 152-154, 162-165, 173-176)

The females have the following characteristics (11 species examined):

1. Ocelli located far from occipital margin and not elevated from the cuticle.
2. Pronotum anterolaterally unarmed or armed with a pair of small teeth.
3. Mesoscutum as long as broad, or slightly longer than broad.
4. Median line of mesoscutum present only in anterior 1/3 of the disc.
5. Parapsidal furrows longer than half the mesoscutum.
6. Parapsides narrowed posteriorly.
7. Paraptera of mesothorax convex laterally (paraptera of metathorax too small to recognize).
8. Mesoscutellum as long as broad, smaller than mesoscutum.
9. Metanotum short, distinctly impressed.
10. Mesoscutum in lateral view relatively high, convex, forming the highest portion of the dorsal plane of mesosoma; mesoscutellum slightly lower than mesoscutum.
11. Propodeum usually with short to medium-sized spines (only in one species the spines entirely absent).
12. Petiole with two spines, which are usually medium in length and not close to each other, or rarely short; spines can be diverging, curved or straight, and sometimes with two denticles between spines.

2.3.3 Synopsis of the species of *Myrmatopa*

In this study, a total of 21 Indo-Malayan species of *Myrmatopa* are recognised in four species-groups on the basis of their external morphological characteristics.

***flavicornis*-group**

antedoridens sp. nov.

constructor F. Smith, 1857: 60

= *piliventris* F. Smith, 1858: 60, syn. nov.

= *elii* Emery, 1900: 711, syn. nov.

flavicornis F. Smith, 1857: 63

= *ruficornis* F. Smith, 1857: 60, syn. nov.

kohouti sp. nov.

varicolor Viehmeyer, 1916: 163

***schang*-group**

cnemidata Emery, 1900: 710, stat. nov.

dolomedes F. Smith, 1863: 14

parvicella Forel, 1911: 214, stat. nov.

solmsi Emery, 1887: 224

tawauensis sp. nov.

***simillima*-group stat. nov.**

angusticlypealis sp. nov.

simillima Emery, 1900: 711

watanasiti sp. nov.

wiwatwitayai sp. nov.

wallacei-group

- jacobsoni* Forel, 1909: 230
liliana Forel, 1911: 213
lombokensis Emery, 1898: 239
subtridens Emery, 1900: 711
vanispina sp. nov.
wartburgi Forel, 1901: 76
yamanei sp. nov.

2.3.4 Key to species-groups of Indo-Malayan *Myrmatopa* based on the worker

1. Petiole with two spines, and provided with two median denticles between the spines (Fig. 124) *simillima*-group
 Petiole with two spines, without denticles between the spines 2
2. Mesonotum distinctly higher than propodeum, with a distinct posterior slope which is as long as flat dorsal portion in lateral view (Fig. 88-92)
 *schang*-group
 Mesonotum slightly higher than propodeum, without a distinct posterior slope in lateral view 3
3. Petiole in lateral view with anterior slope almost straight (Fig. 155-161); pronotum in dorsal view convex and narrowed posteriorly, unarmed with anterolateral teeth (Fig. 166-172) *wallacei*-group
 Petiole in lateral view with anterior slope slightly to distinctly convex (Fig. 33-38); pronotum in dorsal view convex and narrowed posteriorly, armed with anterolateral teeth (Fig. 45-50) *flavicornis*-group

2.3.4.1 Key to Indo-Malayan species of the *P. (Myrmatopa) flavicornis*-group based on the worker

1. Antennal scape with many yellow short standing hairs (Fig. 22-23); dorsum of mesosoma with a few yellow short standing hairs (Fig. 34-35)
..... *constructor* F. Smith
- Antennal scape without short standing hairs (Fig. 21, 24-26); dorsum of mesosoma without short standing hairs (Fig. 33, 36-38) 2
2. Petiolar spine in lateral view vertical and distinctly curved backwards, or curved backwards from the base, as long as or longer than the height of petiole (Fig. 36-38) 3
- Petiolar spine in lateral view vertical and almost straight, shorter than the height of petiole, measuring approximately half the latter (Fig. 33)
..... *antedoridens* sp. nov.
3. Pronotum distinctly marginate laterally (Fig. 49-50) 4
- Pronotum weakly marginate laterally (Fig. 48) *flavicornis* F. Smith
4. Antennal scape short in full-face view, extending beyond the occipital margin of head by approximately 1/3 of its length (SL: 1.60-1.75, SI 128.00-134.21) (Fig. 25); head (excluding mandible, antennal scape and flagellum reddish brown to dark brown), mesosoma and petiole black (Fig. 13, 25)
..... *kohouti* sp. nov.
- Antennal scape long, extending beyond the occipital margin of head by at least half its length (SL: 1.63-1.93, SI 148.65-158.06) (Fig. 26); head (including mandible, antennal scape and flagellum), mesosoma and petiole reddish brown to dark reddish brown (Fig. 14, 26) *varicolor* Viehmeyer

2.3.4.2 Key to Indo-Malayan species of the *P. (Myrmatopa) schang*-group based on the worker

1. Anterior extremity of clypeus with a median tooth which is bifid apically (Fig. 82) *tawauensis* sp. nov.
- Anterior extremity of clypeus with a pair of teeth or angles (Fig. 77-81) ... 2

2. Petiolar spine in lateral view directed backwards, as long as the height of petiole (Fig. 90) *dolomedes* F. Smith
 Petiolar spine in lateral view vertical, longer than the height of petiole 3
3. Mesonotum in lateral view strongly elevated in the middle (Fig. 88-89) *cnemidata* Emery
 Mesonotum in lateral view slightly elevated in the middle 4
4. Head behind eyes more strongly elongate and narrowed posteriorly with the sides straight (Fig. 80) *parvicella* Forel
 Head behind eyes less elongate, with the sides slightly convex (Fig. 81) *solmsi* Emery

2.3.4.3 Key to Indo-Malayan species of the *P. (Myrmatopa) simillima*-group based on the worker

1. Medium-sized species (PrW > 0.90 mm.); two median denticles between the petiolar spines located close to each other 2
 Smaller species (PrW < 0.90 mm.); two median denticles between the petiolar spines distantly located from each other 3
2. Larger species, with broader head (HW 1.20-1.25, HL 1.50-1.55, CI 77.42-83.33); eye convex, moderately protruding from the lateral outline of head (Fig. 116); gaster brownish black (Fig. 112) *simillima* Emery
 Smaller species, with more elongate head (HW 1.15, HL 1.35, CI 85.19); eye convex (Fig. 118), slightly protruding from the lateral outline of head; gaster reddish brown (Fig. 114) *wiwatwitayai* sp. nov.
3. Antero-median portion of clypeus broad, approximately as broad as lateral portion of clypeus (Fig. 117) *watanasiti* sp. nov.
 Antero-median portion of clypeus narrow, approximately less than lateral portion of clypeus (Fig. 115) *angusticlypealis* sp. nov.

2.3.4.4 Key to Indo-Malayan species of the *P. (Myrmatopa) wallacei*-group based on the worker

1. Propodeum with spines (Fig. 155-158, 160-161) 2
 Propodeal spine entirely absent (Fig. 159) *vanispina* sp. nov.
2. Head behind eye distinctly elongate with its posterior margin almost straight, and sides of head nearly parallel (Fig. 151) ; head with slanting long hairs (Fig. 151); pronotum, mesonotum and petiolar spine with long standing hairs (Fig. 161) *yamanei* sp. nov.
 Head behind eye relatively broad, with convex posterior margin in full-face view; head without slanting long hairs; pronotum, mesonotum and petiolar spine without long standing hairs 3
3. Anterior margin of clypeus truncate with acute lateral angles which often form small denticles 4
 Anterior margin of clypeus truncate with blunt lateral angles (Fig. 147) *lombokensis* Emery
4. Petiole provided with a median denticle between the spines (Fig. 166) 5
 Petiole without a median denticle between the spines (Fig. 167) 6
5. Petiolar spine in lateral view slightly longer than the petiolar height, measuring approximately half the latter (Fig. 155) *jacobsoni* Forel
 Petiolar spine in lateral view very short, distinctly less than half the petiolar height (Fig. 158) *subtridens* Emery
6. Pronotum in dorsal view anterolaterally produced to form tubercles (Fig. 166); posterior and lateral portions of head, mesosoma and legs, orangish brown (Fig. 135, 146) *liliana*e Forel
 Pronotum in dorsal view anterolaterally rounded, without distinct tubercles (Fig. 171); posterior and lateral portions of head, mesosoma, brown to dark brown (Fig. 139, 150) *wartburgi* Forel

2.3.5 Provisional key to Indo-Malayan *Myrmatopa* species-groups based on the queen

The queen caste is not known for all species of Indo-Malayan *Myrmatopa*, and the limits of variation remain uncertain in species for which only a few specimens are available. In this study, for 11 species in three species groups queens are known that are associated with workers. Key to species of the *schang*-group has been omitted due to the limitation of the material and absence of discriminating characteristics.

1. Petiolar spine in lateral view vertical, and almost straight; petiole in lateral view with anterior slope almost straight (Fig. 162-165) *wallacei*-group
 Petiolar spine in lateral view not vertical, but curved and/or directed backwards; petiole in lateral view with anterior slope distinctly convex 2
2. Pronotum in dorsal view with anterolateral teeth that are sometimes much reduced (Fig. 51-56) *flavicornis* -group
 Pronotum in dorsal view rounded anterolaterally, without any trace of teeth (Fig. 103-106) *schang* -group

2.3.5.1 Key to the Indo-Malayan species of the *P. (Myrmatopa) flavicornis*-group based on the queen

1. Antennal scape with many yellow short standing hairs; larger species (HW 1.53-1.70, HL 1.90-2.20, SL 2.80-3.07; n=7) (Fig. 27-29)
 *constructor* F. Smith
 Antennal scape without short standing hairs; smaller species (HW 0.97-1.35, HL 1.27-1.70, SL 1.80-2.20; n=17) (Fig. 31-32) 2
2. Frontal lobe of head, mesoscutum and parapside reddish, partly with black stains (Fig. 20, 32, 56) *varicolor* Viehmeyer
 Entire head and mesosoma except for appendages black (Fig. 18-19, 30-31, 54-55) *flavicornis* F. Smith

2.3.5.2 Key to the Indo-Malayan species of the *P. (Myrmatopa) wallacei*-group based on the queen

1. Anterior margin of clypeus truncate with blunt lateral angles (Fig. 153); mesosoma almost wholly blackish brown; gaster brown (Fig. 143)
..... *lombokensis* Emery
- Anterior margin of clypeus truncate with more acute lateral angles which often form small denticles (Fig. 152, 154); mesosoma orangish, if mesosoma partly darker the gaster blackish brown (Fig. 141, 142, 144) 2
2. Petiolar spine in lateral view slightly longer, measuring approximately half the petiolar height (Fig. 163, 165) 3
- Petiolar spine in lateral view very short, distinctly less than half the petiolar height (Fig. 162) *jacobsoni* Forel
3. Mesoscutellum, metanotum, propodeum and petiole orangish (Fig. 163)
..... *liliana*e Forel
- Mesoscutellum, metanotum, propodeum and petiole blackish (dorsa of these regions more reddish) (Fig. 165) *wartburgi* Forel

2.3.6 Species accounts

2.3.6.1 *Polyrhachis flavicornis*-group

Workers of this group can be recognised by the following characteristics: clypeus weakly convex in lateral view. Eye convex, slightly protruding from the lateral outline of head. Antennal scape long, extending beyond the posterior margin of head by at least half its length, except in *P. kohouti* sp. nov., which its antennal scape short, extending beyond the posterior margin of head measuring approximately 2/3 of its length. Mesosoma laterally marginate throughout. Pronotum in dorsal view convex and narrowed posteriorly, armed with anterolateral teeth. Mesonotum only slightly higher than propodeum. Propodeal dorsum slightly sloping; propodeal spine small to medium-sized, directed upward. Petiole in lateral view with anterior slope distinctly convex. Petiole with two spines, without denticles between the spines. Petiolar spine in lateral view curved backwards, as long as or

longer than the height of petiole, except in *P. antedoridens* sp. nov., in which petiolar spine in lateral view almost straight.

***Polyrhachis (Myrmatopa) antedoridens* sp. nov.**

(Fig. 9, 21, 33, 45)

Holotype: worker, E. Malaysia, Borneo, Sarawak, Lambir Hills N.P., v-vi.2003, HT03-0735 (H. Tanaka & T. Itioka) (SKYC).

Worker measurements

HW 1.50, HL 1.55, SL 2.00, CI 96.77, SI 133.33, PrW 1.10, MPL 1.70, MTL 1.58, MTI 105.33, PL 0.35, PH 0.25, PW 0.35, PI 71.43, PLI 140.00 (holotype).

Worker description

Medium-sized species. Head relatively broad, narrowed anteriorly, and with convex posterior margin in full-face view. Clypeus weakly convex in lateral view; anterior extremity of clypeus with a pair of short teeth that are rather broadly separated. Frontal carina well elevated and weakly sinuate in full-face view. Antennal scape long, extending beyond the occipital margin of head by at least half its length. Eye convex, slightly protruding from the lateral outline of head. Pronotum in dorsal view convex laterally and narrowed posteriorly, armed with anterolateral teeth that are distinctly protruding from the pronotum. Mesosoma laterally weakly marginate throughout. Mesonotum only slightly higher than propodeum. Propodeal dorsum slightly sloping; propodeal spine medium-sized, directed upward. Petiolar spines seen from back strongly divergent, in lateral view almost straight, shorter than the height of petiole measuring approximately half the latter; petiole in lateral view with anterodorsal margin of petiole rounded; anterior slope distinctly convex, while posterior slope slightly convex; subpetiolar process low, with posteroventral corner rounded.

Mandible very finely superficially microsculptured, scattered over the surface and shining. Head including clypeus and frontal lobe, dorsa of mesosoma and petiole with superficial sparse punctures; dorsa of pronotum and mesonotum irregularly sculptured. Sides of mesosoma closely puncto-reticulate and shining. Antenna and legs densely microsculptured and shining. Gaster densely microsculptured and dull.

Antennal flagellum with very fine sparse pubescence, without standing hairs except at apical segment; flagellar segment with many yellow short standing hairs. Head, clypeus, frontal lobe, mandible, coxae, trochanters, femora below, petiolar pedicel above and below with a few yellow standing hairs. Gaster ventrally with some yellow standing hairs and sparse pubescence. Pubescence on clypeus, mandible and gastral tergites minute and sparse.

Head and mesosoma black. Mandible, antennal scape and flagellum, legs, petiole, gaster brownish black.

Etymology

The name refers to the pronotum which armed with distinctly protruding anterolateral teeth.

Discussion

Worker of this species can be distinguished from those of other members of the *flavicornis*-group by the pronotum in dorsal view armed with anterolateral teeth which are distinctly protruding from the pronotum. Moreover, the petiolar spines are seen from back distinctly divergent, in lateral view vertical and almost straight, shorter than the height of petiole measuring approximately half the latter.

Distribution

This species is known only from Lambir Hills N.P., Sarawak, Borneo, E. Malaysia (Fig. 4).

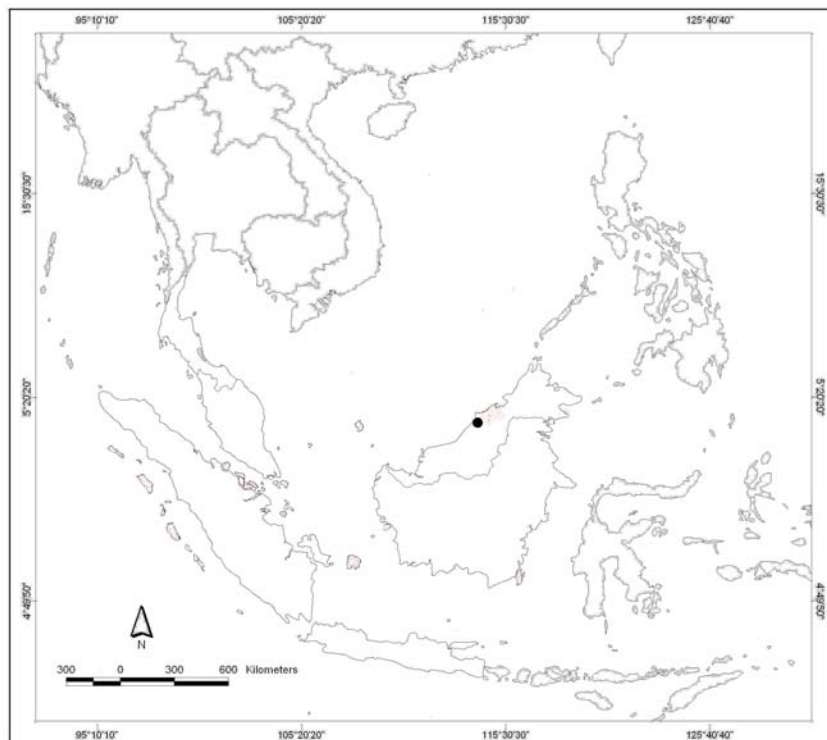


Figure 4. Distribution of *P. antedoridens* sp. nov.

(modified from the Southern Remote Sensing GIS Center, Prince of Songkla University, 2008).

***Polyrhachis (Myrmatopa) constructor* F. Smith**

(Fig. 10-11, 15-17, 22-23, 27-29, 34-35, 39-41, 46-47, 51-53)

Polyrhachis constructor F. Smith, 1857: 60. Type locality: E. Malaysia, Borneo, Sarawak (A.R. Wallace) [OXUM] (one syntype queen examined).

Polyrhachis piliventris F. Smith, 1858: 60, pl. 4, fig. 24. Type locality: Singapore (A.R. Wallace) [BMNH] (one syntype queen examined); Dorow, 1995: 44 (combination in *P. (Myrmatopa)*).

Polyrhachis elii Emery, 1900: 711. Type locality: Indonesia, Mentawai I., Sipora, Sereinu, v-vi.1894 (E. Modigliani) [MCSN] (two syntype workers examined); Emery, 1925: 180 (combination in *P. (Myrmatopa)*).

Non-type material examined

E. Malaysia: Borneo, Sabah, Tawu Hills N.P., 12.vii.1996, Colony A (SKY) (worker, queen). **S. Thailand:** Songkhla Prov., Ton Nga Chang W.S. 100-300 m, 22.v.2004, nesting on lower vegetation, 2.40 m above ground, Colony B (NAW) (workers); Phangnga Prov., Lumpee Waterfall 0-100 m, 19.iv.2005, nesting on lower vegetation, 2.20 m above ground, Colony C (NAW) (workers, queen); Trang Prov., Pak Jam Waterfall 130-190 m, 28.ii.2006, nesting on lower vegetation, 1.83 m above ground, Colony D (NAW) (workers); Prajuab Khiri Khan Prov., Pala U Waterfall 220-350 m, 29.i.2007, nesting on lower vegetation, 2.00 m above ground, Colony E (NAW) (workers, queens); Prajuab Khiri Khan Prov., Pala U Waterfall 220-350 m, 30.i.2007, nesting on lower vegetation, 2.80 m above ground, Colony F (NAW) (workers, queen).

Worker measurements (syntypes cited first)

HW 1.47-1.50, 1.03-1.57; HL 1.77-1.90, 1.33-1.87; SL 2.57-2.60, 1.83-2.77; CI 78.95-83.02, 74.00-86.27; SI 173.33-175.00, 171.05-184.21; PrW 1.03-1.27, 0.83-1.33; MPL 1.77-1.83, 1.27-1.93; MTL 2.47-2.67, 1.90-2.67; MTI 168.18-177.78, 168.42-184.21; PL 0.57-0.60, 0.43-0.67; PH 0.37-0.43, 0.33-0.40; PW 0.60-0.67, 0.47-0.70; PI 61.11-65.00, 52.63-72.22; PLI 138.46-154.55, 115.38-172.73 (2 syntypes, 17 non-type workers measured).

Worker description

Medium to large-sized species. Head distinctly elongate with its posterior margin almost straight in full-face view. Clypeus weakly convex in lateral view; anterior extremity of clypeus with a pair of short teeth that are rather broadly separated. Frontal carinae well elevated and weakly sinuate in full-face view. Antennal scape long, extending beyond the posterior margin of head by at least half of its length. Eye convex, slightly protruding from the lateral outline of head. Pronotum in dorsal view convex and slightly narrowed posteriorly, armed with anterolateral teeth. Mesosoma laterally distinctly marginate throughout. Mesonotum only slightly

higher than propodeum. Propodeal dorsum slightly sloping; propodeal spine small-sized, directed upward. Petiolar spines seen from back divergent, in lateral view slightly curved backwards, as long as the height of petiole. Anterodorsal margin of petiole rounded; anterior slope distinctly convex, while posterior slope only slightly convex. Subpetiolar process low, with posteroventral corner angulate.

Mandible very fine and superficially microsculpture scattered over the surface and dull. Head including clypeus, frontal lobe, dorsa of mesosoma and petiole with superficial sparse punctures and other irregular sculpture. Dorsa of pronotum longitudinally striate rather than punctate. Side of mesosoma puncto-reticulate to puncto-striate and shining. Antenna and legs densely microsculptured and shining. Gaster very superficially microsculptured and weakly shining.

Antennal scape and flagellum with many yellow standing short hairs and very fine sparse pubescence. Head, clypeus, frontal lobe, mandible, dorsa of mesosoma, petiole, petiolar spine, coxae, trochanters, femora below, petiolar pedicel above and below, subpetiolar process posteriorly with a few yellow standing hairs. Gaster ventrally and tergites with some yellow standing hairs and sparse pubescence. Pubescence on clypeus, frontal lobe and mandible minute and sparse.

Head, mesosoma and petiole black. Mandible, antennal scape and flagellum, legs and gaster reddish brown to dark brown.

Queen measurements (syntypes cited first)

HW 1.57, 1.53-1.70; HL 2.03-2.10, 1.90-2.20; SL 2.80, 2.80-3.07; CI 74.60-77.05, 74.19-82.46; SI 178.72, 175.00-191.30; PrW 1.73-1.87, 1.73-1.87; MPL 2.37, 2.23-2.50; MTL 2.67-2.83, 2.70-3.13; MTI 170.21-180.85, 168.75-193.48; PL 0.63-0.67, 0.60-0.67; PH 0.30-0.50, 0.30-0.53; PW 0.73, 0.73-0.93; PI 40.91-68.18, 40.91-58.33; PLI 133.33-211.11, 112.50-158.33 (2 syntypes, 6 non-type queens measured).

Queen description

Head slightly longer than broad. Pronotum armed with anterolateral teeth. Propodeal dorsum in lateral view distinctly shorter than declivity. Petiolar spine in lateral view stout and curved backward, as long as the height of petiole.

Body sculpture similar to that in workers, but dorsa of pronotum with a close punctation, lacking striation.

Similar to workers in pilosity, but dorsa of mesoscutum and mesoscutellum with a few yellow standing hairs.

Similar to workers in coloration.

Discussion

P. constructor workers can be recognised by their antennal scape with many yellow standing short hairs. In addition, this species can be separated from other members of the *flavicornis*-group, by the possession of a few yellow standing hairs on the dorsa of mesosoma, petiole, and petiolar spine.

Workers of this species show the variation in the shape of petiolar spine. In most workers from S. Thailand, the petiolar spines in front view divergent and slightly slender in frontal view. But the syntypes of *P. elii* from Mentawai I., Indonesia and specimen from Sabah, Borneo, the petiolar spines slightly convergent and stout.

In the queen this species can be distinguished from other members of the *flavicornis*-group, by the combination of large size (HW 1.53-1.70, HL 1.90-2.20, SL 2.80-3.07), presence of many yellow standing short hairs antennal scape, and the presence of a few yellow standing hairs on petiole and petiolar spine.

Distribution

P. constructor is known from Mentawai I., Borneo, Singapore and Peninsular Thailand (Fig. 5), where the colonies were collected on the lower vegetation in undisturbed sites of the lowland rain forest.

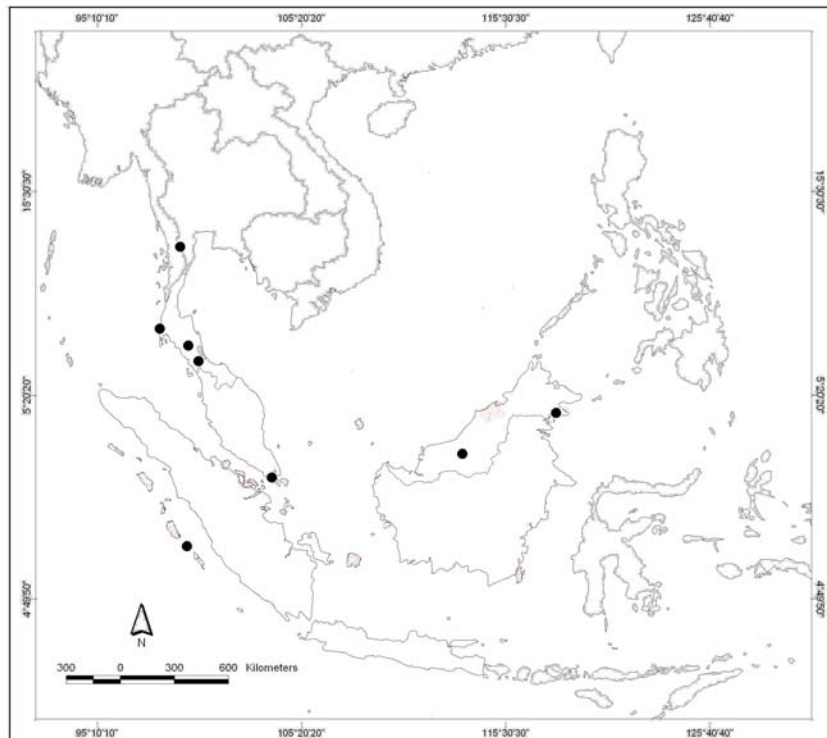


Figure 5. Distribution of *P. constructor* F. Smith

(modified from the Southern Remote Sensing GIS Center, Prince of Songkla University, 2008).

***Polyrhachis (Myrmatopa) flavicornis* F. Smith**

(Fig. 12, 18-19, 24, 30-31, 36, 42-43, 48, 54, 55)

Polyrhachis flavicornis F. Smith, 1857: 63. Type locality: Singapore (A. R. Wallace) [OXUM] (one syntype worker and one syntype queen examined); Donisthorpe, 1932: 446 (combination in *P. (Myrmatopa)*).

Polyrhachis ruficornis F. Smith, 1857: 60. Type locality: E. Malaysia, Borneo, Sarawak (A. R. Wallace) [OXUM] (one syntype queen examined); Donisthorpe, 1932: 445 (combination in *P. (Myrmatopa)*).

Non-type material examined

Indonesia: West Sumatra, Pinang-Pinang, Ulu Gadut, nr. Padang, 10-18.ix.1989, Colony A (E. Suzuki) (worker); West Sumatra, Jambi, Danau Kerinci 0-600 m, 5.xi.2006, nesting on lower vegetation, 2.20 m above ground, Colony B (Syaukani) (workers, queens); same loc., 7.xi.2006, nesting on lower vegetation, 2.35 m above ground, Colony C (Syaukani) (workers, queens). **E. Malaysia:** Borneo, Sabah, Danum Valley, 3-4.iii.1999, Colony D (SKY) (workers). **S. Thailand:** Narathiwat Prov., Bala Forest, Hala-Bala W.S. 50-300 m, 15.i.2002, on lower vegetation (NAW) (workers); Satun Prov., Ludu Waterfall, Tatutao N.P. 0-200 m, 6.iii.2005, on lower vegetation (NAW) (workers); Songkhla Prov., Ton Nga Chang W.S. 100-300 m, 21.i.2002, canopy fogging (S. Tongjerm) (workers); same loc., 27.iii.2004, nesting on lower vegetation, 1.84 m above ground, Colony E (NAW) (workers, queen); Phatthalung Prov., Ton Pra Tong Waterfall 100-200 m, 19.iii.2005, nesting on lower vegetation, 1.63 m above ground, Colony F (NAW) (workers); Nakhon Si Thammarat Prov., Aey Kiew Waterfall, Khao Luang N.P. 100-300 m, 8.viii.2005, on lower vegetation (NAW) (workers); Nakhon Si Thammarat Prov., Khao Nun N.P. 100-500 m, 16.iv.2005, nesting on lower vegetation, 2.35 m above ground, Colony G (NAW) (workers, queen); Surat Thani Prov., inner mainland, Klong Sang W.S. 100-300 m, 1.v.1994, canopy fogging (L. Lebel) (workers); Surat Thani Prov., Tai Rom Yen N.P. 400-500 m, 31.vii.2005, nesting on lower vegetation, 2.25 m above ground, Colony H (NAW) (workers); Ranong Prov., Kuan Mayoy Mom W.S. 190-250 m, 28.ix.2005, nesting on lower vegetation, 2.20 m above ground, Colony I (NAW) (workers, queens); Prajuab Khiri Khan Prov., Ka Oon Waterfall 100-200 m, 10.ii.2007, nesting on lower vegetation, 2.05 m above ground, Colony J (NAW) (workers, queen); Prajuab Khiri Khan Prov., Kuy Buri N.P. 100-300 m, 30.v.2005, nesting on lower vegetation, 1.93 m above ground, Colony K (NAW) (workers, queen). **C. Thailand:** Phetchaburi Prov., Kaeng Krachan N.P. 250-350 m, 30.v.2005, nesting on lower vegetation, 2.30 m above ground, Colony L (NAW) (workers, queens). **E. Thailand:** Chacheungsao Prov., Lumchangwat, Khao Ang Reu Nai W.S., 2003, THO3-SKY-18, (SKY) (workers); same loc., THO3-SKY-61, (SKY)

(workers); same loc., THO3-SKY-62, (SKY) (workers, queen); same loc., THO3-SKY-67, (SKY) (workers).

Worker measurements (syntype cited first)

HW 1.13, 0.90-1.13; HL 1.40, 1.13-1.43; SL 1.80, 1.47-1.90; CI 80.95, 74.36-86.49; SI 158.82, 152.94-183.87; PrW 0.93, 0.73-1.00; MPL 1.23, 1.07-1.37; MTL 1.67, 1.33-1.80; MTI 147.06, 140.00-174.19; PL 0.33, 0.30-0.40; PH 0.23, 0.20-0.33; PW 0.50, 0.37-0.53; PI 46.67, 46.15-76.92; PLI 142.86, 110.00-183.33 (1 syntype and 26 non-type workers measured)

Worker description

Medium-sized species, with slightly elongate head. Clypeus convex in lateral view; anterior extremity of clypeus with short pair of teeth that are rather broadly separated. Frontal carina well elevated and sinuate. Antennal scape long, extending beyond the occipital margin of head by at least half its length. Eye convex, slightly protruding from the lateral outline of head. Pronotum in dorsal view convex and slightly narrowed posteriorly, armed with anterolateral teeth. Mesosoma laterally distinctly marginate throughout. Mesonotum only slightly higher than propodeum. Propodeal dorsum slightly sloping; propodeal spine small-sized, directed upward. Petiolar spine in lateral view curved backward, as long as or longer than the height of petiole. Anterodorsal margin of petiole in lateral view rounded; anterior and posterior slope distinctly convex. Subpetiolar process low, with posteroventral corner angulate.

Mandible microstriate basally and very superficially microsculptured apically, with scattered small macropunctures. Clypeus, frons, sides of head and petiole with close punctation. Dense and close punctures on dorsa and sides of mesosoma larger than those on head; dorsa of pronotum longitudinally striate rather than punctate. Gaster with dense micropunctation and dull.

Antennal flagellum with dense pubescence. Head, clypeus, frontal lobe, coxae, trochanters, femora below, petiolar pedicel above and below, subpetiolar process posteriorly, and gastral tergites posteriorly with a few yellow standing hairs.

Clypeus, frontal lobe and subpetiolar process with sparse pubescence. Pubescence on gastral tergites dense. Mandible and ventral side of gaster with many yellow standing hairs and sparse pubescence.

Head, mesosoma, petiole and petiolar spine, reddish brown to black. Mandible, legs and antennal flagellum reddish brown; scape and first flagellar segment reddish brown to black. Gaster black to reddish brown.

Queen measurements (syntypes cited first)

HW 1.17-1.27, 0.97-1.23; HL 1.53-1.63, 1.27-1.63; SL 1.93-2.17, 1.80-2.13; CI 76.09-77.55, 72.92-81.58; SI 165.71-171.05, 162.16-190.91; PrW 1.37, 1.17-1.43; MPL 1.75-1.83, 1.50-1.87; MTL 2.03, 1.73-2.00; MTI 160.53, 155.56-183.33; PL 0.43-0.47, 0.37-0.50; PH 0.30-0.37, 0.23-0.33; PW 0.57-0.60, 0.40-0.57; PI 50.00-64.71, 47.06-62.50; PLI 118.18-155.56, 120.00-175.00 (2 syntypes and 12 non-type queens measured).

Queen description

Head slightly longer than broad. Pronotum armed with much reduced anterolateral teeth. Propodeal dorsum in lateral view distinctly shorter than declivity. Petiolar spine in lateral view stout and curved backward, as long as the height of petiole.

Body sculpture similar to that in workers, but dorsa of pronotum with a close punctation, lacking striation.

Similar to workers in pilosity, but dorsa of mesoscutum and mesoscutellum with a few yellow standing hairs.

Similar to workers in coloration, but antennal scape and the first flagellar segment black to reddish brown; the remaining segments of antennal flagellum reddish brown.

Discussion

P. flavicornis workers can be recognised by the combination of the following conditions: pronotum weakly marginate laterally; mandible, legs and antennal flagellum reddish brown; scape and first flagellar segment reddish brown to black.

Queens of *P. flavicornis* differs from those of *P. varicolor* in their entirely black head and mesosoma, except appendages.

Distribution

P. flavicornis is widely distributed from W. Sumatra, Borneo, Singapore and Peninsular Thailand to East Thailand (Fig. 6). In Peninsular Thailand, nests have been found on the lower vegetation, and some specimens were found among fogging samples from the lowland rain forest.

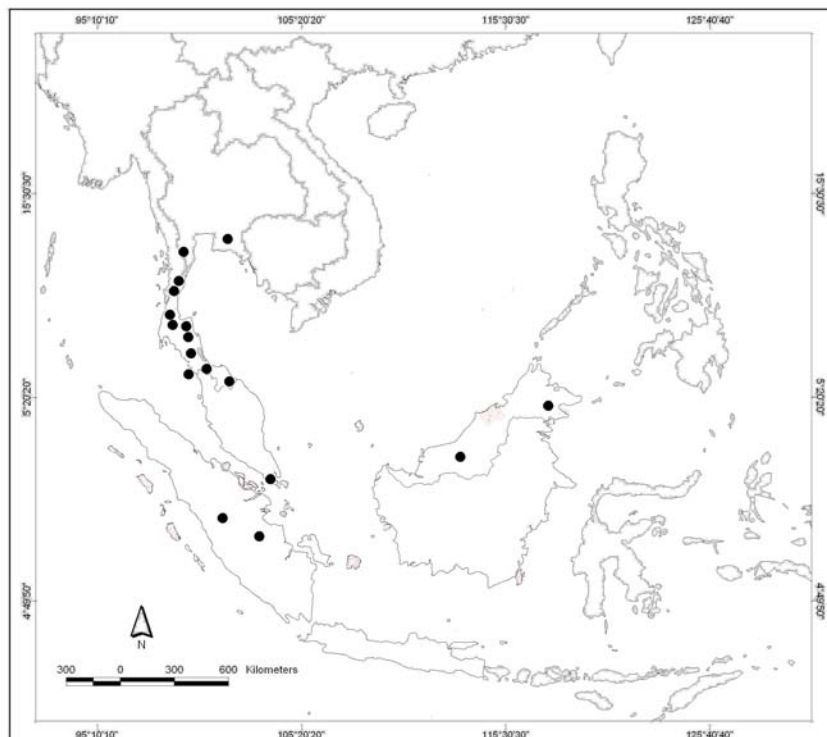


Figure 6. Distribution of *P. flavicornis* F. Smith

(modified from the Southern Remote Sensing GIS Center, Prince of Songkla University, 2008).

***Polyrhachis (Myrmatopa) kohouti* sp. nov.**

(Fig. 13, 25, 37, 49)

Holotype: worker, E. Malaysia, Borneo, Sarawak, Lambir Hills N.P., 5.xiii.1995 (H. Okido) (SKYC).

Non-type material examined

E. Malaysia: Borneo, Sarawak, Lambir Hills N.P., 1.i.1998, night walk on the tower (SKY) (worker). **S. Thailand:** Songkhla Prov., Ton Nga Chang W.S. 100-300 m, 26.iii.2002, canopy fogging (S. Tongjerm) (workers); Songkhla Prov., Reserve area of Prince of Songkla University, 80-300 m, vii.2004, canopy fogging (A. Nusamean) (workers).

Worker measurements (holotype cited first)

HW 1.25, 1.25-1.35; HL 1.50, 1.50-1.57; SL 1.60, 1.65-1.75; CI 83.33, 80.65-90.00; SI 128.00, 129.63-134.21; PrW 1.10, 1.10-1.20; MPL 1.35, 1.43-1.60; MTL 1.77, 1.73-1.80; MTI 141.33, 133.33-141.33; PL 0.45, 0.45-0.50; PH 0.20, 0.25-0.30; PW 0.45, 0.55-0.60; PI 44.44, 45.45-54.55; PLI 225.00, 150.00-200.00 (holotype and 5 non-type workers measured).

Worker description

Medium-sized species, with slightly elongate head. Clypeus weakly convex in lateral view; anterior extremity of clypeus with a pair of short teeth that are rather broadly separated. Frontal carina well elevated and weakly sinuate in full-face view. Antennal scape short, extending beyond the posterior margin of head by approximately 1/3 of its length. Eye convex, slightly protruding from the lateral outline of head. Pronotum in dorsal view convex laterally and slightly narrowed posteriorly, armed with anterolateral teeth. Mesosoma laterally distinctly marginate throughout. Mesonotum only slightly higher than propodeum. Propodeal dorsum

slightly sloping; propodeal spine small-sized, directed upward. Petiolar spines seen from back slightly diverging, in lateral view distinctly curved backwards, longer than the height of petiole. Petiole in lateral view with anterodorsal margin rounded; anterior slope distinctly convex, while posterior slope slightly convex. Subpetiolar process low, with posteroventral corner more or less angulate.

Mandible with a very fine and superficially microsculpture scattered over the surface, and shining. Head including clypeus and frontal lobe, dorsa of mesosoma and petiole with superficial sparse punctures; dorsa of pronotum longitudinally striate rather than punctate. Antenna densely microsculptured and shining. Sides of mesosoma closely puncto-reticulate and shining. Gaster densely microsculptured and shining. Legs densely microsculptured and dull.

Antennal flagellum with very fine sparse pubescence. Head, clypeus, mandible, coxae, trochanters, femora below, petiolar pedicel below, subpetiolar process posteriorly with a few yellow standing hairs. Gaster ventrally with some yellow standing hairs and sparse pubescence. Pubescence on clypeus, frontal lobe, mandible and gastral tergites minute and sparse.

Head, mesosoma and petiole black. Mandible, antennal scape and gaster dark brown. Antennal flagellum and legs reddish brown to dark brown.

Etymology

Name in honour of Dr. Rudy J. Kohout, who described many new *Polyrhachis* species and guided my first step in my studies on *Polyrhachis* ants.

Discussion

In the worker of this species is similar to *P. flavicornis* and *P. varicolor* but differs from the two latter in its broader head and shorter antennal scape that extends beyond the occipital margin of head by approximately 1/3 of its length (SI < 140.00). In addition, this species can be separated from them by the coloration, the shape of petiolar spine in lateral view and the nesting habits (nests might be constructed in the tree canopies).

Distribution

This species is known from two localities on the island of Borneo and two sites in Peninsular Thailand (Fig. 7). Specimens from the lowland rain forest of Peninsular Thailand were found among fogging samples.

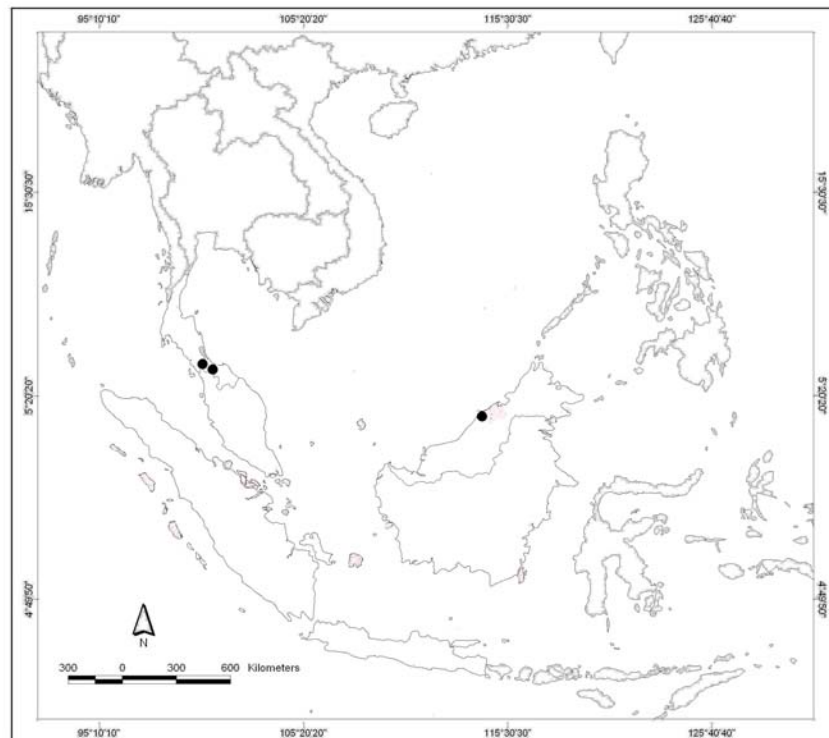


Figure 7. Distribution of *P. kohouti* sp. nov.

(modified from the Southern Remote Sensing GIS Center, Prince of Songkla University, 2008).

***Polyrhachis (Myrmatopa) varicolor* Viehmeyer**

(Fig. 14, 20, 26, 32, 38, 44, 50, 56)

Polyrhachis fruhstorferi Emery, 1898: 238. Type locality: Indonesia, Sulawesi, Toli-Toli (H. Fruhstorfer) [MCSN] (four syntype workers examined); Emery, 1925: 180 (combination in *P. (Myrmatopa)*).

Polyrhachis fruhstorferi subsp. *varicolor* Viehmeyer, 1916: 163. Type locality: Singapore (H. Overbeck) [MNHU] (not examined); Emery, 1925: 180 (combination in *P. (Myrmatopa)*).

Polyrhachis varicolor Viehmeyer: Kohout, 2008: 259. Raised to species.

Non-type material examined

S. Thailand: Songkhla Prov., Kuan Mod Dang, Prince of Songkla University 0-100 m, 17.vii.2007, nesting on lower vegetation, 1.85 m above ground, Colony A (NAW) (workers, queens); Songkhla Prov., Ton Nga Chang W.S. 100-300 m, 25.vii.2002, canopy fogging (S. Tongjerm) (workers); same loc., 16.xi.2002, canopy fogging (S. Tongjerm) (workers); Phatthalung Prov., Khao Pu-Khao Ya N.P. 0-300 m, 4.iv.2006, nesting on lower vegetation, 2.00 m above ground, Colony B (NAW) (workers, queen); Nakhon Si Thammarat Prov., Khiriwong Village 100-400 m, 21.iii.2008, nesting on lower vegetation, 1.37 m above ground, Colony C (NAW) (workers); Surat Thani Prov., inner mainland, Klong Sang W.S. 100-300 m, 1.v.1994, canopy fogging (L. Lebel) (workers); Surat Thani Prov., Island edge, Klong Sang W.S. 100-300 m, 1994, canopy fogging (L. Lebel) (workers); Prajuab Khiri Khan Prov., Ka Oon Waterfall 100-200 m, 28.xii.2005, nesting on lower vegetation, 1.38 m above ground, Colony D (NAW) (workers); same loc., 8.iii.2006, nesting on lower vegetation, 2.55 m above ground, Colony E (NAW) (workers, queen); same loc., 9.ii.2007, nesting on lower vegetation, 2.30 m above ground, Colony F (NAW) (workers, queen); same loc., 9.ii.2007, nesting on lower vegetation, 2.73 m above ground, Colony G (NAW) (workers, queen). same loc., 9.ii.2007, nesting on lower vegetation, 2.60 m above ground, Colony H (NAW) (workers).

Worker measurements

HW 1.03-1.30; HL 0.93-1.50; SL 1.63-1.93; CI 79.49-123.21; SI 148.65-158.06; PrW 0.83-1.03; MPL 1.20-1.47; MTL 1.47-1.87; MTI 135.14-152.78; PL 0.35-0.47; PH 0.23-0.33; PW 0.43-1.30; PI 20.51-69.23; PLI 116.67-171.43 (14 non-type workers measured).

Worker description

Medium-sized species, with slightly elongate head. Clypeus weakly convex in lateral view; anterior extremity of clypeus with a pair of short teeth that are slightly broad separated. Frontal carina well elevated and weakly sinuate in full-face view. Antennal scape long, extending beyond the posterior margin of head by at least half of its length. Eye convex, slightly protruding from the lateral outline of head. Pronotum in dorsal view convex laterally and slightly narrowed posteriorly, armed with anterolateral teeth. Mesosoma laterally distinctly marginate throughout. Mesonotum only slightly higher than propodeum. Propodeal dorsum slightly sloping; propodeal spine small directed upward. Petiolar spines seen from back slightly diverging, in lateral view distinctly curved backward, longer than the height of petiole. Petiole in lateral view with anterodorsal margin rounded, anterior slope distinctly convex and posterior slope slightly convex. Subpetiolar process low, with posteroventral corner more or less angulate.

Mandible with a very fine and superficially microsculpture scattered over the surface and shining. Head including clypeus and frontal lobe, dorsa of mesosoma and petiole with superficial sparse punctures; dorsa of pronotum punctate to puncto-striate. Antenna densely microsculptured and shining. Sides of mesosoma closely puncto-reticulate and shining. Gaster densely microsculptured and shining. Legs densely microsculptured and dull.

Antennal flagellum with very fine sparse pubescence. Head, clypeus, frontal lobe, mandible, coxae, trochanters, femora below, petiolar pedicel above and below, subpetiolar process posteriorly with a few yellow standing hairs. Gaster ventrally with many yellow standing hairs and sparse pubescence. Pubescence on clypeus, frontal lobe, mandible and gastral tergites minute and sparse.

Head including mandible, antennal scape and flagellum, mesosoma, petiole and legs reddish brown to dark reddish brown. Gaster reddish brown to black.

Queen measurements

HW 1.25-1.35; HL 1.70; SL 2.10-2.20; CI 73.53-79.41; SI 161.54-162.96; PrW 1.40-1.55; MPL 1.80-1.95; MTL 2.07-2.17; MTI 158.02-166.67; PL 0.45-0.50; PH 0.30-0.40; PW 0.60-0.65; PI 50.00-61.54; PLI 125.00-150.00 (3 non-type queens measured).

Queen description

Similar to the worker in structure, but pronotum in dorsal view with reduced anterolateral teeth. Propodeal dorsum in lateral view distinctly shorter than declivity, propodeal spine much reduced. Petiolar spine in lateral view stout.

Body sculpture similar to that in the worker, but dorsa of pronotum lacking striation.

Similar to worker in pilosity, but dorsa of mesoscutum and mesoscutellum with a few yellow standing hairs.

Similar to the worker in coloration but head, mesosoma, and petiole reddish brown to black.

Discussion

This species is very similar to *P. flavicornis* but can be diagnosed by a suite of worker characteristics: the pronotum is slightly marginate laterally; and the head, mesosoma, legs, petiole and petiolar spine are more reddish. Besides, in the queen the frontal lobe, mesoscutum and parapside are reddish, partly with black stains.

Distribution

This species is known from Singapore and Peninsular Thailand (Fig. 8). Habitats from which it has been recorded include undisturbed and disturbed lowland rain forest, but one nest was found from an orchard near forest edge. Most of the material consists of individuals from colonies located on the lower vegetation and specimens found among the fogging samples.

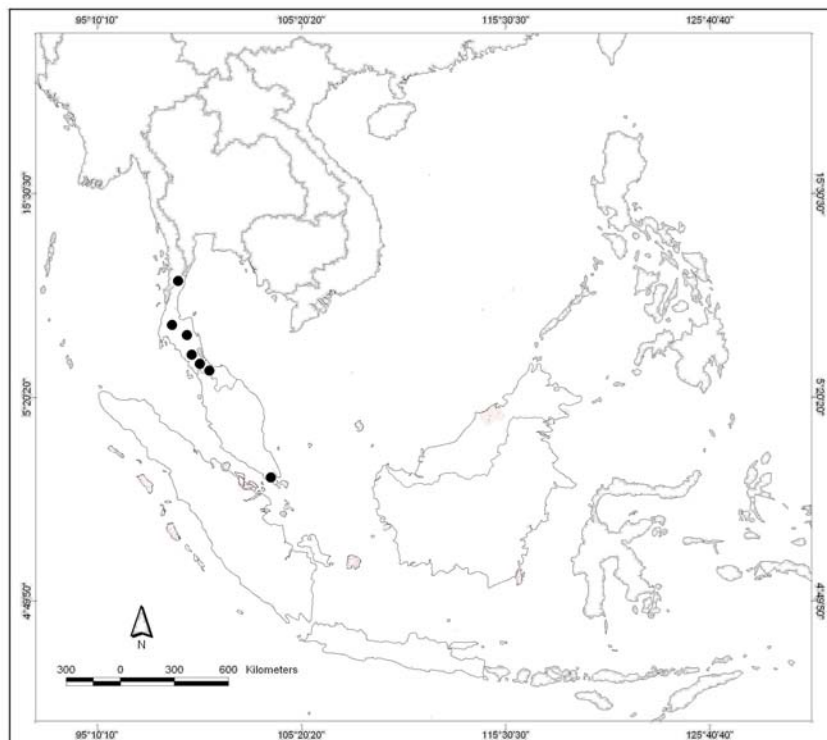


Figure 8. Distribution of *P. varicolor* Viehmeyer

(modified from the Southern Remote Sensing GIS Center, Prince of Songkla University, 2008).

2.3.6.2 *Polyrhachis schang*-group

Workers of this group can be recognised by the following characteristics: clypeus convex in lateral view. Eye convex, slightly protruding from the lateral outline of head. Antennal scape long, extending beyond the posterior margin of head by at least half its length. Pronotum laterally not marginate; mesonotum and propodeum weakly marginate laterally. Pronotum in dorsal view convex and slightly narrowed posteriorly, unarmed with anterolateral teeth. Mesonotum in lateral view higher than propodeum; with a distinct posterior slope which is as long as flat dorsal portion. Propodeal dorsum slightly sloping; propodeal spine small-sized, directed upward. Petiole in lateral view with anterodorsal margin of petiole rounded; anterior slope distinctly convex, while posterior slope slightly convex. Petiole with two spines, without denticles between the spines. Petiolar spine in lateral view directed backwards, as long as or longer than the height of petiole.



Figure 9. *P. antedoridens* sp. nov.
worker in lateral view of hole body.



Figure 10. *P. constructor* F. Smith
worker in lateral view of hole body.



Figure 11. *P. elii* Emery worker
(syntype) in lateral view of hole body.



Figure 12. *P. flavicornis* F. Smith
worker in lateral view of hole body.



Figure 13. *P. kohouti* sp. nov.
worker in lateral view of hole body.



Figure 14. *P. varicolor* Viehmeyer
worker in lateral view of hole body.



Figure 15. *P. constructor* F. Smith queen (syntype) in lateral view of hole body.



Figure 16. *P. constructor* F. Smith queen in lateral view of hole body.

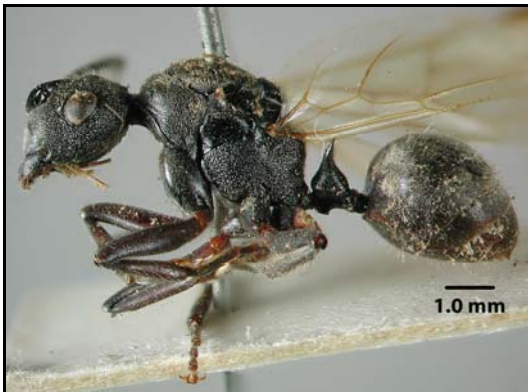


Figure 17. *P. piliventris* F. Smith queen (syntype) in lateral view of hole body.



Figure 18. *P. ruficornis* F. Smith queen (syntype) in lateral view of hole body.



Figure 19. *P. flavicornis* F. Smith queen in lateral view of hole body.



Figure 20. *P. varicolor* Viehmeyer queen in lateral view of hole body.

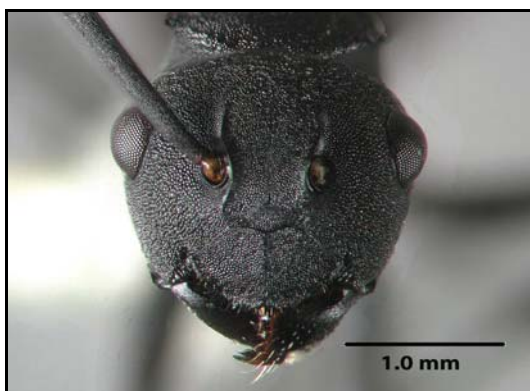


Figure 21. *P. antedoridens* sp. nov.
worker, head in full face view.



Figure 22. *P. constructor* F. Smith
worker, head in full face view.

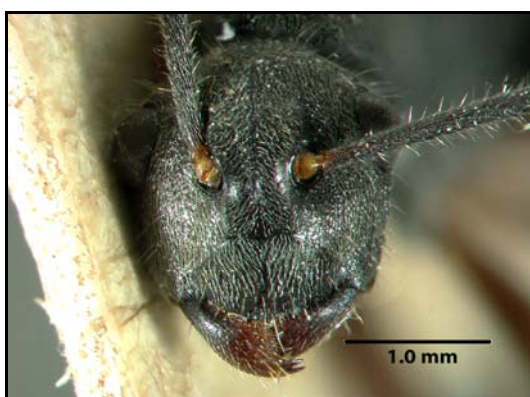


Figure 23. *P. elii* Emery worker
(syntype), head in full face view.

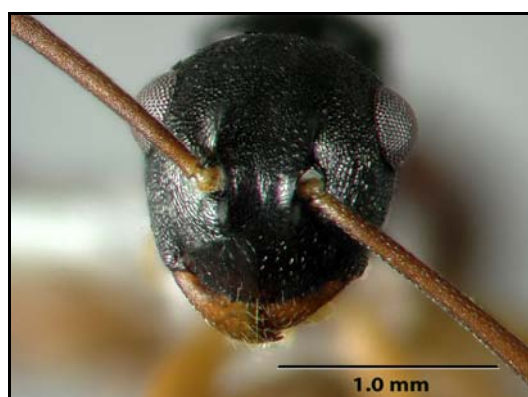


Figure 24. *P. flavicornis* F. Smith
worker, head in full face view.

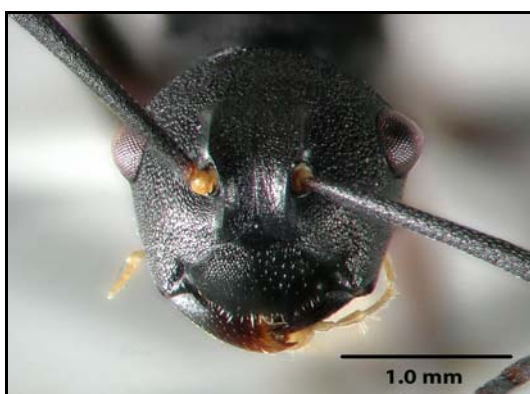


Figure 25. *P. kohouti* sp. nov.
worker, head in full face view.



Figure 26. *P. varicolor* Viehmeyer
worker, head in full face view.

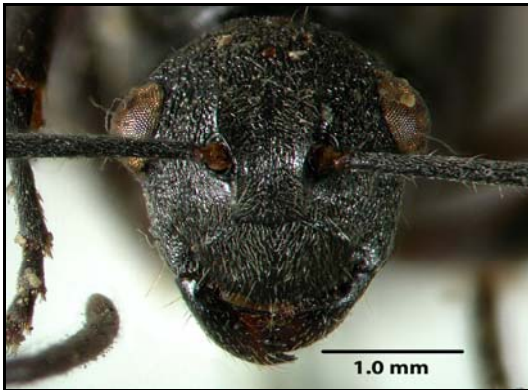


Figure 27. *P. constructor* F. Smith queen (syntype), head in full face view.

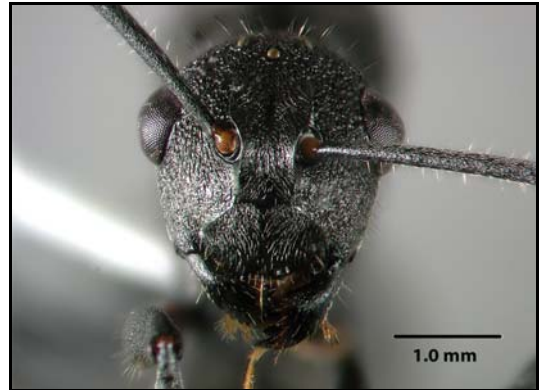


Figure 28. *P. constructor* F. Smith queen, head in full face view.

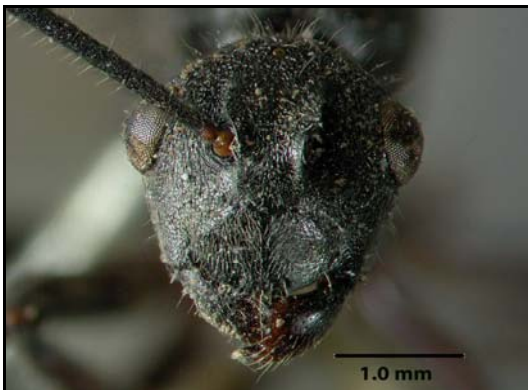


Figure 29. *P. piliventris* F. Smith queen (syntype), head in full face view.

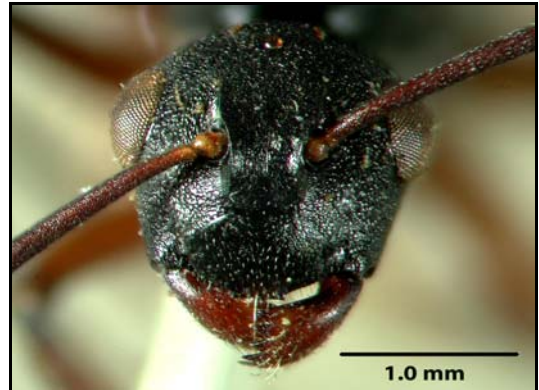


Figure 30. *P. ruficornis* F. Smith queen (syntype), head in full face view.

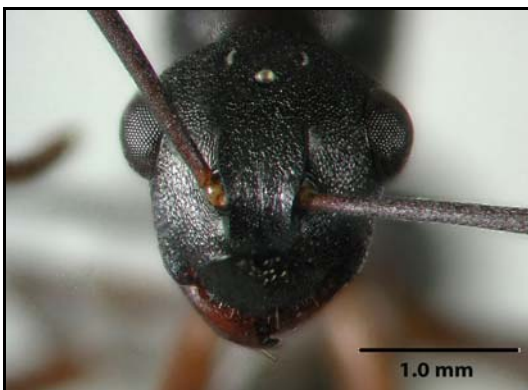


Figure 31. *P. flavicornis* F. Smith queen, head in full face view.

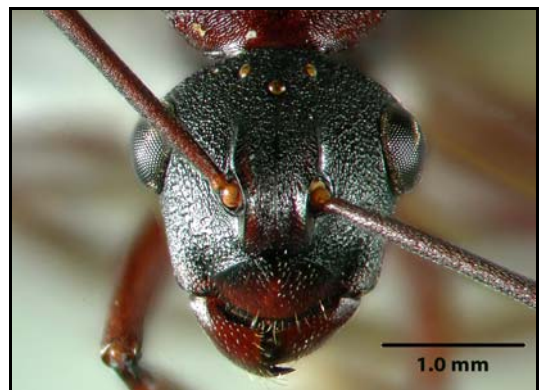


Figure 32. *P. varicolor* Viehmeyer queen, head in full face view.

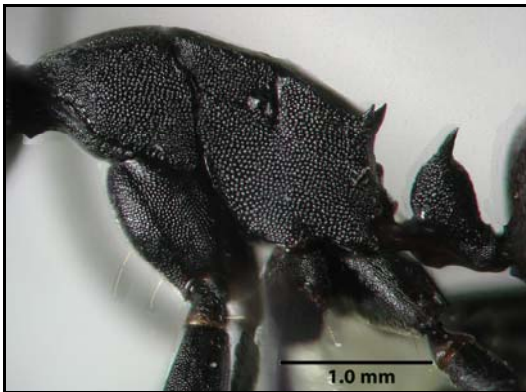


Figure 33. *P. antedoridens* sp. nov. worker in lateral view of mesosoma and petiole.



Figure 34. *P. constructor* F. Smith worker in lateral view of mesosoma and petiole.

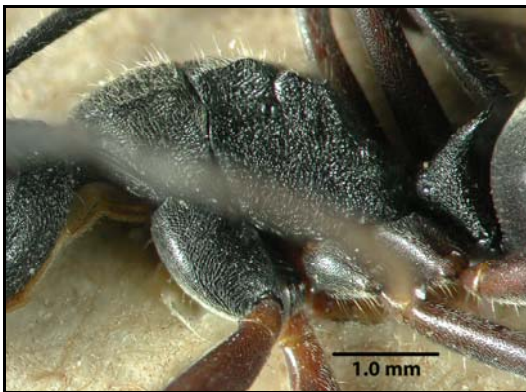


Figure 35. *P. elii* Emery worker (syntype) in lateral view of mesosoma and petiole.



Figure 36. *P. flavicornis* F. Smith worker in lateral view of mesosoma and petiole.



Figure 37. *P. kohouti* sp. nov. worker in lateral view of mesosoma and petiole.



Figure 38. *P. varicolor* Viehmeyer worker in lateral view of mesosoma and petiole.

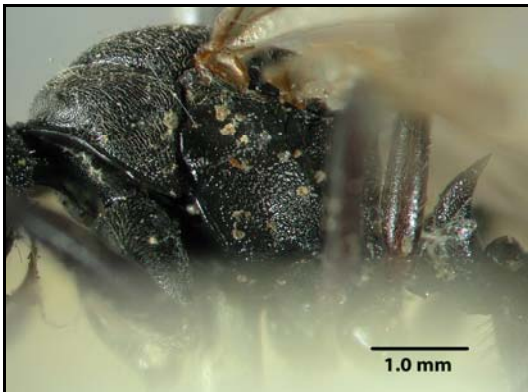


Figure 39. *P. constructor* F. Smith queen (syntype) in lateral view of mesosoma and petiole.



Figure 40. *P. constructor* F. Smith queen in lateral view of mesosoma and petiole.

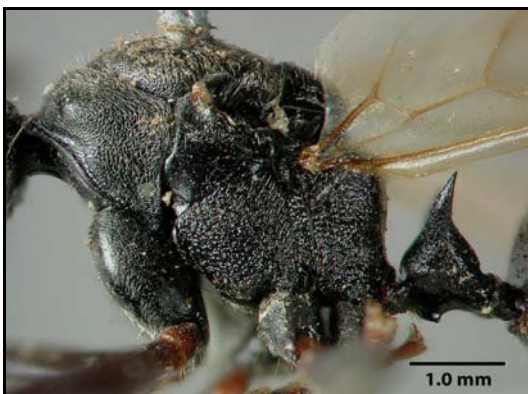


Figure 41. *P. piliventris* F. Smith queen (syntype) in lateral view of mesosoma and petiole.



Figure 42. *P. ruficornis* F. Smith queen (syntype) in lateral view of mesosoma and petiole.



Figure 43. *P. flavicornis* F. Smith queen in lateral view of mesosoma and petiole.



Figure 44. *P. varicolor* Viehmeyer queen in lateral view of mesosoma and petiole.

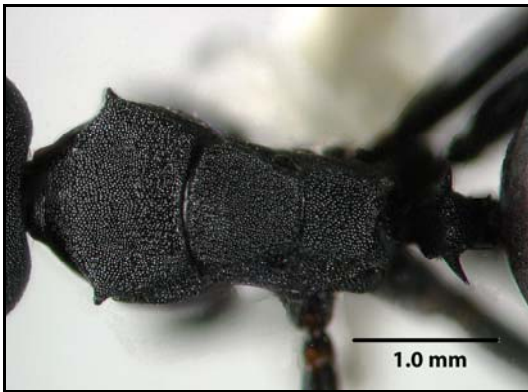


Figure 45. *P. antedoridens* sp. nov. worker in dorsal view of mesosoma and petiole.

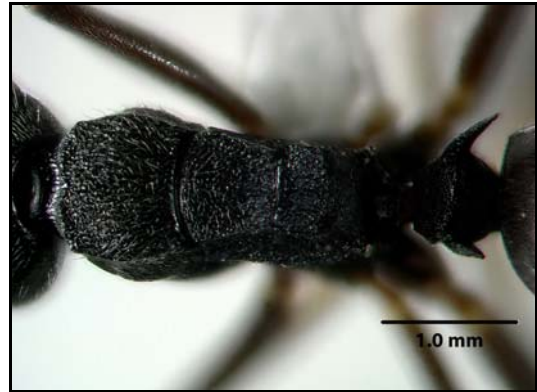


Figure 46. *P. constructor* F. Smith worker in dorsal view of mesosoma and petiole.



Figure 47. *P. elii* Emery worker (syntype) in dorsal view of mesosoma and petiole.

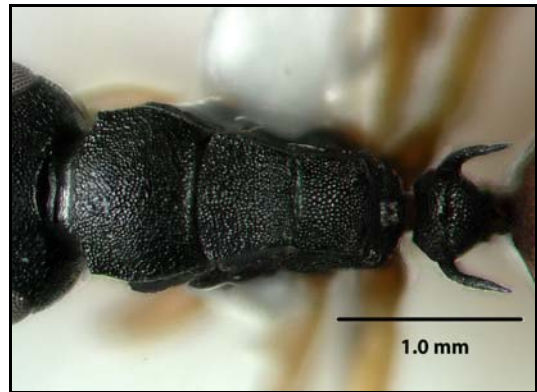


Figure 48. *P. flavicornis* F. Smith worker in dorsal view of mesosoma and petiole.

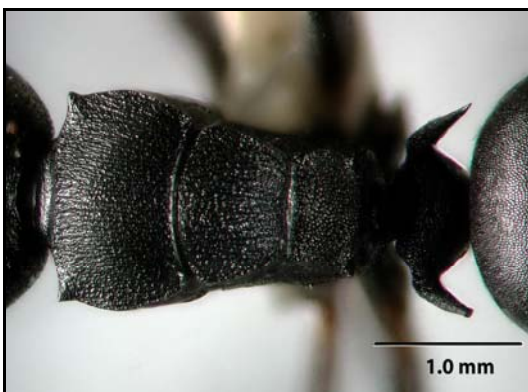


Figure 49. *P. kohouti* sp. nov. worker in dorsal view of mesosoma and petiole.

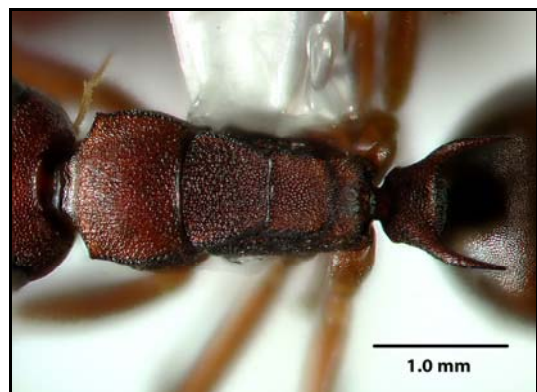


Figure 50. *P. varicolor* Viehmeyer worker in dorsal view of mesosoma and petiole.

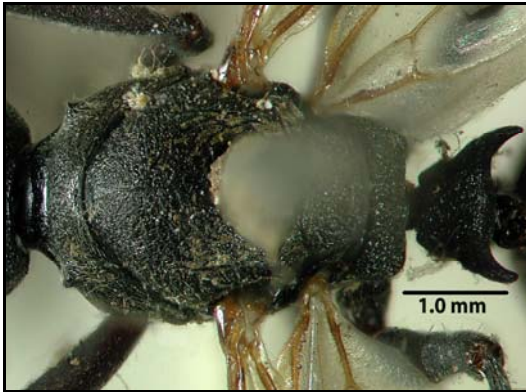


Figure 51. *P. constructor* F. Smith queen (syntype) in dorsal view of mesosoma and petiole.



Figure 52. *P. constructor* F. Smith queen in dorsal view of mesosoma and petiole.

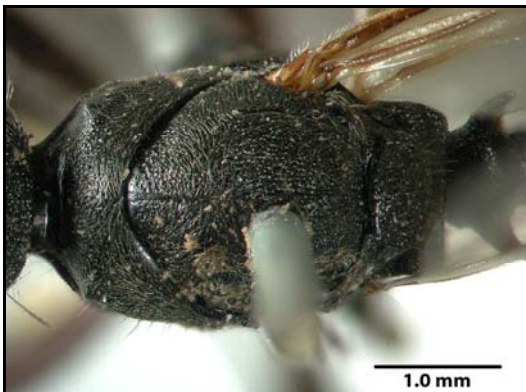


Figure 53. *P. piliventris* F. Smith queen (syntype) in dorsal view of mesosoma and petiole.



Figure 54. *P. ruficornis* F. Smith queen (syntype) in dorsal view of mesosoma and petiole.

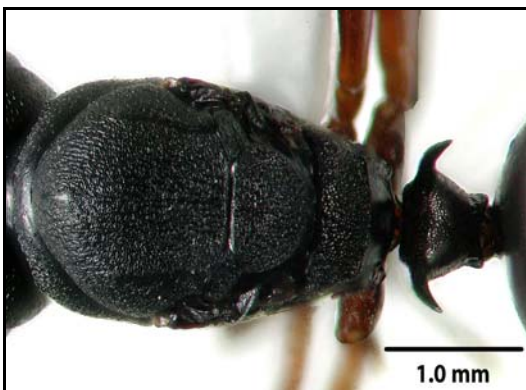


Figure 55. *P. flavicornis* F. Smith queen in dorsal view of mesosoma and petiole.

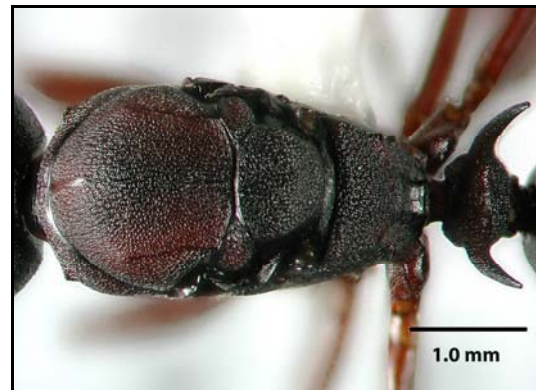


Figure 56. *P. varicolor* Viehmeyer queen in dorsal view of mesosoma and petiole.

***Polyrhachis (Myrmatopa) cnemidata* Emery, stat. nov.**

(Fig. 62-63, 70-71, 77-78, 83-84, 88-89, 93-94, 97, 99, 103-104)

Polyrhachis gracilis var. *cnemidata* Emery, 1900: 710. Type locality: Indonesia, Engago, Kifa juc., v.1891 (E. Modigliani); Indonesia, Mentawai I., Sipora, v-vi.1894 (E. Modigliani) [MCSN] (four syntype workers and one syntype queen examined).

Polyrhachis gracilis Emery: Forel, 1909: 232. Junior synonym of *P. schang* Forel Emery, 1925: 181 (combination in *P. (Myrmatopa)* and variety of *schang*).

Non-type material examined

Indonesia: West Sumatra, Mentawai I., 23.ii.2007, SUO1-SKY-092 (SKY) (workers). **E. Malaysia:** Borneo, Sabah, Danum Valley, xi.1995, canopy fogging, Colony B (E. Widodo) (workers, queens). **S. Thailand:** Yala Prov., Betong, Julaporn 10, 500-600 m, 9.ii.2006, nesting on lower vegetation, 2.40 m above ground, Colony C (NAW) (workers, queen); Satun Prov., Talowow, Tarutao N.P. 0-150 m, 7.iii.2008, nesting on lower vegetation, 2.10 m above ground, Colony D (NAW) (workers); Songkhla Prov., Ton Nga Chang W.S. 100-300 m, 21.iii.2002, canopy fogging (S. Tongjerm) (workers); same loc., 25.iii.2002, canopy fogging (S. Tongjerm) (workers); Phatthalung Prov., Lan Mom Juy Waterfall, Khao Bun Tud W.S. 40-100 m, 4.ix.2004, nesting on lower vegetation, 1.84 m above ground, Colony E (NAW) (workers, queen); Trang Prov., Pak Jam Waterfall 100-200 m, 8.xi.2005, nesting on lower vegetation, 2.00 m above ground, Colony F (NAW) (workers, queen); Nakhon Si Thammarat Prov., Khao Nun N.P., Papra 200-400 m, 14.iii.2007, nesting on lower vegetation, 1.90 m above ground, Colony G (NAW) (workers, queen); same loc., 10.xi.2007, nesting on lower vegetation, 1.57 m above ground, Colony H (NAW) (workers); Surat Thani Prov., inner mainland, Klong Sang W.S. 100-300 m, 1.v.1994, canopy fogging (L. Lebel) (workers); Surat Thani Prov., Khao Sok N.P. 50-100 m, 11.iii.2006, nesting on lower vegetation, 2.50 m above ground, Colony I (NAW) (workers, queen); Prajuab Khiri Khan Prov., Ka Oon Waterfall 100-

200 m, 9.ii.2007, nesting on lower vegetation, 2.8 m above ground, Colony J (NAW) (workers, queens); same loc., 10.ii.2007, nesting on lower vegetation, 2.50 m above ground, Colony K (NAW) (workers, queen).

Worker measurements (syntypes cited first)

HW 1.10-1.30, 1.07-1.27; HL 1.43-1.57, 1.20-1.63; SL 2.17-2.67, 2.20-2.67; CI 70.21-86.67, 74.42-88.89; SI 166.67-242.42, 191.89-225.71; PrW 0.93-1.10, 0.90-1.17; MPL 1.40-1.80, 1.33-1.67; MTL 2.43-2.90, 2.43-2.93; MTI 187.18-263.64, 200.00-245.71; PL 0.37-0.47, 0.40-0.53; PH 0.30-0.33, 0.20-0.37; PW 0.33-0.37, 0.27-0.40; PI 81.82-100.00, 72.73-100.00; PLI 122.22-140.00, 133.33-216.67 (4 syntypes and 29 non-type workers measured).

Worker description

Medium-sized species. Head distinctly elongate with occipital corners of head slightly convex curve to the occipital margin, its posterior margin almost straight in full-face view. Clypeus convex in lateral view; anterior extremity of clypeus with a pair of short teeth that are rather broadly separated. Frontal carina well elevated and weakly sinuate in full-face view. Antennal scape long, extending beyond the posterior margin of head by at least half of its length. Eye convex, slightly protruding from the lateral outline of head. Pronotum in dorsal view convex and slightly narrowed posteriorly, unarmed with anterolateral teeth. Pronotum laterally not marginate; mesonotum and propodeum weakly marginate laterally. Mesonotum distinctly higher than propodeum, with a distinct posterior slope which is as long as flat dorsal portion. Propodeal dorsum slightly sloping; propodeal spine small-sized, directed upward. Petiolar spines seen from back much more parallel, in lateral view directed backwards, as longer than the height of petiole. Petiole in lateral view with anterodorsal margin of petiole rounded; anterior slope distinctly convex, while posterior slope slightly convex. Subpetiolar process low, with posteroventral corner round.

Mandible very finely superficially microsculptured, scattered over the surface and shining. Head and dorsa of mesosoma with superficial sparse punctures and other irregular sculpture, and shining; clypeus and frontal lobe with superficially dense microsculptured and weakly shining. Sides of pronotum and petiole striato-reticulate and weakly shining. Mesopleuron and sides of propodeum closely puncto-reticulate and shining. Antenna densely microsculptured and dull. Gaster densely microsculptured and shining. Legs densely microsculptured and dull.

Antennal scape and flagellum with very fine sparse pubescence. Clypeus, frontal lobe, mandible, coxae, trochanters, femora below, petiolar pedicel above and below, subpetiolar process posteriorly with a few yellow standing hairs. Gaster ventrally with some yellow standing hairs and sparse pubescence. Pubescence on head, clypeus, frontal lobe, mandible, dorsa and sides of pronotum and gastral tergites minute and sparse.

Mandible light orangish brown. Head, antennal scape and flagellum, mesosoma, legs, petiole and gaster light to dark orangish brown.

Queen measurements (syntype cited first)

HW 1.33, 0.90-1.27; HL 1.63, 1.53-1.73; SL 2.70, 2.33-2.73; CI 81.63, 51.92-82.61; SI 202.50, 194.44-281.48; PrW 1.60, 1.40-1.50; MPL 2.03, 1.90-2.00; MTL 2.93, 2.33-2.87; MTI 220.00, 194.44-300.00; PL 0.60, 0.50-0.60; PH 0.30, 0.30-0.37; PW 0.47, 0.37-0.50; PI 64.29, 69.23-90.91; PLI 200.00, 145.45-188.89 (1 syntype and 7 non-type queens measured).

Queen description

Similar to workers in structure, but propodeal dorsum in lateral view distinctly shorter than declivity and propodeal spine reduced. Petiolar spine in lateral view stout and curved backward, as long as the height of petiole.

Body sculpture similar to that in workers.

Similar to workers in pilosity, but dorsa of mesoscutum and mesoscutellum with to without a few yellow standing hairs.

Similar to workers in coloration.

Discussion

P. cnemidata workers are closely similar to *P. dolomedes*, in its mesonotum in lateral view strongly elevated in the middle. However, this species can be separated from the latter by the combination of the following conditions: petiolar spine in lateral view more vertical and longer than the height of petiole, and the length of metatibia are longer than *P. dolomedes* (MTL >2.40).

Distribution

P. cnemidata is widely distributed from West Sumatra, Borneo and Peninsular Thailand (Fig. 57). In Peninsular Thailand, nests have been found on the lower vegetation and some specimens were found among the fogging samples from the lowland rain forest.

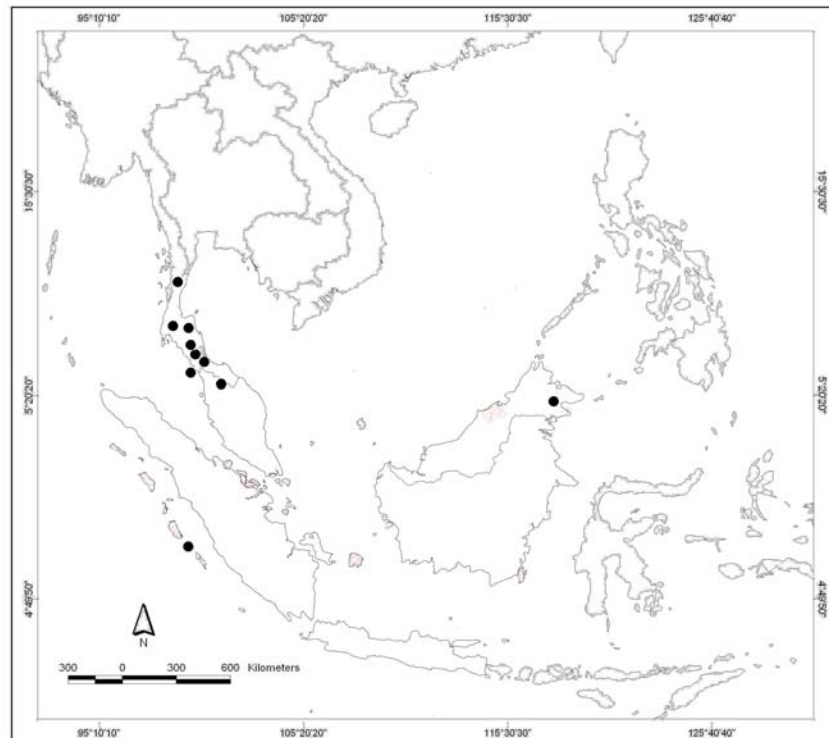


Figure 57. Distribution of *P. cnemidata* Emery

(modified from the Southern Remote Sensing GIS Center, Prince of Songkla University, 2008).

***Polyrhachis (Myrmatopa) dolomedes* F. Smith**

(Fig. 64, 72, 79, 85, 90, 95, 98, 105)

Polyrhachis dolomedes F. Smith, 1863: 14. Type locality: Indonesia, Seram I. (A. R. Wallace) [BHNH, OXUM] (two syntype workers and one syntype queen examined).

Polyrhachis dolomedes F. Smith: Donisthorpe, 1932: 469 (combination in *P. (Myrmatopa)*).

Syntype worker measurements

HW 1.03-1.13, HL 1.20-1.40, SL 2.03-2.17, CI 73.81-94.44, SI 191.18-196.77, PrW 0.90-0.97, MPL 1.10-1.43, MTL 1.77-2.17, MTI 170.97-191.18, PL 0.37-0.40, PH 0.30, PW 0.33, PI 90.00, PLI 122.22-133.33 (2 syntypes measured).

Worker description

Medium-sized species. Head slightly elongate with occipital corners of head distinctly convex curve to the occipital margin, its posterior margin almost straight in full-face view. Clypeus convex in lateral view; anterior extremity of clypeus with a pair of short teeth that are rather broadly separated. Frontal carina well elevated and weakly sinuate in full-face view. Antennal scape long, extending beyond the posterior margin of head by at least half its length. Eye convex, slightly protruding from the lateral outline of head. Pronotum in dorsal view convex and slightly narrowed posteriorly, unarmed with anterolateral teeth. Pronotum laterally not marginate; mesonotum and propodeum weakly marginate laterally. Mesonotum distinctly higher than propodeum, with a distinct posterior slope which is as long as flat dorsal portion. Propodeal dorsum slightly sloping; propodeal spine small-sized, directed upward. Petiolar spines seen from back much more parallel, in lateral view directed backwards, as long as the height of petiole. Petiole in lateral view with anterodorsal margin of petiole rounded; anterior slope distinctly convex, while posterior slope slightly convex. Subpetiolar process low, with posteroventral corner round.

Mandible very finely superficially microsculptured, scattered over the surface and shining. Head, side of pronotum, dorsa of mesosoma, and petiole with superficial sparse punctures and other irregular sculpture, and weakly shining; clypeus and frontal lobe with superficially dense microsculptured and weakly shining. Mesopleuron and sides of propodeum closely puncto-reticulate and weakly shining. Antenna densely microsculptured and dull. Gaster densely microsculptured and shining. Legs densely microsculptured and shining.

Antennal scape and flagellum with very fine sparse pubescence. Clypeus, frontal lobe, mandible, coxae, trochanters, femora below, petiolar pedicel

below, subpetiolar process posteriorly with a few yellow standing hairs. Gaster ventrally with some yellow standing hairs and sparse pubescence. Pubescence on head, clypeus, frontal lobe, mandible, dorsa and sides of pronotum and gastral tergites minute and sparse.

Mandible, antennal scape and flagellum, legs and gaster light redish brown to brown. Head, mesosoma and petiole dark brown to black.

Syntype queen measurements

HW 1.33, HL 1.63, SL 2.50, CI 81.63, SI 187.50, PrW 1.50, MPL 1.97, MTL 2.53, MTI 190.00, PL 0.43, PH 0.37, PW 0.50, PI 73.33, PLI 118.18 (1 syntype measured).

Queen description

Similar to workers in structure, but propodeal dorsum in lateral view distinctly shorter than declivity. Petiolar spine in lateral view stout.

Body sculpture similar to that in workers.

Similar to workers in pilosity, but dorsa of mesoscutum and mesoscutellum without a few yellow standing hairs.

Similar to workers in coloration.

Discussion

Workers of this species are closely similar to *P. cnemidata*, but it can be recognised from those of other members of the *schang*-group by the petiolar spine in lateral view directed backwards, as long as the height of petiole.

Distribution

P. dolomedes is known only from the type localities in Seram I., Indonesia (Fig. 58).

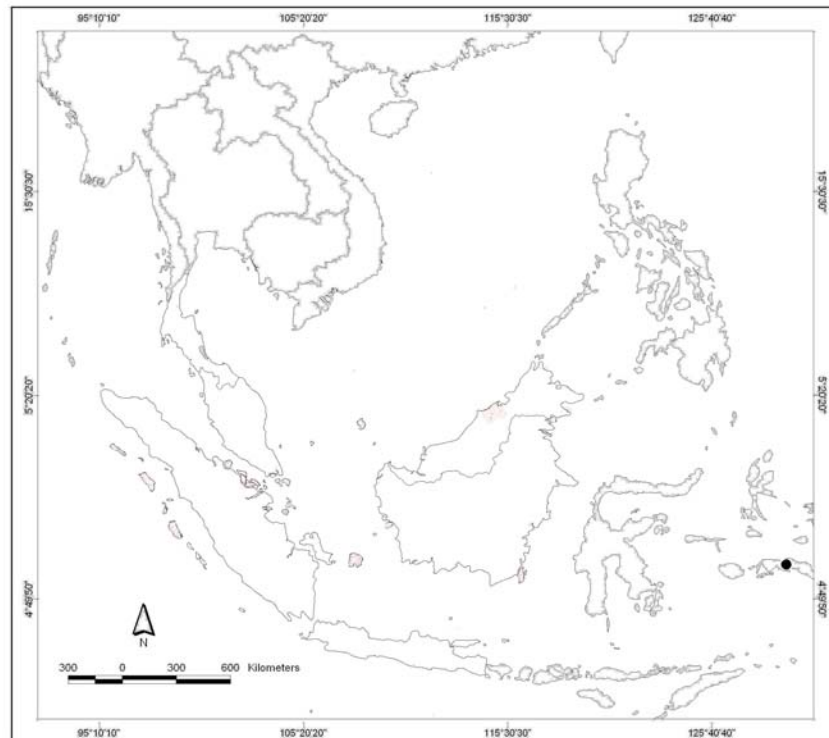


Figure 58. Distribution of *P. dolomedes* F. Smith

(modified from the Southern Remote Sensing GIS Center, Prince of Songkla University, 2008).

***Polyrhachis (Myrmatopa) parvicella* Forel, stat. nov.**

(Fig. 65, 73, 80, 86, 91, 96, 100, 106)

Polyrhachis gracilis var. *parvicella* Forel, 1911: 214. Type locality: Indonesia, Java, Goenoeng Oengaran, x.1909 (E. Jacobson) [MHNG] (two syntype workers and one queen stntype examined). Emery, 1925; Karavaiev, 1927: 11 (combination in *P. (Myrmatopa)* and variety of *schang*).

Syntype worker measurements

HW 1.03-1.07, HL 1.37-1.50, SL 2.03-2.10, CI 71.11-75.61, SI 190.63-203.23, PrW 0.87-1.00, MPL 1.27-1.37, MTL 2.20-2.23, MTI 209.38-212.90, PL 0.40-0.43, PH 0.27, PW 0.27-0.30, PI 88.89-100.00, PLI 150.00-162.50 (2 syntypes measured).

Worker description

Medium-sized species. Head distinctly elongate with occipital corners of head slightly convex curve to the occipital margin, its posterior margin almost straight in full-face view. Clypeus convex in lateral view; anterior extremity of clypeus with a pair of teeth which are distantly located from each other. Frontal carina well elevated and weakly sinuate in full-face view. Antennal scape long, extending beyond the posterior margin of head by at least half its length. Eye convex, slightly protruding from the lateral outline of head. Pronotum in dorsal view convex and slightly narrowed posteriorly, unarmed with anterolateral teeth. Pronotum laterally not marginate; mesonotum and propodeum weakly marginate laterally. Mesonotum in lateral view only moderately elevated at the middle; slightly higher than propodeum; with a distinct posterior slope which is as long as flat dorsal portion. Propodeal dorsum slightly sloping; propodeal spine small-sized, directed upward. Petiolar spines seen from back strongly divergent, in lateral view directed backwards, as longer than the height of petiole. Petiole in lateral view with anterodorsal margin of petiole rounded; anterior slope distinctly convex, while posterior slope slightly convex. Subpetiolar process low, with posteroventral corner round.

Mandible very finely superficially microsculptured, scattered over the surface and shining. Head and dorsa of mesosoma with superficial sparse punctures and other irregular sculpture, and shining; clypeus and frontal lobe with superficially dense microsculptured and weakly shining. Sides of pronotum and petiole striato-reticulate and weakly shining. Mesopleuron and sides of propodeum closely puncto-reticulate and shining. Antenna densely microsculptured and dull. Gaster densely microsculptured and shining. Legs densely microsculptured and dull.

Antennal scape and flagellum with very fine sparse pubescence. Clypeus, frontal lobe, mandible, coxae, trochanters, femora below, petiolar pedicel above and below, subpetiolar process posteriorly and gastral tergites with a few yellow standing hairs. Gaster ventrally with some yellow standing hairs and sparse pubescence. Pubescence on head, clypeus, frontal lobe, mandible, dorsa and sides of pronotum and gastral tergites minute and sparse.

Mandible, fron, clypeus, antennal scape and flagellum, light orangish brown to brown. Head, mesosoma, legs, petiole, and gaster light to dark reddish brown.

Syntype queen measurements

HW 1.50, HL 1.97, SL 2.87, CI 76.27, SI 191.11, PrW 1.73, MPL 2.37, MTL 3.07, MTI 204.44, PL 0.60, PH 0.40, PW 0.30, PI 133.33, PLI 150.00 (1 syntype measured).

Queen description

Similar to workers in structure, but propodeal dorsum in lateral view distinctly shorter than declivity. Petiolar spine in lateral view stout.

Body sculpture similar to that in workers.

Similar to workers in pilosity, but dorsa of mesoscutellum with a few yellow standing hairs.

Similar to workers in coloration.

Discussion

In the worker this species bears some similarity to *P. solmsi*, especially with respect to the moderately elevated in the middle of mesonotum, but differs from the latter in its head behind eyes more strongly elongate and narrowed posteriorly with the sides straight.

Distribution

P. parvicella is known only from the type locality in Java, Indonesia (Fig. 59).

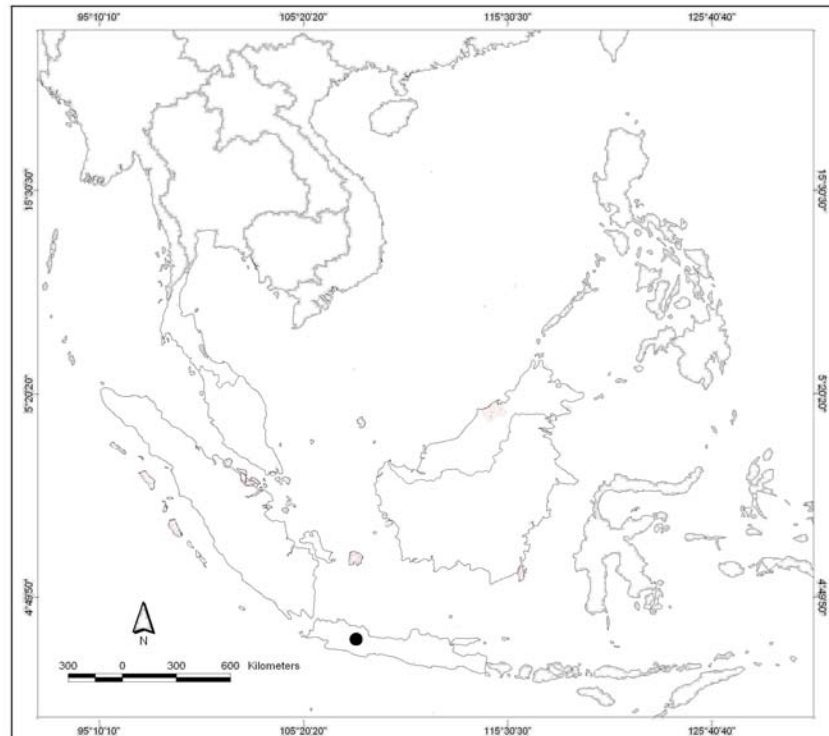


Figure 59. Distribution of *P. parvicella* Forel

(modified from the Southern Remote Sensing GIS Center, Prince of Songkla University, 2008).

***Polyrhachis (Myrmatopa) solmsi* Emery**

(Fig. 66, 67, 74-76, 81, 87, 92, 101)

Polyrhachis solmsi Emery, 1887: 224 (footnote), pl. 3, fig. 12. Type locality: Indonesia, Java, Buitenzorg (Bogor), 1884 (Conte Solms Laubach) [MCSN] (two syntype workers and three syntype queens examined). Emery, 1925: 181 (combination in *P. (Myrmatopa)*).

Polyrhachis solmsi Emery; Santschi, 1928: 247.

Non-type material examined

Indonesia: West Java, Bogor Botanical Garden, 19.ix.2004, JVO4-SKY-60 (SKY) (workers, queen); same loc., xii.1990, Colony B (F. Ito) (workers, queen); West Java, Kebun Raya, Bogor, xii.1990, Colony C (F. Ito) (worker).

Worker measurements (syntypes cited first)

HW 1.33-1.40, 1.23-1.37; HL 1.80-1.83, 1.33-1.77; SL 2.50-2.73, 2.33-2.57; CI 72.73-77.78, 71.15-92.50; SI 187.50-195.24, 184.21-202.70; PrW 1.10-1.27, 1.07-1.23; MPL 1.80-1.83, 1.53-1.77; MTL 2.70-2.93, 2.50-2.73; MTI 202.50-209.52, 192.31-210.81; PL 0.57-0.60, 0.50-0.60; PH 0.33, 0.30-0.33; PW 0.43-0.50, 0.33-0.53; PI 66.67-76.92, 56.25-100.00; PLI 170.00-180.00, 150.00-200.00 (2 syntypes and 20 non-type workers measured).

Worker description

Medium-sized species. Head slightly elongate with occipital corners of head distinctly convex curve to the occipital margin, its posterior margin almost straight in full-face view. Clypeus convex in lateral view; anterior extremity of clypeus with a pair of teeth which are distantly located from each other. Frontal carina well elevated and weakly sinuate in full-face view. Antennal scape long, extending beyond the posterior margin of head by at least half its length. Eye convex, slightly

protruding from the lateral outline of head. Pronotum in dorsal view convex and slightly narrowed posteriorly, unarmed with anterolateral teeth. Pronotum laterally not marginate; mesonotum and propodeum weakly marginate laterally. Mesonotum in lateral view only moderately elevated at the middle; slightly higher than propodeum; with a distinct posterior slope which is as long as flat dorsal portion. Propodeal dorsum slightly sloping; propodeal spine small-sized, directed upward. Petiolar spines seen from back strongly divergent, in lateral view directed backwards, as longer than the height of petiole. Petiole in lateral view with anterodorsal margin of petiole rounded; anterior slope distinctly convex, while posterior slope slightly convex. Subpetiolar process low, with posteroventral corner round.

Mandible very finely superficially microsculptured, scattered over the surface and shining. Head and dorsa of mesosoma with superficial sparse punctures and other irregular sculpture, and shining; clypeus and frontal lobe with superficially dense microsculptured and weakly shining. Sides of pronotum and petiole striato-reticulate and weakly shining. Mesopleuron and sides of propodeum closely puncto-reticulate and shining. Antenna densely microsculptured and dull. Gaster densely microsculptured and shining. Legs densely microsculptured and dull.

Antennal scape and flagellum with very fine sparse pubescence. Clypeus, frontal lobe, mandible, coxae, trochanters, femora below, petiolar pedicel above and below, subpetiolar process posteriorly and gastral tergites with a few yellow standing hairs. Gaster ventrally with some yellow standing hairs and sparse pubescence. Pubescence on head, clypeus, frontal lobe, mandible, dorsa and sides of pronotum and gastral tergites minute and sparse.

Antennal scape and flagellum, head, clypeus, mandible, mesosoma, legs, petiole light to dark reddish brown. Gaster light reddish brown to black

Queen measurements (syntypes cited first)

HW 1.37-1.50, 1.40-1.47; HL 1.87-2.03, 1.87-2.00; SL 2.73-2.90, 2.80-2.90; CI 68.33-80.36, 70.00-78.57; SI 193.33-200.00, 190.91-207.14; PrW 1.63-1.77, 1.70-1.73; MPL 2.23-2.43, 2.33; MTL 2.93-3.00, 3.03; MTI 200.00-214.63, 206.82-216.67; PL 0.63-0.67, 0.60-0.63; PH 0.37-0.47, 0.43; PW 0.57-0.60, 0.57-0.67; PI 64.71-77.78, 65.00-76.47; PLI 142.86-181.82, 146.15-138.46 (3 syntypes and 2 non-type queens measured).

Queen description

Similar to workers in structure, but propodeal dorsum in lateral view distinctly shorter than declivity. Petiolar spine in lateral view stout.

Body sculpture similar to that in workers.

Similar to workers in pilosity, but dorsa of mesoscutellum with a few yellow standing hairs.

Similar to workers in coloration.

Discussion

P. solmsi workers are closely similar to *P. parvicella* but differs from the latter by the combination of the following conditions: head behind eye less elongate and the sides of head slightly convex.

Distribution

P. solmsi is known only from Bogor Botanical Garden, Java, Indonesia (Fig. 60.).

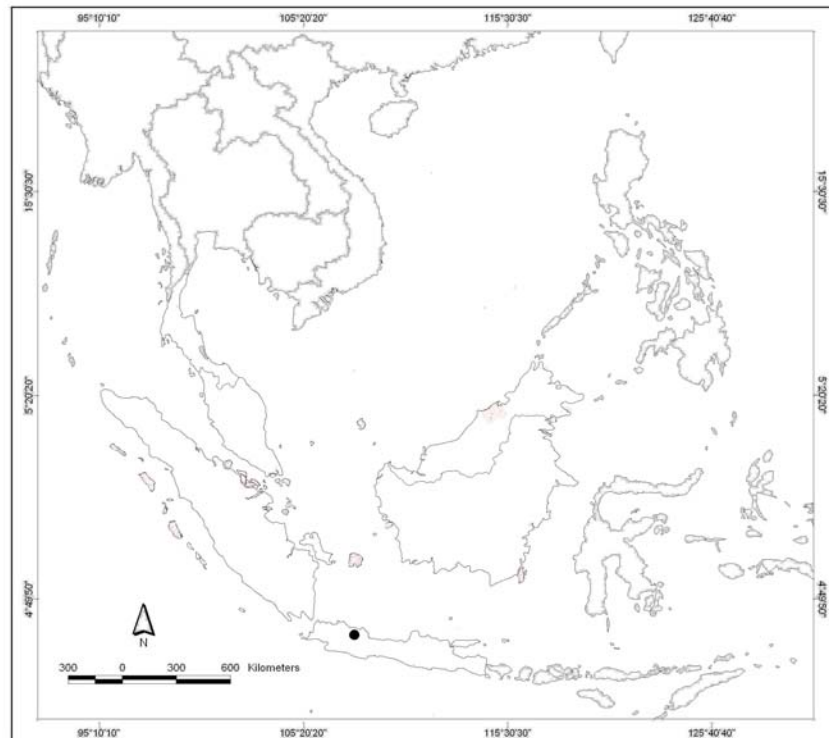


Figure 60. Distribution of *P. solmsi* Emery

(modified from the Southern Remote Sensing GIS Center, Prince of Songkla University, 2008).

***Polyrhachis (Myrmatopa) tawauensis* sp. nov.**

(Fig. 68, 69, 82, 102)

Holotype: worker, E. Malaysia, Borneo, Sabah, Tawau Hills N.P., 7.vii.1996, forest night (Sk. Yamane) (SKYC).

Worker measurements

HW 1.27, HL 1.53, SL 2.00, CI 82.61, SI 157.89, PrW 1.20, MPL 1.70, MTL 1.68, MTI 132.63, PL 0.53, PH 0.33, PW 0.43, PI 76.92, PLI 160.00 (holotype).

Worker description

Medium-sized species. Head slightly elongate with occipital corners of head distinctly convex curve to the occipital margin, its posterior margin almost straight in full-face view. Clypeus convex in lateral view; anterior extremity of clypeus with a median tooth which is bifid apically. Frontal carina well elevated and weakly sinuate in full-face view. Antennal scape long, extending beyond the posterior margin of head by at least half its length. Eye convex, slightly protruding from the lateral outline of head. Pronotum in dorsal view convex and slightly narrowed posteriorly, unarmed with anterolateral teeth. Pronotum laterally not marginate; mesonotum and propodeum weakly marginate laterally. Mesonotum in lateral view strongly elevated at the middle; distinctly higher than propodeum; with a distinct posterior slope which is as long as flat dorsal portion. Propodeal dorsum slightly sloping; propodeal spine small-sized, directed upward. Petiolar spines seen from back strongly divergent, in lateral view directed backwards, as longer than the height of petiole. Petiole in lateral view with anterodorsal margin of petiole rounded; anterior slope distinctly convex, while posterior slope slightly convex. Subpetiolar process low, with posteroventral corner angulate.

Mandible and clypeus almost smooth and shining. Head, frontal lobe, dorsa of mesosoma and petiole with superficial sparse punctures and other irregular sculpture, and shining. Sides of pronotum and petiole striato-reticulate and weakly shining. Mesopleuron and sides of propodeum closely puncto-reticulate and shining. Antenna densely microsculptured and dull. Gaster densely microsculptured and shining. Legs densely microsculptured and dull.

Antennal scape and flagellum with very fine sparse pubescence. Clypeus, frontal lobe, mandible, coxae, trochanters, femora below, petiolar pedicel above and below, subpetiolar process posteriorly and gastral tergites with a few yellow standing hairs. Gaster ventrally with some yellow standing hairs and sparse pubescence. Pubescence on head, clypeus, frontal lobe, mandible, dorsa and sides of pronotum and gastral tergites minute and sparse.

Mandible, clypeus and frontal lobe orangish brown. Posterior and lateral portions of head, antennal scape and flagellum, mesosoma, legs, petiole and gaster light to dark brown.

Etymology

Name after the type locality, Tawau Hills N.P. in Borneo, E. Malaysia.

Discussion

Worker of this species can be distinguished from those of other members of the *schang*-group by the anterior extremity of clypeus with a median tooth which is bifid apically.

Distribution

This species is known only from Tawau Hills N.P., Sabah, Borneo, E. Malaysia (Fig. 61). The type was found from the lower vegetation at the night.

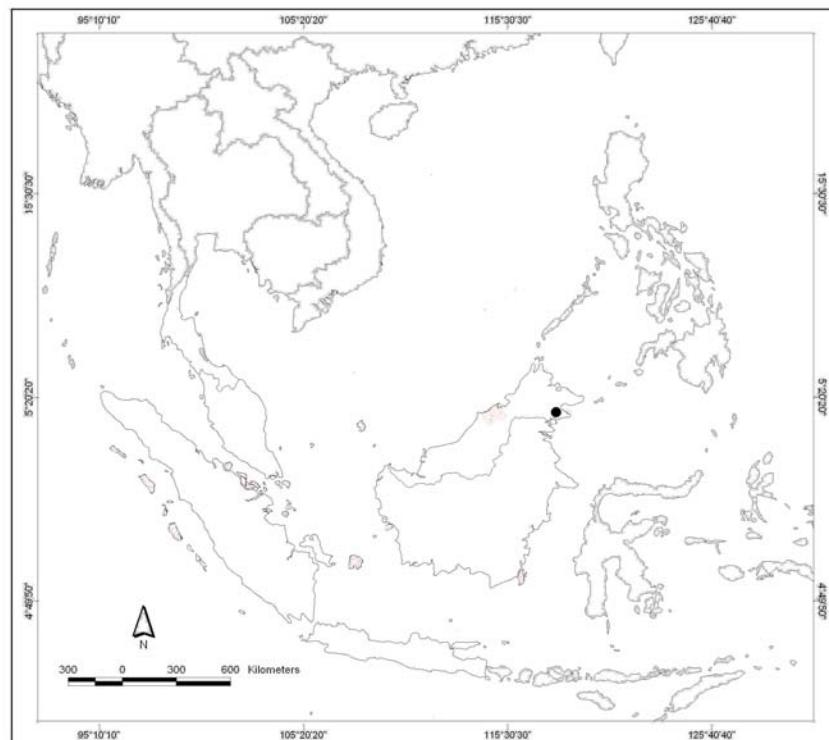


Figure 61. Distribution of *P. tawauensis* sp. nov.

(modified from the Southern Remote Sensing GIS Center, Prince of Songkla University, 2008).

2.3.6.3 *Polyrhachis simillima*-group

Workers of this group can be recognised by the following characteristics: clypeus weakly convex in lateral view. Eye convex, slightly protruding from the lateral outline of head. Antennal scape short, extending beyond the posterior margin of head measuring approximately $2/3$ of its length. Mesosoma laterally marginate throughout. Pronotum in dorsal view convex and slightly narrowed posteriorly, armed with anterolateral teeth. Mesonotum only slightly higher than propodeum. Propodeal dorsum slightly sloping; propodeal spine small-sized, directed upward. Petiolar spines seen from back strongly divergent, distantly from each other; two median denticles small to medium-sized between the petiolar spines. Petiolar spine in lateral view curved backwards and stout, as long as the height of petiole; anterodorsal margin of petiole rounded; anterior slope slightly convex, while posterior slope slightly straight.



Figure 62. *P. cnemidata* Emery worker (syntype) in lateral view of hole body.



Figure 63. *P. cnemidata* Emery worker in lateral view of hole body.

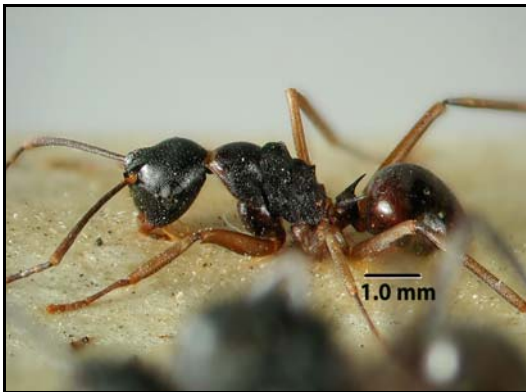


Figure 64. *P. dolomedes* F. Smith worker (syntype) in lateral view of hole body.

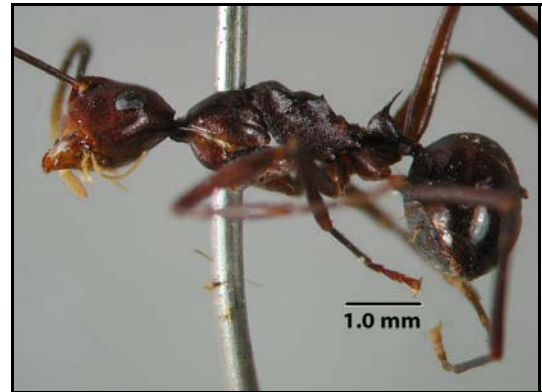


Figure 65. *P. parvicella* Forel worker (syntype) in lateral view of hole body.



Figure 66. *P. solmsi* Emery worker (syntype) in lateral view of hole body.



Figure 67. *P. solmsi* Emery worker in lateral view of hole body.



Figure 68. *P. tawauensis* sp. nov. worker in lateral view of head and mesosoma.



Figure 69. *P. tawauensis* sp. nov. worker in lateral view of petiole and gaster.



Figure 70. *P. cnemidata* Emery queen (syntype) in lateral view of hole body.



Figure 71. *P. cnemidata* Emery queen in lateral view of hole body.



Figure 72. *P. dolomedes* F. Smith queen (syntype) in lateral view of hole body.



Figure 73. *P. parvicella* Forel queen (syntype) in lateral view of hole body.



Figure 74. *P. solmsi* Emery queen (syntype) in lateral view of whole body.



Figure 75. *P. solmsi* Emery queen in lateral view of head and mesosoma.

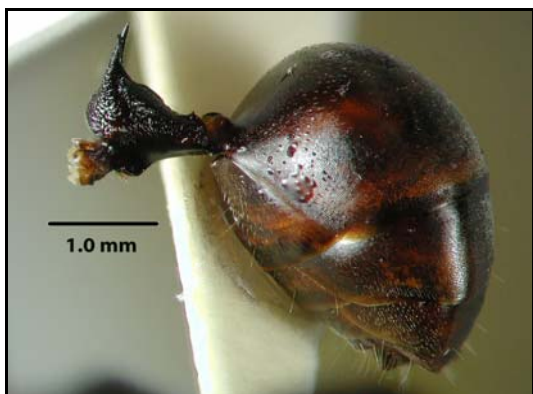


Figure 76. *P. solmsi* Emery queen in lateral view of petiole and gaster.

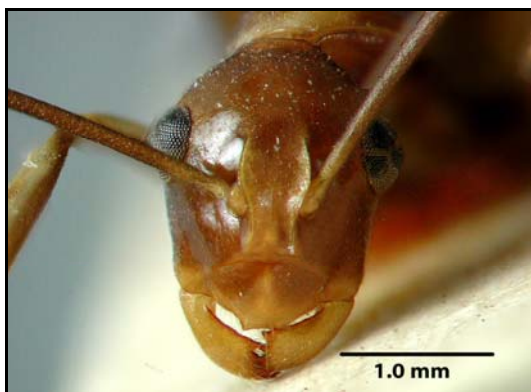


Figure 77. *P. cnemidata* Emery worker (syntype), head in full face view.

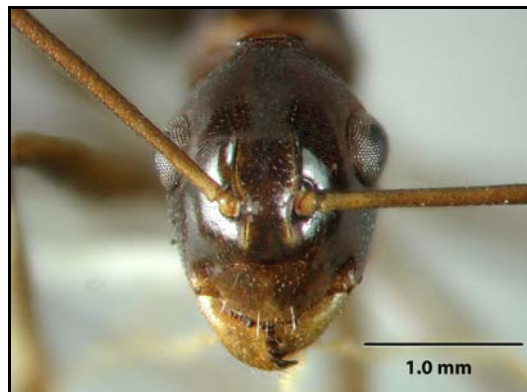


Figure 78. *P. cnemidata* Emery worker, head in full face view.



Figure 79. *P. dolomedes* F. Smith worker (syntype), head in full face view.

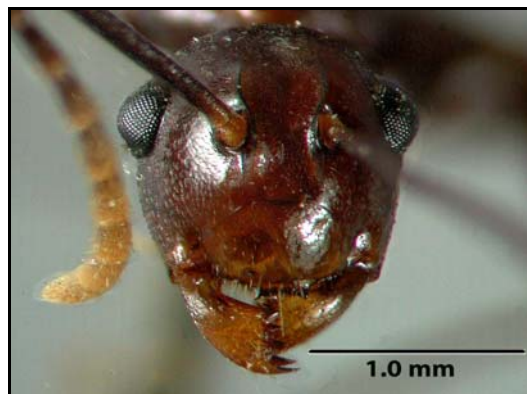


Figure 80. *P. parvicella* Forel worker (syntype), head in full face view.



Figure 81. *P. solmsi* Emery worker, head in full face view.



Figure 82. *P. tawauensis* sp. nov. worker, head in full face view.



Figure 83. *P. cnemidata* Emery queen (syntype), head in full face view.

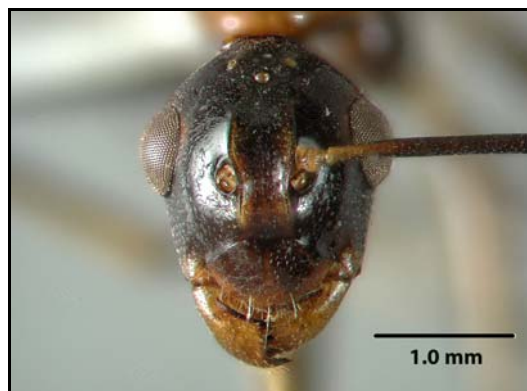


Figure 84. *P. cnemidata* Emery queen, head in full face view.



Figure 85. *P. dolomedes* F. Smith queen (syntype), head in full face view.

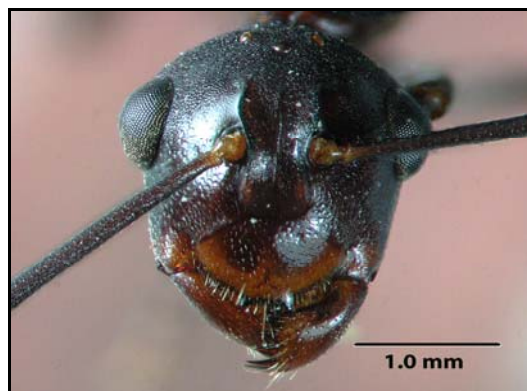


Figure 86. *P. parvicella* Forel queen (syntype), head in full face view.

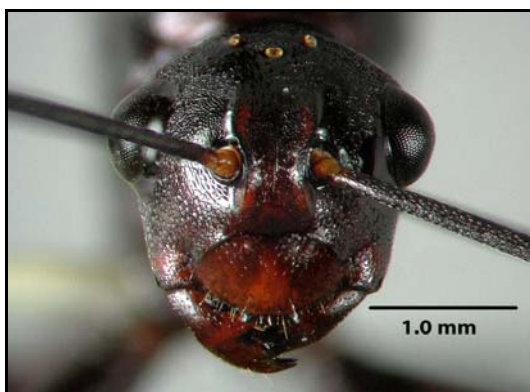


Figure 87. *P. solmsi* Emery queen, head in full face view.



Figure 88. *P. cnemidata* Emery worker (syntype) in lateral view of mesosoma and petiole.



Figure 89. *P. cnemidata* Emery worker in lateral view of mesosoma and petiole.

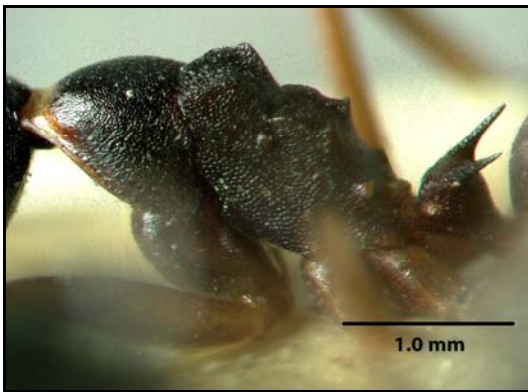


Figure 90. *P. dolomedes* F. Smith worker (syntype) in lateral view of mesosoma and petiole.

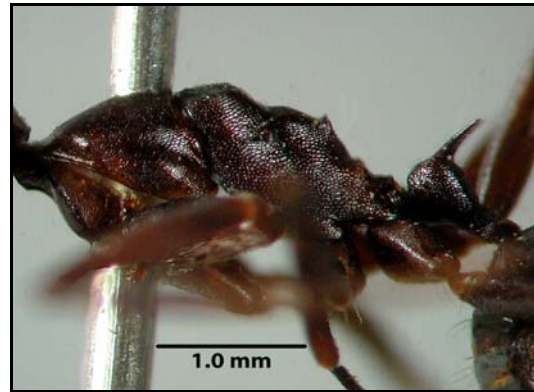


Figure 91. *P. parvicella* Forel worker (syntype) in lateral view of mesosoma and petiole.



Figure 92. *P. solmsi* Emery worker in lateral view of mesosoma and petiole.

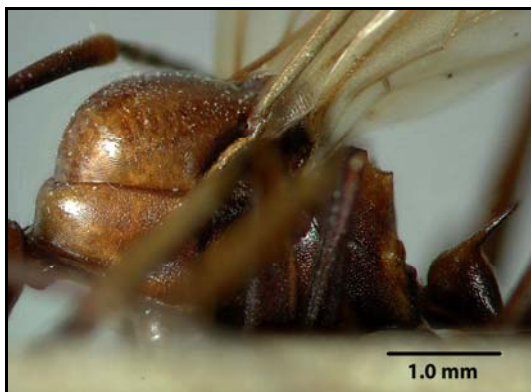


Figure 93. *P. cnemidata* Emery queen (syntype) in lateral view of mesosoma and petiole.



Figure 94. *P. cnemidata* Emery queen in lateral view of mesosoma and petiole.



Figure 95. *P. dolomedes* F. Smith queen (syntype) in lateral view of mesosoma and petiole.



Figure 96. *P. parvicella* Forel queen (syntype) in lateral view of mesosoma and petiole.



Figure 97. *P. cnemidata* Emery worker (syntype) in dorsal view of mesosoma and petiole.



Figure 98. *P. dolomedes* F. Smith worker (syntype) in dorsal view of mesosoma and petiole.

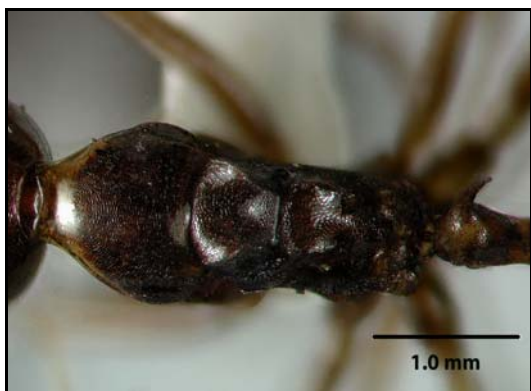


Figure 99. *P. cnemidata* Emery worker in dorsal view of mesosoma and petiole.



Figure 100. *P. parvicella* Forel worker (syntype) in dorsal view of mesosoma and petiole.

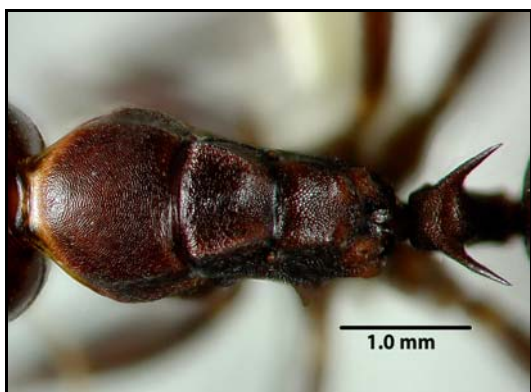


Figure 101. *P. solmsi* Emery worker in dorsal view of mesosoma and petiole.

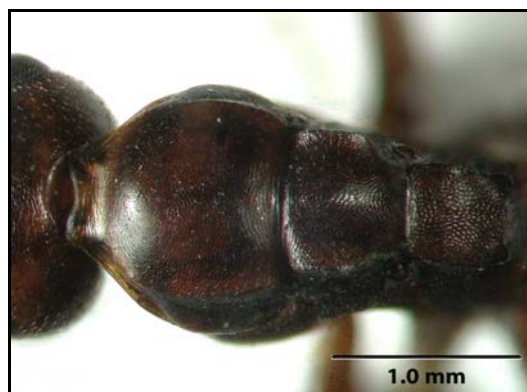


Figure 102. *P. tawauensis* sp. nov. worker in dorsal view of mesosoma and petiole.

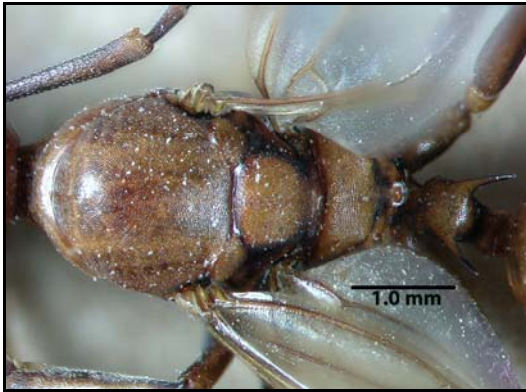


Figure 103. *P. cnemidata* Emery queen (syntype) in dorsal view of mesosoma and petiole.

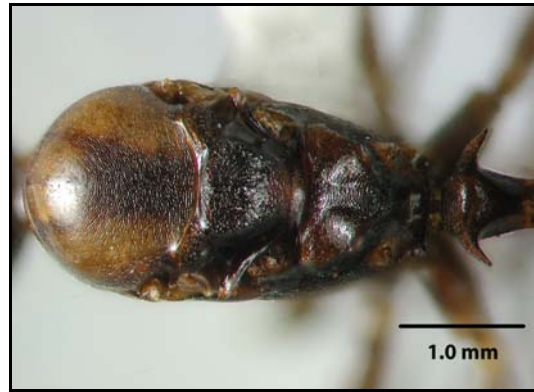


Figure 104. *P. cnemidata* Emery queen, in dorsal view of mesosoma and petiole.

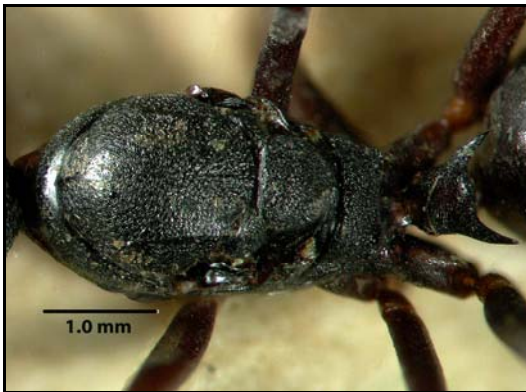


Figure 105. *P. dolomedes* F. Smith queen (syntype) in dorsal view of mesosoma and petiole.

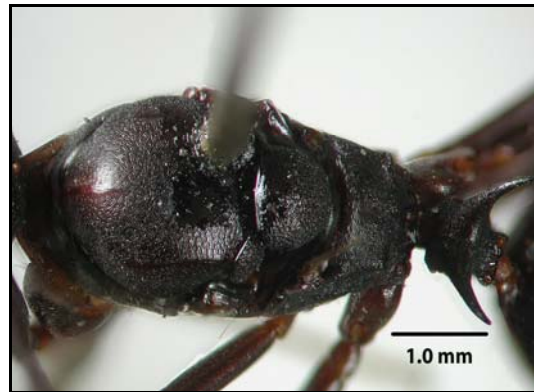


Figure 106. *P. parvicella* Forel queen (syntype) in dorsal view of mesosoma and petiole.

***Polyrhachis (Myrmatopa) angusticlypealis* sp. nov.**

(Fig. 111, 115, 119, 123)

Holotype: worker, E. Malaysia, Borneo, Sabah, Danum Valley 150 m., xii.2002, canopy fogging (E. Widodo & Morimoto Y.) (SKYC).

Worker measurements

HW 1.00, HL 1.17, SL 1.27, CI 85.71, SI 126.67, PrW 0.77, MPL 1.03, MTL 1.20, MTI 120.00, PL 0.30, PH 0.27, PW 0.37, PI 72.73, PLI 112.50 (holotype).

Worker description

Small-sized species, with slightly elongate head. Clypeus weakly convex in lateral view; anterior extremity of clypeus with a pair of short teeth that are rather broadly separated. Frontal carina well elevated and weakly sinuate in full-face view. Antennal scape short, extending beyond the posterior margin of head measuring approximately 2/3 of its length. Eye convex, slightly protruding from the lateral outline of head. Pronotum in dorsal view convex and slightly narrowed posteriorly, armed with anterolateral teeth. Mesosoma laterally distinctly marginate throughout. Mesonotum only slightly higher than propodeum. Propodeal dorsum slightly sloping; propodeal spine small-sized, directed upward. Petiolar spines seen from back strongly divergent, distantly from each other; two median denticles small-sized between the petiolar spines distantly located from each other. Petiolar spine in lateral view curved backwards and stout, as long as the height of petiole; anterodorsal margin of petiole rounded; anterior slope slightly convex, while posterior slope slightly straight. Subpetiolar process low, with posteroventral corner angulate.

Head with sparse and close microsculptured and shining; clypeus with superficially dense microsculptured and shining. Antennae densely microsculptured and dull. Mandible very finely superficially microsculptured, scattered over the surface and shining. Dense and close punctures on dorsa of mesosoma and petiole; dorsa of pronotum longitudinally striate rather than punctate. Sides of mesosome

closely puncto-reticulate and shining. Gaster densely microsculptured and weakly shining. Legs densely microsculptured and shining.

Antennal flagellum with very fine sparse pubescence. Head, frontal lobe, clypeus, mandible, coxae, trochanters, femora below, petiolar pedicel above, subpetiolar process posteriorly with a few yellow standing hairs. Gaster ventrally with some yellow standing hairs and sparse pubescence. Pubescence on head, clypeus, frontal lobe, mandible, and gastral tergites minute and sparse.

Head, mesosoma, coxa and petiole black. Mandible, antennal flagellum, legs excluding coxa reddish brown. Antennal scape and gaster dark brown to black.

Etymology

The name refers to the antero-median portion of clypeus which narrow, approximately less than lateral portion of clypeus.

Discussion

This species is very similar to *P. watanasiti* sp. nov. but can be diagnosed by a suite of worker characteristics: head in full-face view with the antero-median portion of clypeus narrow, approximately less than lateral portion of clypeus. Besides, mandible, antennal scape and flagellum, legs excluding coxa, gaster, more dark reddish brown.

Distribution

This species is known only from Danum Valley, Sabah, Borneo, Malaysia (Fig. 107). The type was found among the fogging samples.

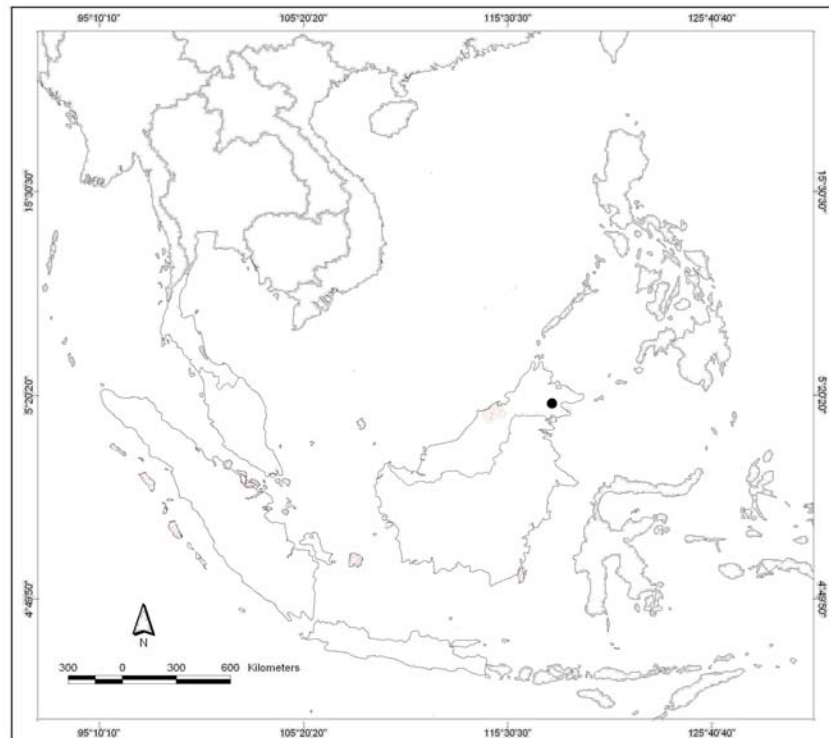


Figure 107. Distribution of *P. angusticlypealis* sp. nov.

(modified from the Southern Remote Sensing GIS Center, Prince of Songkla University, 2008).

***Polyrhachis (Myrmatopa) simillima* Emery**

(Fig. 112, 116, 120, 124)

Polyrhachis simillima Emery, 1900: 711. Type locality: Indonesia, Mentawai I., Sipora, Sereinu, v-vi.1894 (E. Modigliani) [MCSN] (two syntype workers examined). Emery, 1925: 181 (combination in *P. (Myrmatopa)*).

Non-type material examined

S. Thailand: Songkhla Prov., Ton Nga Chang W.S. 100-300 m, 21.x.2002, canopy fogging (S. Tongjerm) (worker).

Worker measurements (syntypes cited first)

HW 1.20-1.25, 1.25; HL 1.50-1.55, 1.50; SL 1.45-1.60, 1.50; CI 77.42-83.33, 83.33; SI 116.00-133.33, 120.00; PrW 1.05, 1.05; MPL 1.10-1.20, 1.35; MTL 1.00-1.53, 1.15; MTI 83.33-122.67, 92.00; PL 0.30-0.40, 0.40; PH 0.25-0.30, 0.35; PW 0.45-0.50, 0.35; PI 50.00-66.67, 100.00; PLI 120.00-133.33, 114.29 (2 syntypes and 1 non-type worker measured).

Worker description

Medium-sized species, with slightly elongate head. Clypeus weakly convex in lateral view; anterior extremity of clypeus with a pair of short teeth that are rather broadly separated. Frontal carina well elevated and weakly sinuate in full-face view. Antennal scape short, extending beyond the posterior margin of head measuring approximately 2/3 of its length. Eye convex, moderately protruding from the lateral outline of head. Pronotum in dorsal view convex and slightly narrowed posteriorly, armed with anterolateral teeth. Mesosoma laterally distinctly marginate throughout. Mesonotum only slightly higher than propodeum. Propodeal dorsum slightly sloping; propodeal spine small-sized, directed upward. Petiolar spines seen from back strongly divergent, distantly from each other; two median denticles medium-sized between the petiolar spines located close to each other. Petiolar spine in lateral view curved backwards and stout, as long as the height of petiole; anterodorsal margin of petiole rounded; anterior slope slightly convex, while posterior slope slightly straight. Subpetiolar process low, with posteroventral corner rounded.

Head with sparse punctures and other irregular sculpture, and shining; clypeus with superficially dense microsculptured and shining. Mandible very finely superficially microsculptured, scattered over the surface and shining. Antennae densely microsculptured and dull. Dense and close punctures on dorsa of mesosoma and petiole; dorsa of mesosoma longitudinally striate rather than punctate. Sides of mesosoma closely puncto-striate and shining. Gaster densely microsculptured and weakly shining. Legs densely microsculptured and shining.

Antennal flagellum with very fine sparse pubescence, without standing hairs except at apical segment; flagellar segment with a few yellow short standing

hairs. Clypeus, frontal lobe, mandible, trochanters, femora below, petiolar pedicel above and below, with a few yellow standing hairs. Gaster ventrally with some yellow standing hairs and sparse pubescence. Pubescence on head, clypeus, frontal lobe, mandible, and gastral tergites minute and sparse.

Whole body brownish black.

Discussion

Workers of this species are closely similar to *P. wihatwitayai* sp. nov., in its medium sized (PrW > 0.90 mm.) and two median denticles between the petiolar spines located close to each other. However, this species can be separated from the latter by the combination of the following conditions: head in full-face view with broader head (HW 1.20-1.25, HL 1.50-1.55, CI 77.42-83.33), the eye convex moderately protruding from the lateral outline of head, and brownish black gaster.

Distribution

P. simillima is known from the type locality in Mentawai I., Indonesia and Peninsular Thailand (Fig. 108). Habitat in Peninsular Thailand which it have been recorded is undisturbed lowland rain forest and specimen was found the among fogging samples.

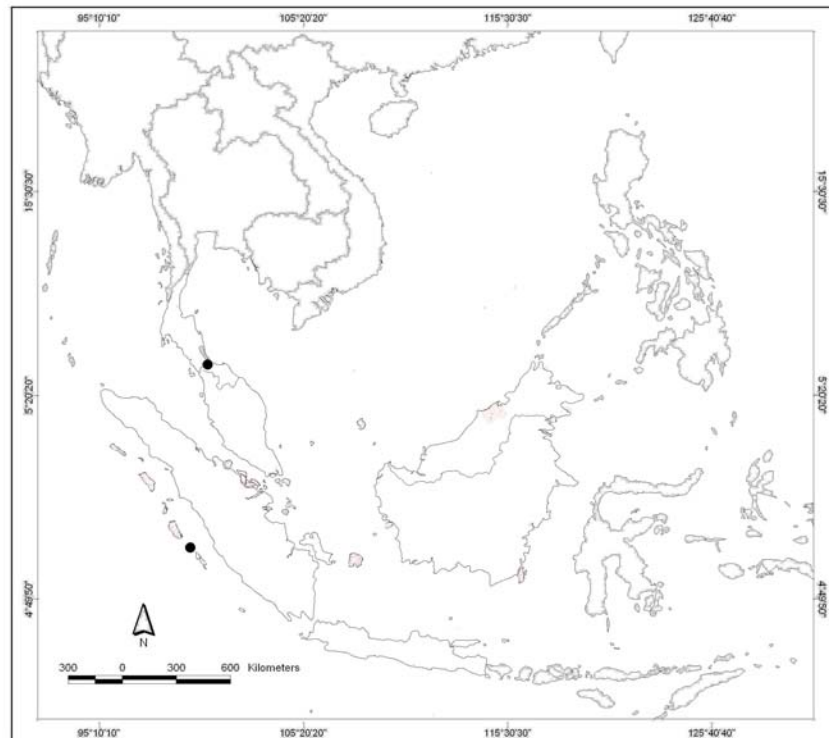


Figure 108. Distribution of *P. simillima* Emery
(modified from the Southern Remote Sensing GIS Center, Prince of Songkla University, 2008).

***Polyrhachis (Myrmatopa) watanasiti* sp. nov.**

(Fig. 113, 117, 121, 125)

Holotype: worker, S. Thailand, Songkhla Prov., Ton Nga Chang W.S. 100-300 m, 25.iii.2002, canopy fogging (S. Tongjerm) (PSNH).

Worker measurements

HW 0.95, HL 1.20, SL 1.35, CI 79.17, SI 142.11, PrW 0.75, MPL 1.05, MTL 0.94, MTI 98.95, PL 0.25, PH 0.25, PW 0.30, PI 83.33, PLI 100.00 (holotype).

Worker description

Small-sized species, with slightly elongate head. Clypeus weakly convex in lateral view; anterior extremity of clypeus with a pair of short teeth that are rather broadly separated. Frontal carina well elevated and weakly sinuate in full-face view. Antennal scape short, extending beyond the posterior margin of head measuring approximately 2/3 of its length. Eye convex, slightly protruding from the lateral outline of head. Pronotum in dorsal view convex and slightly narrowed posteriorly, armed with anterolateral teeth. Mesosoma distinctly marginate throughout laterally. Mesonotum only slightly higher than propodeum. Propodeal dorsum slightly sloping; propodeal spine small-sized, directed upward. Petiolar spines seen from back strongly divergent, distantly from each other; two median denticles small-sized between the petiolar spines, distant to each other. Petiolar spine in lateral view curved backwards and stout, as long as the height of petiole; anterodorsal margin of petiole rounded; anterior slope slightly convex, while posterior slope slightly straight. Subpetiolar process low, with posteroventral corner angulate.

Head with sparse and close microsculptured and shining; clypeus with superficially dense microsculptured and shining. Antennae densely microsculptured and dull. Mandible very finely superficially microsculptured, scattered over the surface and shining. Dense and close punctures on dorsa of mesosoma and petiole; dorsa of pronotum longitudinally striate rather than punctate. Sides of mesosoma closely puncto-reticulate and shining. Gaster densely microsculptured and weakly shining. Legs densely microsculptured and shining.

Antennal flagellum with very fine sparse pubescence. Head, frontal lobe, clypeus, mandible, coxae, trochanters, femora below, petiolar pedicel above and below, subpetiolar process posteriorly with a few yellow standing hairs. Gaster ventrally with some yellow standing hairs and sparse pubescence. Pubescence on head, clypeus, frontal lobe, mandible, and gastral tergites minute and sparse.

Head black. Mandible, antennal scape and flagellum, subpetiolar process, legs, and gaster reddish brown. Mesosoma and petiole black to reddish brown.

Etymology

Name in honour of Assoc. Prof. Suparoek Watanasit, who introduced me to my first step in my studies on taxonomy and ecology of the ants.

Discussion

Worker of this species is closely similar to *P. angusticlypealis* sp. nov., especially with respect to the smaller sized (PrW < 0.90 mm.) and two median denticles between the petiolar spines distantly located from each other. However, this species can be distinguished from the latter by the head in full-face view with the antero-median portion of clypeus broad, approximately as broad as lateral portion of clypeus.

Distribution

This species is known only from Ton Nga Chang W.S., Songkhla Prov., S. Thailand (Fig. 109). The type was found among the fogging samples.

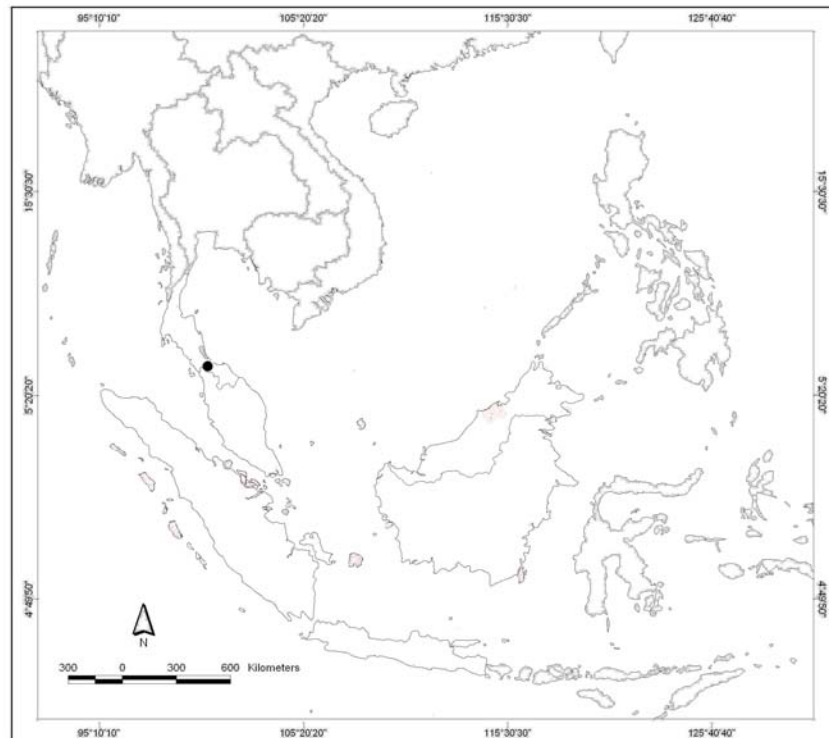


Figure 109. Distribution of *P. watanasiti* sp. nov.

(modified from the Southern Remote Sensing GIS Center, Prince of Songkla University, 2008).

***Polyrhachis (Myrmatopa) wiwatwitayai* sp. nov.**

(Fig. 114, 118, 122, 126)

Holotype: worker, S. Thailand, Songkhla Prov., Ton Nga Chang W.S. 100-300 m, 16.xi.2001, canopy fogging (S. Tongjerm) (PSNH).

Worker measurements

HW 1.15, HL 1.35, SL 1.45, CI 85.19, SI 126.09, PrW 1.00, MPL 1.25, MTL 1.10, MTI 95.65, PL 0.35, PH 0.30, PW 0.45, PI 66.67, PLI 116.67 (holotype).

Worker description

Medium-sized species, with slightly elongate head. Clypeus weakly convex in lateral view; anterior extremity of clypeus with a pair of short teeth that are rather broadly separated. Frontal carina well elevated and weakly sinuate in full-face view. Antennal scape short, extending beyond the posterior margin of head measuring approximately 2/3 of its length. Eye convex, slightly protruding from the lateral outline of head. Pronotum in dorsal view convex and slightly narrowed posteriorly, armed with anterolateral teeth. Mesosoma laterally distinctly marginate throughout. Mesonotum only slightly higher than propodeum. Propodeal dorsum slightly sloping; propodeal spine small-sized, directed upward. Petiolar spines seen from back strongly divergent, distantly from each other; two median denticles medium-sized between the petiolar spines located close to each other. Petiolar spine in lateral view curved backwards and stout, as long as the height of petiole; anterodorsal margin of petiole rounded; anterior slope slightly convex, while posterior slope slightly straight. Subpetiolar process low, with posteroventral corner angulate.

Head with sparse punctures and other irregular sculpture, and shining; clypeus with superficially dense microsculptured and shining. Mandible very finely superficially microsculptured, scattered over the surface and shining. Antennae densely microsculptured and dull. Dense and close punctures on dorsa of mesosoma and petiole; dorsa of pronotum longitudinally striate rather than punctate. Sides of mesosoma closely puncto-reticulate and shining. Gaster densely microsculptured and weakly shining. Legs densely microsculptured and shining.

Antennal flagellum with very fine sparse pubescence, without standing hairs except at apical segment; flagellar segment with a few yellow short standing hairs. Clypeus, frontal lobe, mandible, coxae, trochanters, femora below and petiolar pedicel above, with a few yellow standing hairs. Pubescence on head, clypeus, frontal lobe, and mandible minute and sparse. Gaster ventrally with some yellow standing hairs and sparse pubescence. Pubescence on gastral tergites minute and sparse.

Head black. Mandible, antennal scape and flagellum, legs and gaster reddish brown. Mesosoma and petiole black to reddish brown.

Etymology

Name in honour of Assoc. Prof. Dr. Decha Wiwatwitaya, who introduced me to my second step in my studies on taxonomy and ecology of the ants.

Discussion

In the worker this species is similar to *P. simillima* but differ from the latter by the combination of the following conditions: head in full-face smaller sized with more elongate head (HW 1.15, CI 85.19), eye convex slightly protruding from the lateral outline of head, and reddish brown gaster.

Distribution

This species is known only from Ton Nga Chang W.S., Songkhla Prov., S. Thailand (Fig. 110). The specimen was found among the fogging samples.

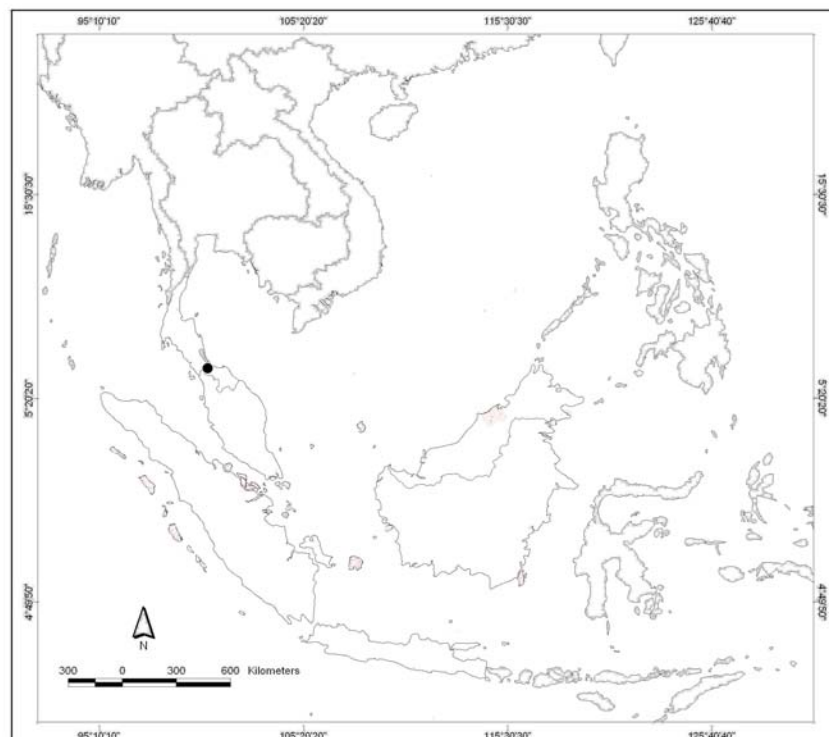


Figure 110. Distribution of *P. wiwatwitayai* sp. nov.

(modified from the Southern Remote Sensing GIS Center, Prince of Songkla University, 2008).



Figure 111. *P. angusticlypealis* sp. nov. worker in lateral view of hole body.



Figure 112. *P. simillima* Emery worker (syntype) in lateral view of hole body.



Figure 113. *P. watanasiti* sp. nov. worker in lateral view of hole body.



Figure 114. *P. wiwatwitayai* sp. nov. worker in lateral view of hole body.

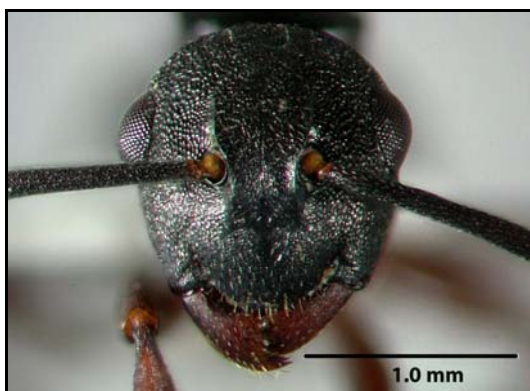


Figure 115. *P. angusticlypealis* sp. nov.
worker, head in full face view.

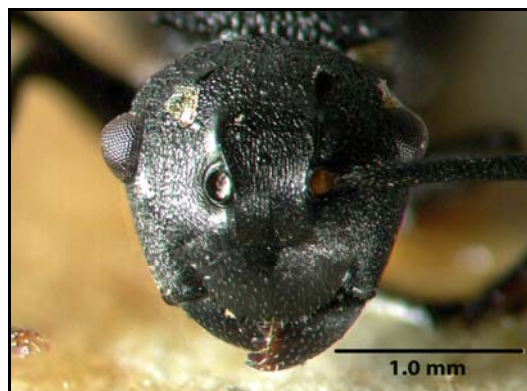


Figure 116. *P. simillima* Emery worker
(syntype), head in full face view.

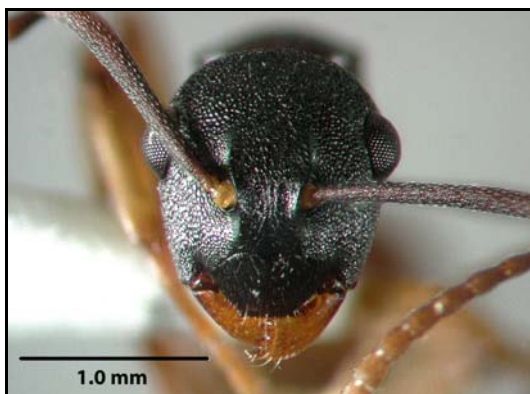


Figure 117. *P. watanasiti* sp. nov.
worker, head in full face view.

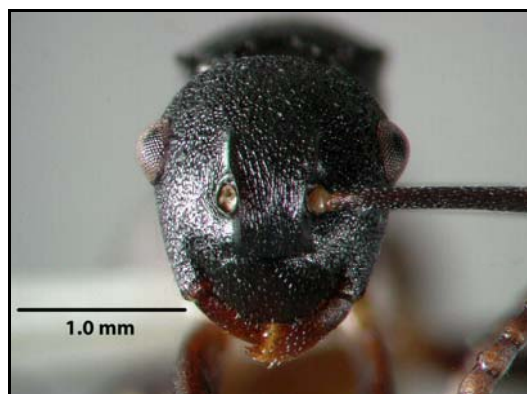


Figure 118. *P. wiwatwitayai* sp. nov.
worker, head in full face view.



Figure 119. *P. angusticlypealis* sp. nov. worker in lateral view of mesosoma and petiole.

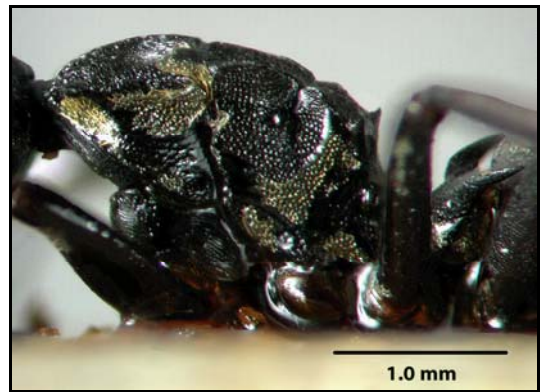


Figure 120. *P. simillima* Emery worker (syntype) in lateral view of mesosoma and petiole.



Figure 121. *P. watanasiti* sp. nov. worker in lateral view of mesosoma and petiole.



Figure 122. *P. wiwatwitayai* sp. nov. worker in lateral view of mesosoma and petiole.

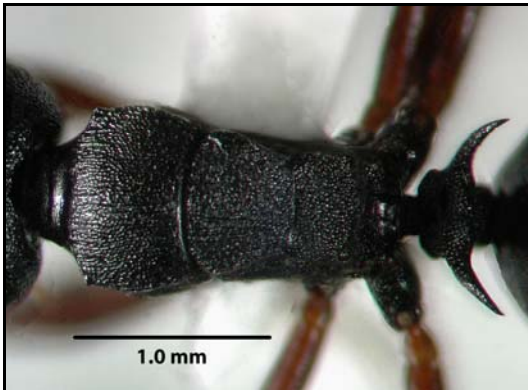


Figure 123. *P. angusticlypealis* sp. nov. worker in dorsal view of mesosoma and petiole.

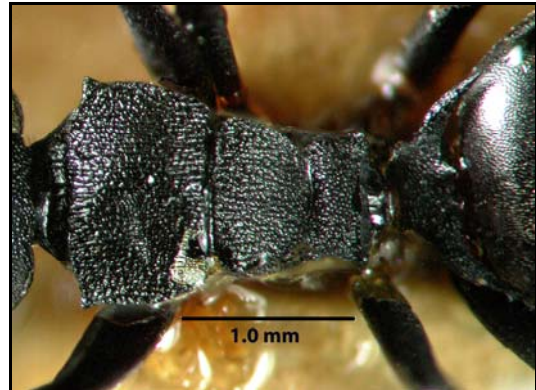


Figure 124. *P. simillima* Emery worker (syntype) in dorsal view of mesosoma and petiole.



Figure 125. *P. watanasiti* sp. nov. worker in dorsal view of mesosoma and petiole.

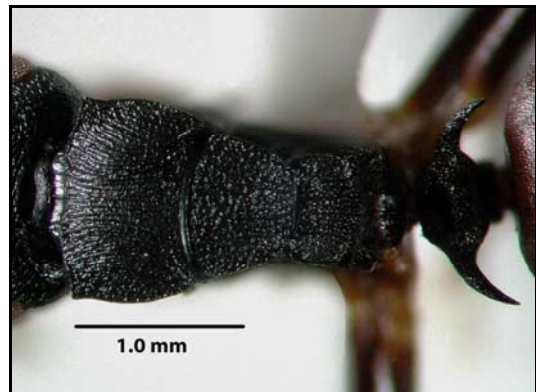


Figure 126. *P. wiwatwitayai* sp. nov. worker in dorsal view of mesosoma and petiole.

2.3.6.4 *Polyrhachis wallacei*-group

Workers of this group can be recognised by the following characteristics: clypeus convex in lateral view. Eye convex, slightly to moderately protruding from the lateral outline of head. Antennal scape long, extending beyond the posterior margin of head by at least half its length. Pronotum laterally not marginate. Pronotum in dorsal view convex and narrowed posteriorly, unarmed with anterolateral teeth. Mesonotum slightly higher than propodeum. Petiole in lateral view with anterior slope almost straight. Petiole with two spines, without denticles between the spines, except in *P. jacobsoni* Forel and *P. subtridens* Emery, in which their petiole provided with one median denticle between the spines. Petiolar spine in lateral view vertical and almost straight.

Polyrhachis (Myrmatopa) jacobsoni Forel

(Fig. 134, 141, 145, 155, 162, 166, 173)

Polyrhachis jacobsoni Forel 1909: 230. Type locality: Indonesia, Java, Wonosobo, 1909 (E. Jacobson) [MHNG] (four syntype workers and one syntype queen examined). Emery, 1925: 181 (combination in *P. (Myrmatopa)*).

Syntype worker measurements

HW 1.10-1.30, HL 1.40-1.60, SL 1.55-1.85, CI 78.57-82.76, SI 137.50-142.31, PrW 0.80-0.90, MPL 1.30-1.50, MTL 1.83-2.07, MTI 158.97-166.67, PL 0.30-0.35, PH 0.20-0.30, PW 0.35-0.40, PI 57.14-75.00, PLI 116.67-150.00 (4 syntypes measured).

Worker description

Medium-sized species. Head relatively broad, narrowed anteriorly, and with convex posterior margin in full-face view. Clypeus convex in lateral view, suddenly raised near its base; anterior extremity of clypeus with a pair of short teeth

that are rather broadly separated; anterior margin between the teeth almost truncate. Frontal carina well elevated and sinuate in full-face view. Antennal scape long, extending beyond the posterior margin of head by at least half its length. Eye convex, slightly protruding from the lateral outline of head. Pronotum in dorsal view convex by distinct angles and slightly narrowed posteriorly, unarmed with anterolateral teeth. Pronotum laterally not marginate; mesonotum and propodeum weakly marginate laterally. Mesonotum slightly higher than propodeum. Propodeal dorsum strongly sloping; propodeal spine medium-sized, directed upward. Petiolar spine seen from back strongly diverging, in lateral view vertical and almost straight, shorter than the height of petiole measuring approximately half the latter. Petiole in lateral view with posterodorsal margin distinctly angulate and provided with one median denticle between the spines; its anterior and posterior slope almost straight. Subpetiolar process low, with posteroventral corner more or less angulate.

Mandible smooth and shining with scattered small macropunctures; its basal most portion superficially microsculptured and dull. Head including clypeus, part of pronotal side, smooth and shining, with superficial sparse punctures and other irregular sculpture. Most of pronotal sides, dorsa of mesosoma, mesopleuron, metapleuron, sides of propodeum and sides of petiole closely puncto-reticulate. Gastral tergites very superficially microsculptured and weakly shining. Legs superficially sculptured and shining.

Antennal flagellum with very fine sparse pubescence, without standing hairs except at apical segment; flagellar segment with many yellow short standing hairs as well as pubescence. Clypeus, frontal lobe, coxae and trochanters, femora below, petiolar pedicel above and below, and gastral tergites posteriorly with a few yellow standing hairs. Head including clypeus with sparse pubescence. Mandible with sparse pubescence and apically with some standing hairs. Gaster ventrally with some yellow standing hairs and sparse pubescence. Pubescence on gastral tergites minute and sparse.

Whole body reddish brown.

Syntype queen measurements

HW 1.40, HL 1.70, SL 2.05, CI 82.35, SI 146.43, PrW 1.50, MPL 1.95, MTL 2.20, MTI 157.14, PL 0.40, PH 0.45, PW 0.55, PI 81.82, PLI 88.89 (1 syntype measured).

Queen description

Similar to workers in structure, but pronotum in dorsal view convex by distinct rounded. Propodeal dorsum in lateral view distinctly shorter than declivity, propodeal spine much reduced. Petiolar spine in lateral view stout and shorter than the height of petiole measuring approximately less than half the latter. Petiole in lateral view with posterodorsal margin distinctly convex and provided with one median denticle medium-sized between the spines.

Body sculpture similar to that in workers, but dorsa of pronotum with a close punctation, lacking striation.

Similar to workers in pilosity, but dorsa of mesoscutum and mesoscutellum with a few yellow standing hairs.

Similar to workers in coloration.

Discussion

In the workers this species is similar to *P. subtridens*, but differ from the latter in its slightly longer petiolar spine and reddish brown whole body. Moreover, the queen of this species can be distinguished from those of other member of the *wallacei*-group by the petiolar spine distinctly shorter than half the petiolar height and the coloration which similar to workers.

Distribution

P. jacobsoni is known only from the type locality in Java, Indonesia (Fig. 127).

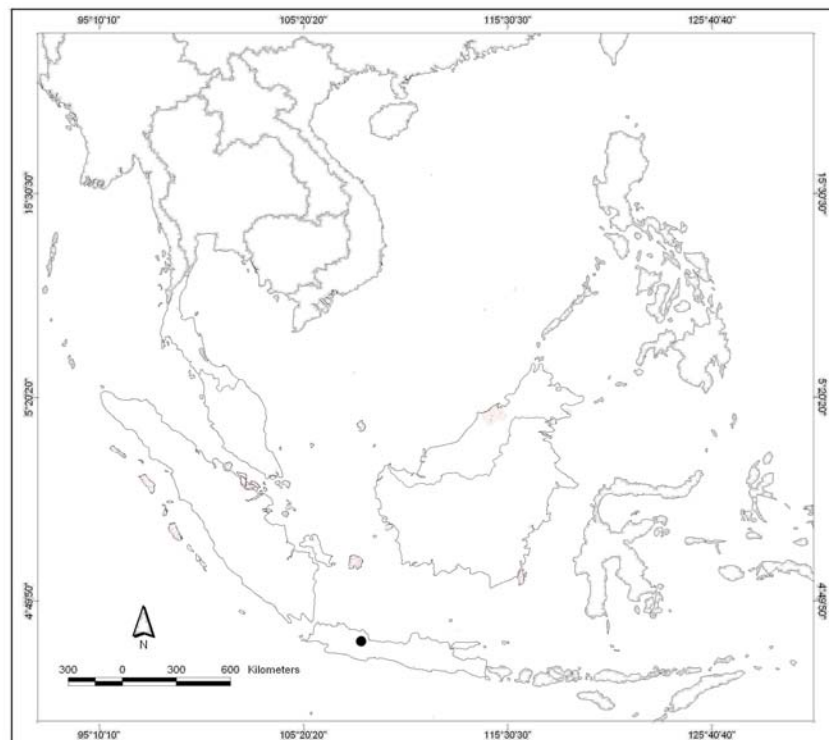


Figure 127. Distribution of *P. jacobsoni* Forel

(modified from the Southern Remote Sensing GIS Center, Prince of Songkla University, 2008).

***Polyrhachis (Myrmatopa) lilianae* Forel**

(Fig. 135, 142, 146, 152, 156, 163, 167, 174)

Polyrhachis lilianae Forel, 1911: 213. Type locality: Indonesia, Java (E. Jacobson) [MHNG] (six syntype workers examined).

Polyrhachis lilianae Forel, 1912: 71. Type locality: Indonesia, Sumatra (Charpillon) [MHNG] (one syntype queen examined). Emery, 1925: 181 (combination in *P. (Myrmatopa)*).

Syntype worker measurements

HW 1.30-1.45, HL 1.50-1.70, SL 1.60-1.85, CI 78.79-90.00, SI 114.29-138.46, PrW 1.05-1.15, MPL 1.50-1.60, MTL 1.90-2.10, MTI 140.74-156.41, PL 0.35, PH 0.30-0.40, PW 0.45-0.50, PI 66.67-88.89, PLI 87.50-116.67 (6 syntypes measured).

Worker description

Medium-sized species. Head relatively broad, narrowed anteriorly, and with convex posterior margin in full-face view. Clypeus convex in lateral view, suddenly raised near its base; anterior extremity of clypeus with a pair of short teeth that are rather broadly separated; anterior margin between the teeth almost truncate. Frontal carina well elevated and sinuate in full-face view. Antennal scape long, extending beyond the posterior margin of head by at least half its length. Eye convex, slightly protruding from the lateral outline of head. Pronotum in dorsal view convex by distinct angles and slightly narrowed posteriorly, unarmed with anterolateral teeth. Pronotum laterally not marginate; mesonotum and propodeum weakly marginate laterally. Mesonotum slightly higher than propodeum. Propodeal dorsum strongly sloping; propodeal spine medium-sized, directed upward. Petiolar spine seen from back strongly diverging, in lateral view vertical and almost straight, shorter than the height of petiole measuring approximately half of the latter. Petiole in lateral view with posterodorsal margin distinctly angulate; its anterior and posterior slope almost straight.

Mandible smooth and shining with scattered small macropunctures. Head including clypeus, most of pronotal sides, dorsa of mesosoma rather smooth and shining, with superficial sparse punctures and other irregular sculpture. Part of pronotal sides, mesopleuron, metapleuron, sides of propodeum and sides of petiole closely puncto-reticulate. Gastral tergites very superficially microsculptured and weakly shining. Legs superficially sculptured and shining.

Antennal flagellum with very fine sparse pubescence, without standing hairs except at apical segment; flagellar segment with many yellow short standing hairs as well as pubescence. Clypeus, frontal lobe, coxae, femora below, petiolar

pedicel above and, and gastral tergites posteriorly with a few yellow standing hairs. Head including clypeus with sparse pubescence. Mandible with sparse pubescence and apically with some standing hairs. Pubescence on gastral tergites minute and sparse.

Clypeus, fron, antennal scape and flagellum, posterior and lateral portions of head, mesosoma and legs orangish brown. Petiole and gaster brown to dark brown.

Syntype queen measurements

HW 1.35, HL 1.70, SL 1.85, CI 79.41, SI 137.04, PrW 1.55, MPL 1.95, MTL 2.20, MTI 162.96, PL 0.35, PH 0.40, PW 0.45, PI 88.89, PLI 87.50 (1 syntype measured).

Queen description

Similar to workers in structure, but propodeal dorsum in lateral view distinctly shorter than declivity, propodeal spine much reduced. Petiole in lateral view with posterodorsal margin distinctly convex.

Body sculpture similar to that in workers.

Similar to workers in pilosity, but clypeus without a yellow standing hairs.

Similar to workers in coloration, but clypeus orangish.

Discussion

This species is very similar to *P. wartburgi* but can be diagnosed by a suite of worker characteristics: the pronotum produce to form anterolaterally tubercles; the posterior and lateral portions of head, mesosoma and legs, are orangish brown. Besides, in the queen the mesoscutellum, metanotum, propodeum and petiole are orangish.

Distribution

P. lilianae is known only from the type localities in Java and Sumatra, Indonesia (Fig. 128).

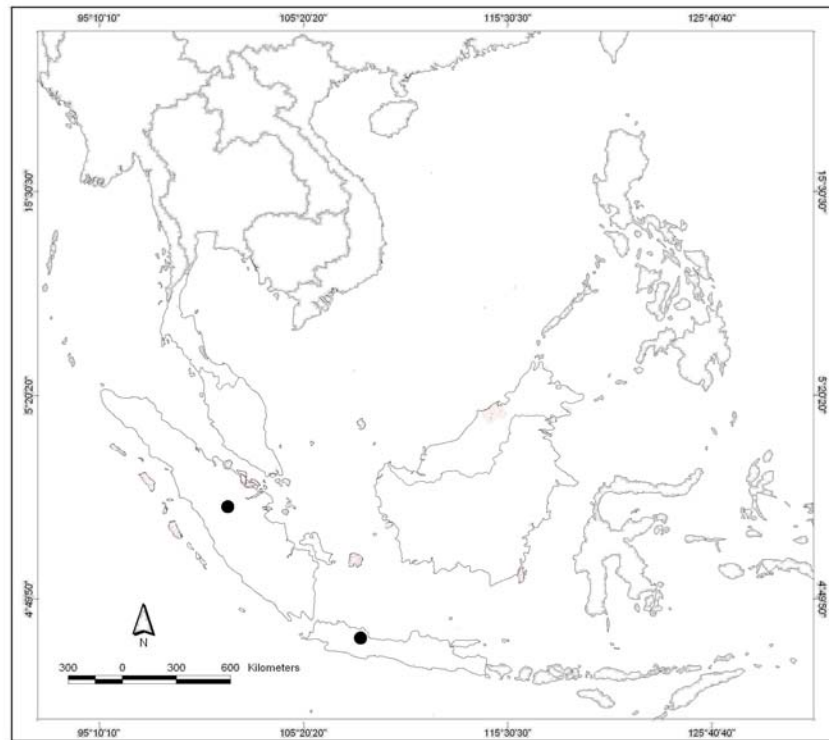


Figure 128. Distribution of *P. lilianae* Forel

(modified from the Southern Remote Sensing GIS Center, Prince of Songkla University, 2008).

***Polyrhachis (Myrmatopa) lombokensis* Emery**

(Fig. 136, 143, 147, 153, 157, 164, 168, 175)

Polyrhachis lombokensis Emery 1898: 239. Type locality: Indonesia, Lombok I., Sapit, v-vi.1896 (H. Fruhstorfer) [MCSN] (two syntype workers and one syntype queen examined). Forel, 1915: 115 (combination in *P. (Myrmatopa)*).

Syntype worker measurements

HW 1.15-1.35, HL 1.45-1.55, SL 1.95-2.15, CI 79.31-87.10, SI 159.26-169.57, PrW 0.80-1.05, MPL 1.40-1.60, MTL 2.07-2.33, MTI 172.84-179.71, PL 0.35, PH 0.25-0.30, PW 0.30, PI 83.33-100.00, PLI 116.67-140.00 (2 syntypes measured).

Worker description

Medium-sized species. Head relatively broad, narrowed anteriorly, and with convex posterior margin in full-face view. Clypeus convex in lateral view, suddenly raised near its base; anterior extremity of clypeus without a pair of short teeth; anterior margin almost striate. Frontal carina well elevated and sinuate in full-face view. Antennal scape long, extending beyond the posterior margin of head by at least half its length. Eye convex, slightly protruding from the lateral outline of head. Pronotum in dorsal view convex by distinct rounded and slightly narrowed posteriorly, unarmed with anterolateral teeth. Pronotum laterally not marginate; mesonotum and propodeum weakly marginate laterally. Mesonotum slightly higher than propodeum. Propodeal dorsum slightly sloping; propodeal spine small-sized, directed upward. Petiolar spine seen from back strongly diverging, in lateral view vertical and almost straight, shorter than the height of petiole measuring approximately less than half the latter. Petiole in lateral view with posterodorsal margin distinctly convex; its anterior and posterior slope almost straight. Subpetiolar process low, with posteroventral corner more or less angulate.

Mandible very finely microsculptured basally, with scattered small macropunctures over the surface and shining; its basal most portion superficially microsculptured and dull. Head including clypeus, dorsa of prosoma rather smooth and slightly shining, with superficial sparse punctures and other irregular sculpture. Part of pronotal sides, dorsa of mesosoma and metasoma, mesopleuron, metapleuron, sides of propodeum and sides of petiole closely puncto-reticulate. Gastral tergites very superficially microsculptured and shining. Legs superficially sculptured and shining.

Antennal flagellum with very fine sparse pubescence, without standing hairs except at apical segment; flagellar segment with many yellow short standing hairs as well as pubescence. Clypeus, frontal lobe, coxae and trochanters, femora below, petiolar pedicel above and below, and gastral tergites posteriorly with a few yellow standing hairs. Head including clypeus with sparse pubescence. Mandible with sparse pubescence and apically with some standing hairs. Gaster ventrally with some yellow standing hairs and sparse pubescence. Pubescence on gastral tergites minute and sparse.

Clypeus, mandible, fron, antennal scape and flagellum, legs, and gaster brown. Posterior and lateral portions of head, mesosoma, and petiole dark brown to black.

Syntype queen measurements

HW 1.45, HL 1.85, SL 2.25, CI 78.38, SI 155.17, PrW 1.70, MPL 2.10, MTL 2.53, MTI 174.71, PL 0.40, PH 0.30, PW 0.50, PI 60.00, PLI 133.33 (1 syntype measured).

Queen description

Similar to workers in structure, but propodeal dorsum in lateral view distinctly shorter than declivity, propodeal spine much reduced.

Body sculpture similar to that in workers.

Similar to workers in pilosity, but dorsa of mesoscutum and mesoscutellum with a few yellow standing hairs.

Similar to workers in coloration.

Discussion

Worker of this species can be distinguished from those of other members of the *wallacei*-group by the anterior margin of clypeus, truncate with blunt lateral angles. Besides, in the queen the mesosoma almost wholly is blackish brown, and the gaster is brown.

Distribution

P. lombokensis is known only from the type locality in Lombok I., Indonesia (Fig. 129).

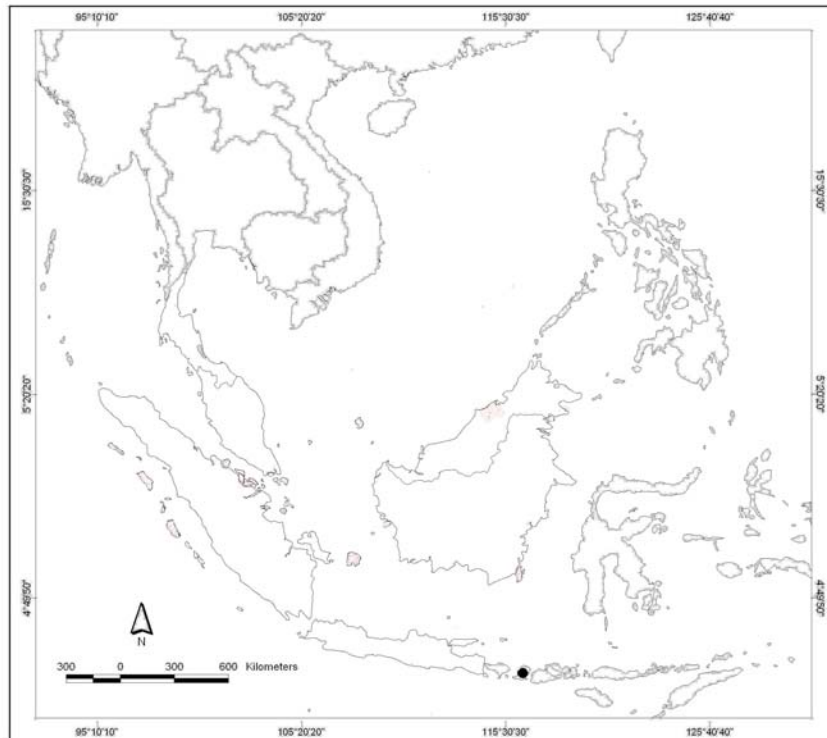


Figure 129. Distribution of *P. lombokensis* Emery

(modified from the Southern Remote Sensing GIS Center, Prince of Songkla University, 2008).

***Polyrhachis (Myrmatopa) subtridens* Emery**

(Fig. 137, 148, 158, 169)

Polyrhachis subtridens Emery 1900: 711. Type locality: Indonesia, Mentawai I., Sipora, Sereinu, v-vi.1894 (Modigliani) [MCSN] (two syntype workers examined). Emery, 1925: 181 (combination in *P. (Myrmatopa)*).

Syntype worker measurements

HW 1.15-1.20, HL 1.30-1.35, SL 1.50-1.70, CI 88.46-88.89, SI 130.43-141.67, PrW 0.90-0.95, MPL 1.00-1.25, MTL 1.67-1.87, MTI 138.89-162.32, PL 0.30, PH 0.30-0.35, PW 0.35, PI 85.71-100.00, PLI 100.00 (2 syntypes measured).

Worker description

Medium-sized species. Head relatively broad, narrowed anteriorly, and with convex posterior margin in full-face view. Clypeus convex in lateral view, suddenly raised near its base; anterior extremity of clypeus with a pair of short teeth that are rather broadly separated; anterior margin between the teeth almost truncate. Frontal carina well elevated and sinuate in full-face view. Antennal scape long, extending beyond the posterior margin of head by at least half its length. Eye convex, slightly protruding from the lateral outline of head. Pronotum in dorsal view convex by distinct rounded and slightly narrowed posteriorly, unarmed with anterolateral teeth. Pronotum laterally not marginate; mesonotum and propodeum weakly marginate laterally. Mesonotum slightly higher than propodeum. Propodeal dorsum slightly sloping; propodeal spine small-sized, directed upward. Petiolar spine seen from back strongly diverging, in lateral view vertical and almost straight, shorter than the height of petiole measuring approximately less than half the latter. Petiole in lateral view with posterodorsal margin slightly angulate and provided with one median denticle between the spines; its anterior and posterior slope almost straight.

Mandible smooth and slightly shining with scattered small macropunctures; its basal most portion superficially microsculptured and dull. Head including clypeus, most of pronotal sides, dorsa of mesosoma rather smooth and slightly shining, with superficial sparse punctures and other irregular sculpture. Part of pronotal sides, mesopleuron, metapleuron, sides of propodeum and sides of petiole closely puncto-reticulate. Gastral tergites very superficially microsculptured and shining. Legs superficially sculptured and shining.

Antennal flagellum with very fine sparse pubescence, without standing hairs except at apical segment; flagellar segment with many yellow short standing hairs as well as pubescence. Clypeus, frontal lobe, coxae and trochanters, femora

below, petiolar pedicel above, and gastral tergites posteriorly with a few yellow standing hairs. Head including clypeus with sparse pubescence. Mandible with sparse pubescence and apically with some standing hairs. Gaster ventrally with some yellow standing hairs and sparse pubescence. Pubescence on gastral tergites minute and sparse.

Clypeus, mandible, antennal scape and flagellum, frons, posterior and lateral portions of head, mesosoma, and petiole, dark brown black. Legs and gaster brown.

Discussion

Worker of this species can be distinguished from those of other members of the *wallacei*-group by the petiolar spine in lateral view distinctly shorter than half the petiolar height. Moreover, the whole body, except legs and gaster, is dark brown black.

Distribution

P. subtridens is known only from the type locality in Mentawai I., Indonesia (Fig. 130).

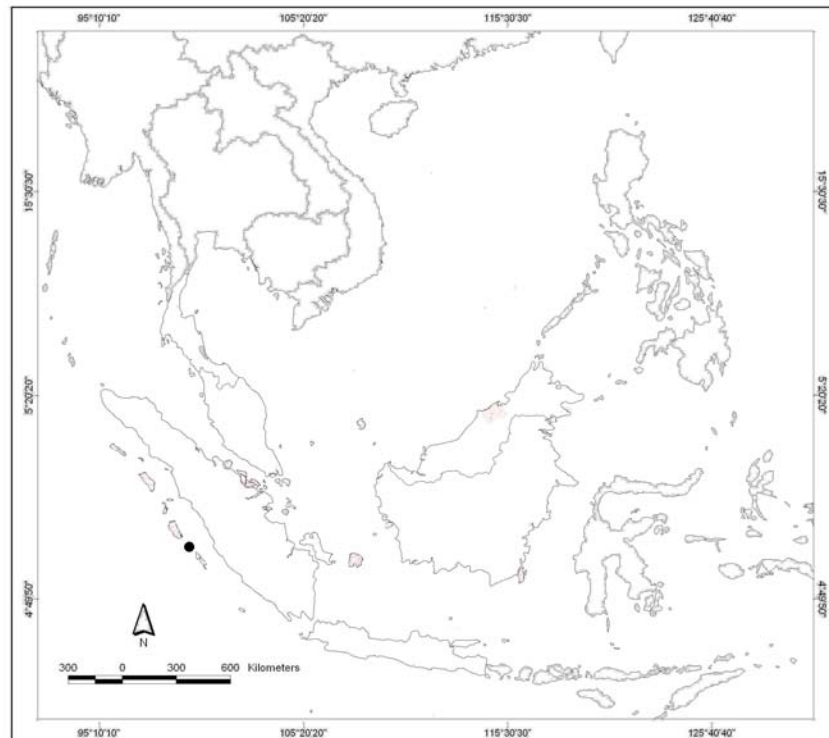


Figure 130. Distribution of *P. subtridens* Emery

(modified from the Southern Remote Sensing GIS Center, Prince of Songkla University, 2008).

***Polyrhachis (Myrmatopa) vanispina* sp. nov.**

(Fig. 138, 149, 159, 170)

Holotype: worker, E. Malaysia, Borneo, Sarawak, Lambir N.P., Miri, 30.x.1996
(Y. Hashimoto) (SKYC).

Worker measurements

HW 1.15, HL 1.35, SL 1.70, CI 85.19, SI 147.83, PrW 0.75, MPL 1.25,
MTL 1.35, MTI 117.39, PL 0.30, PH 0.25, PW 0.30, PI 83.33, PLI 120.00 (holotype).

Worker description

Medium-sized species. Head relatively broad, narrowed anteriorly, and with slightly convex posterior margin in full-face view. Clypeus weakly convex in lateral view; anterior extremity of clypeus with a pair of short teeth that are relatively widely separated; anterior margin between the teeth almost truncate. Frontal carina well elevated and sinuate in full-face view. Antennal scape long, extending beyond the occipital margin of head by at least half its length. Eye convex, moderately protruding from the lateral outline of head. Pronotum in dorsal view convex laterally by distinct rounded and narrowed posteriorly, with rather flat dorsum, unarmed with anterolateral teeth. Pronotum and propodeum laterally not marginate. Mesonotum weakly marginate laterally and only slightly higher than propodeum. Propodeal spine entirely absent. Petiolar spine in lateral view vertical and almost straight, shorter than the height of petiole measuring approximately 1/3 of the latter. In lateral view posterodorsal corner of petiole convex; anterior slope almost straight, while posterior slope slightly convex. Subpetiolar process low, semi-transparent, with posteroventral corner more or less angulate.

Mandible very finely microsculptured basally, with scattered small macropunctures over the surface. Antennal scape very densely microsculptured and dull. Sculpture on head including clypeus, promesonotum, propodeum dorsum and gaster very superficial. Mesopleuron, sides of propodeum and petiole striato-reticulate. Legs superficially microsculptured and weakly shining.

Antennal flagellum with dense pubescence, without standing hairs except at apical segment; flagellar segment with many short yellow standing hairs as well as pubescence. Clypeus, frontal lobe, coxae and trochanters, femora below, petiolar pedicel above, subpetiolar process anteriorly, and gastral tergites posteriorly with a few yellow standing hairs. Head including clypeus and subpetiolar process posteriorly with sparse pubescence. Mandible in particular apically and venter of gaster with rather long yellow standing hairs and sparse pubescence. Gaster extensively with sparse minute pubescence.

Whole body orangish brown.

Etymology

The name refers to the absence of the propodeum spine; *vani* (Latin) means empty combined with *spina* (Latin) means spine.

Discussion

Worker of this species can be distinguished from those of other members of the *wallacei*-group by the propodeal spine entirely absent.

Distribution

This species is known only from Lambir N.P., Miri, Sarawak, Borneo, Malaysia (Fig. 131).

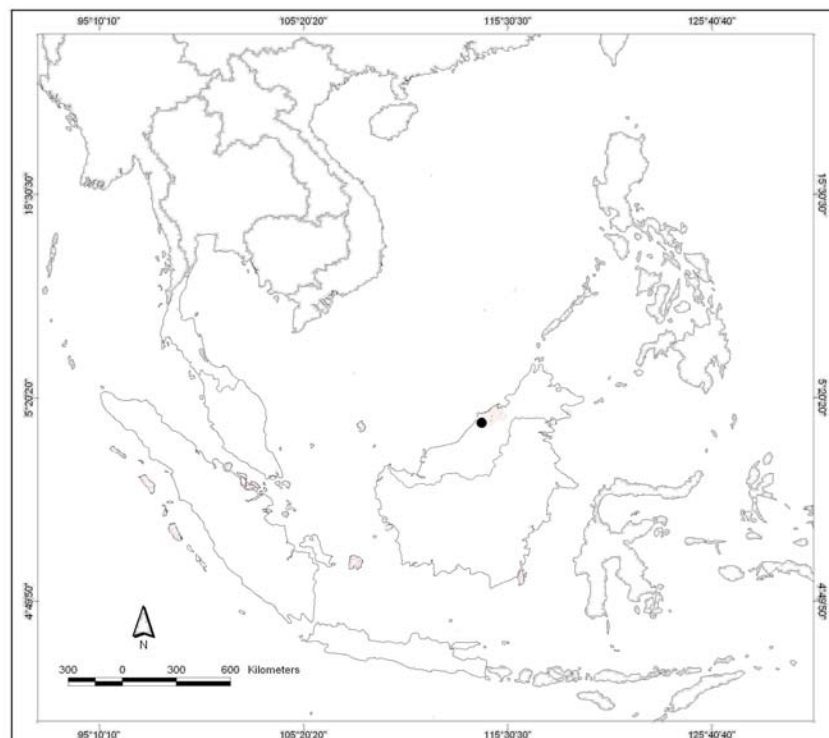


Figure 131. Distribution of *P. vanispina* sp. nov.

(modified from the Southern Remote Sensing GIS Center, Prince of Songkla University, 2008).

***Polyrhachis (Myrmatopa) wartburgi* Forel, stat. nov.**

(Fig. 139, 144, 150, 154, 160, 165, 171, 176)

Polyrhachis wallacei var. *wartburgi* Forel, 1901: 76. Holotype: worker. Type locality : Indonesia, Java, (O. Wartburg) [MHNG] (holotype apparently lost). Emery, 1925: 180 (combination in *P. (Myrmatopa)*).

Neotype designation

Neotype: worker, S. Thailand, Phatthalung Prov., Lan Mom Juy Waterfall, Khao Bun Tud W.S. 0-200 m, 8.iv.2005, nesting on lower vegetation 1.2 m above ground (N. Noon-anant) (PSNH). Paratypes: 11 workers, from same nest to which the neotype belongs (BMNH, AMK, MCSN, MHNG, NHMB, OXUM, QMBA, SKYC, TNHM).

Non-type material examined

S. Thailand: Songkhla Prov., Ton Nga Chang W.S. 100-300 m, 26.iii.2002, canopy fogging (S. Tongjerm) (workers); same loc., 19.ix.2002, canopy fogging (S. Tongjerm) (workers) (PSNH).

Worker measurements (neotype cited first)

HW 1.20, 1.10-1.27; HL 1.53, 1.30-1.47; SL 1.73, 1.50-1.73; CI 78.26, 81.82-92.31; SI 144.44, 125.00-144.44; PrW 0.93, 0.85-1.00; MPL 1.40, 1.25-1.47; MTL 2.00, 1.63-1.97; MTI 166.67, 141.67-163.89; PL 0.35, 0.25-0.40; PH 0.27, 0.20-0.30; PW 0.40, 0.35-0.45; PI 66.67, 50.00-75.00; PLI 131.25, 100.00-150.00 (neotype and 11 non-type workers measured).

Worker description

Medium-sized species. Head relatively broad, narrowed anteriorly, and with convex posterior margin in full-face view. Clypeus convex in lateral view, suddenly raised near its base; anterior extremity of clypeus with a pair of short teeth that are rather broadly separated; anterior margin between the teeth almost truncate. Frontal carinae well elevated and sinuate in full-face view. Antennal scape long, extending beyond the posterior margin of head by at least half its length. Eye convex, slightly protruding from the lateral outline of head. Pronotum in dorsal view convex by distinct rounded and slightly narrowed posteriorly, unarmed with anterolateral teeth. Pronotum laterally not marginate; mesonotum and propodeum weakly marginate laterally. Mesonotum slightly higher than propodeum. Propodeal dorsum strongly sloping; propodeal spine medium-sized, directed upward. Petiolar spines seen from back strongly diverging, in lateral view vertical and almost straight, shorter than the height of petiole measuring approximately half the latter. Petiole in lateral view with posterodorsal margin distinctly angulate; its anterior and posterior slope almost straight. Subpetiolar process low, with posteroventral corner more or less angulate.

Mandible smooth and shining with scattered small macropunctures; its basal most portion superficially microsculptured and dull. Head including clypeus, most of pronotal sides, dorsa of mesosoma rather smooth and shining, with superficial sparse punctures and other irregular sculpture. Part of pronotal sides, mesopleuron, metapleuron, sides of propodeum and sides of petiole closely puncto-reticulate. Gastral tergites very superficially microsculptured and weakly shining. Legs superficially sculptured and shining.

Antennal flagellum with very fine sparse pubescence, without standing hairs except at apical segment; flagellar segment with many yellow short standing hairs as well as pubescence. Clypeus, frontal lobe, coxae and trochanters, femora below, petiolar pedicel above and below, and gastral tergites posteriorly with a few yellow standing hairs. Head including clypeus with sparse pubescence. Mandible with sparse pubescence and apically with some standing hairs. Gaster ventrally with some

yellow standing hairs and sparse pubescence. Pubescence on gastral tergites minute and sparse.

Clypeus, mandible, frons, antennal scape and flagellum, and legs, orangish brown to brown. Posterior and lateral portions of head, mesosoma, and petiole brown to dark brown. Gaster much darker.

Queen measurements

HW 1.27-1.33; HL 1.60-1.67; SL 1.87-1.93; CI 79.17-83.33; SI 145.00-152.63; PrW 1.33-1.40; MPL 1.93-2.00; MTL 2.20-2.30; MTI 165.00-181.58; PL 0.35-0.40; PH 0.27-0.33; PW 0.47-0.53; PI 50.00-71.43; PLI 120.00-150.00 (4 non-type queens measured).

Queen description

Similar to workers in structure, but propodeal dorsum in lateral view distinctly shorter than declivity. Propodeal spine similar to workers to much reduced. Petiolar spine in lateral view stout, provided with to without one median denticle between the spines. Petiole in lateral view with posterodorsal margin distinctly to slightly angulate.

Body sculpture similar to that in workers.

Similar to workers in pilosity, but dorsa of mesoscutum and mesoscutellum with a few yellow standing hairs.

Similar to workers in coloration.

Discussion

This species is very similar to *P. lilianae* but can be diagnosed by a suite of worker characteristics: the pronotum in dorsal view rounded anterolaterally without distinct tubercles; and the posterior and lateral portions of head, mesosoma, are brown to dark brown. Besides, in the queen the mesoscutellum, metanotum, propodeum and petiole are blackish, while dorsa of these regions are reddish.

Distribution

This species is known from the type locality in Java, Indonesia and Peninsular Thailand (Fig. 132). In Peninsular Thailand, nest has been found on the lower vegetation, and some specimens were found among the fogging samples from the lowland rain forest which it has been recorded include undisturbed and disturbed habitat.

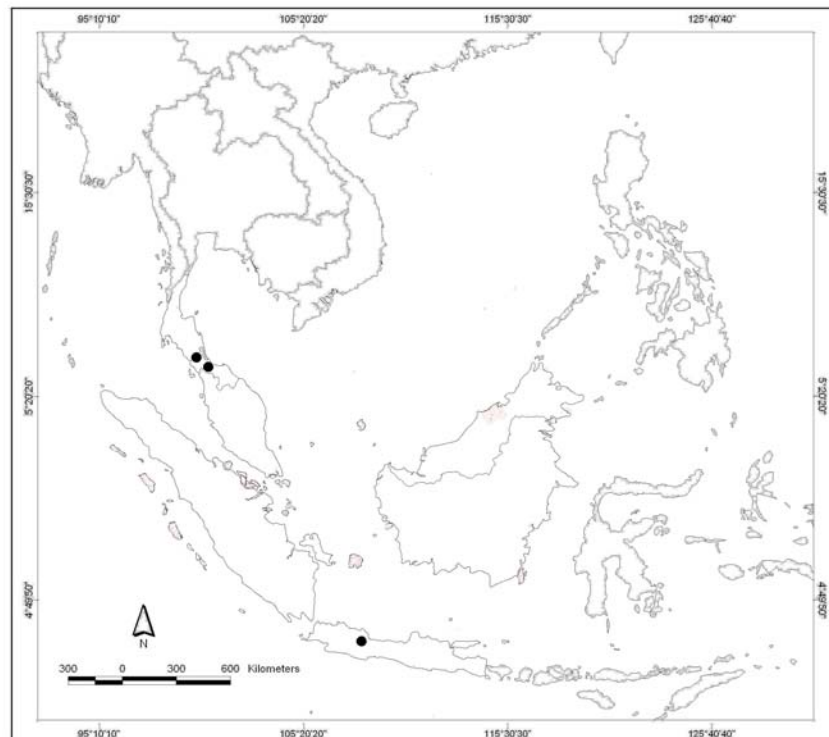


Figure 132. Distribution of *P. wartburgi* Forel

(modified from the Southern Remote Sensing GIS Center, Prince of Songkla University, 2008).

***Polyrhachis (Myrmatopa) yamanei* sp. nov.**

(Fig. 140, 151, 161, 172)

Holotype: worker, E. Malaysia, Borneo, Sabah, Mahua Crocker Range N.P., 20.x.1999 (Y. Hashimoto) (SKYC).

Worker measurements

HW 1.20, HL 1.67, SL 1.93, CI 72.00, SI 161.11, PrW 2.07, MPL 1.47, MTL 1.60, MTI 133.33, PL 0.35, PH 0.53, PW 0.73, PI 72.73, PLI 65.63 (holotype).

Worker description

Medium-sized species. Head distinctly elongate with its posterior margin almost straight in full-face view; sides of head nearly parallel. Clypeus slightly convex in lateral view; its anterior extremity with a pair of medium-sized teeth that are relatively close to each other. Frontal carina well elevated and very weakly sinuate in full-face view. Antennal scape long, extending beyond the occipital margin of head by at least half its length. Eye convex, moderately protruding from the lateral outline of head. Pronotum in dorsal view convex laterally by distinct rounded and slightly narrowed posteriorly, unarmed with anterolateral teeth. Pronotum laterally not marginate; mesonotum and propodeum distinctly marginate laterally. Mesonotum slightly higher than propodeum. Propodeal dorsum slightly sloping; propodeal spine medium-sized and directed upward. Petiolar spines seen from back diverging, in lateral view vertical and almost straight, shorter than the height of petiole measuring approximately half of the latter. Petiole in lateral view with posterodorsal margin distinctly angulate; its anterior slope almost straight, and posterior slope slightly convex. Subpetiolar process low, with a weak angle posteroventrally.

Head superficially sculptured and weakly shining; clypeus with weaker sculpture. Mandible almost smooth and shining with scattered small punctures; its basal portion very superficially microsculptured apically and dull. Antenna densely microsculptured and dull. Dorsa of mesosoma closely and irregularly striate; sides of mesosoma and petiole more strongly puncto-striate to puncto-reticulate. Gaster very densely microsculptured and weakly shining. Legs superficially sculptured, with weak luster.

Head with decumbent or slanting long hairs; some of the hairs on frons and vertex still longer and standing. Antennal scape and flagellum with decumbent to suberect dense hairs. Dorsa of pronotum and mesonotum with long standing hairs.

Petiolar pedicel above and below with some standing hairs. Gastral tergites and sternites with many yellow standing/slanting long hairs; pubescence very sparse and inconspicuous. Legs hairy; coxae, trochanters and femora with long standing/slanting hairs; other segments with suberect to decumbent shorter hairs.

Head including mandible, mesosoma and petiole orangish brown; clypeus yellowish. Antennal scape and legs dark brown. Gaster almost black.

Etymology

Name in honour of Prof. Dr. Seiki Yamane, who introduced and encouraged me to my ongoing work on taxonomy and ecology of the ants.

Discussion

Worker of this species can be distinguished from those of other members of the *wallacei*-group by the head distinctly elongate, with its posterior margin almost straight and sides of head nearly parallel. Moreover, the head with slanting long hairs; the pronotum, mesonotum and petiolar spine with long standing hairs.

Distribution

This species is known only from Mahua Crocker Range N.P., Sabah, Borneo, Malaysia (Fig. 133).

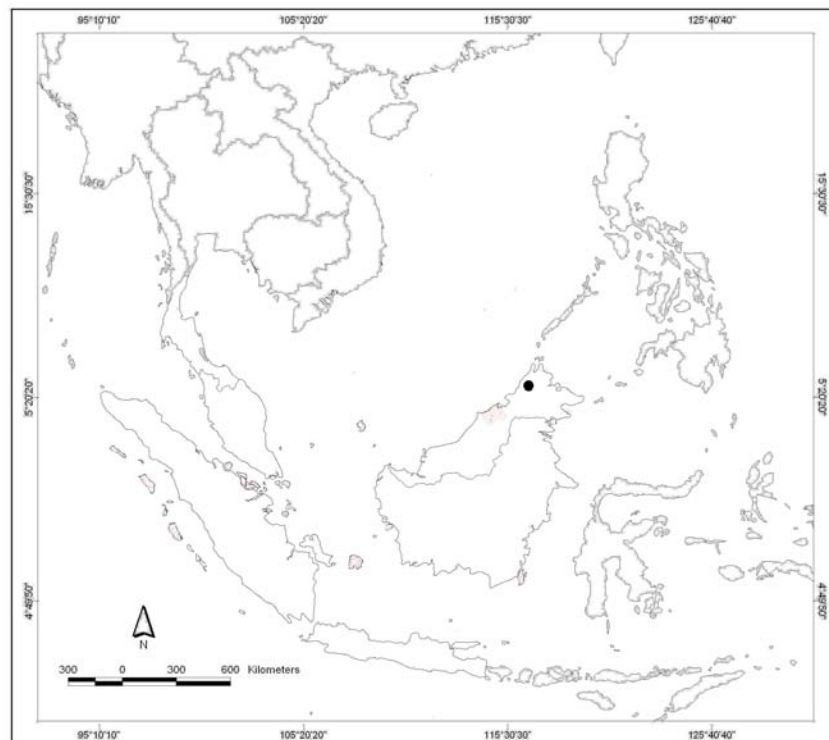


Figure 133. Distribution of *P. yamanei* sp. nov.

(modified from the Southern Remote Sensing GIS Center, Prince of Songkla University, 2008).

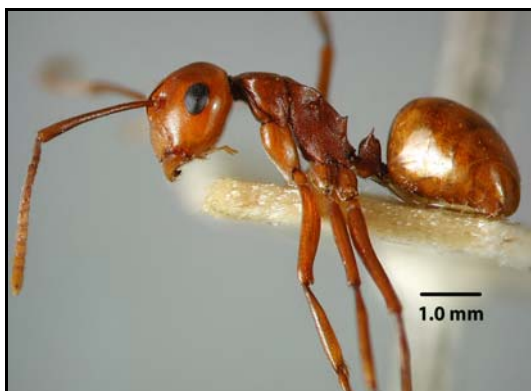


Figure 134. *P. jacobsoni* Forel worker (syntype) in lateral view of hole body.



Figure 135. *P. lilianae* Forel worker (syntype) in lateral view of hole body.



Figure 136. *P. lombokensis* Emery worker (syntype) in lateral view of hole body.



Figure 137. *P. subtridens* Emery worker (syntype) in lateral view of hole body.



Figure 138. *P. vanispina* sp. nov. worker in lateral view of hole body.



Figure 139. *P. wartburgi* Forel worker in lateral view of hole body.



Figure 140. *P. yamanei* sp. nov. worker in lateral view of hole body.

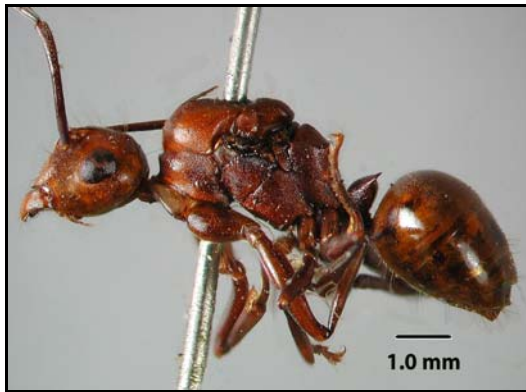


Figure 141. *P. jacobsoni* Forel queen (syntype) in lateral view of hole body.

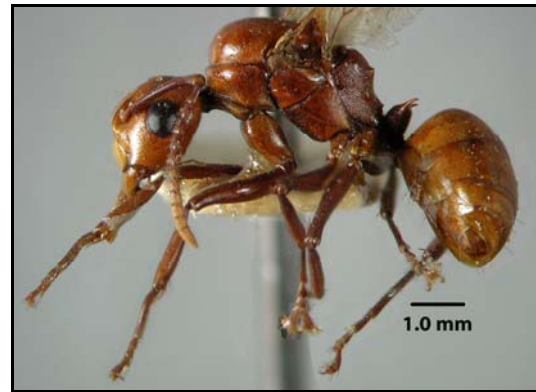


Figure 142. *P. lilianae* Forel queen (syntype) in lateral view of hole body.

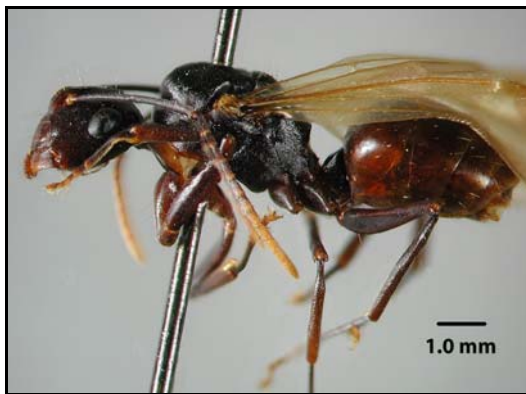


Figure 143. *P. lombokensis* Emery queen (syntype) in lateral view of hole body.



Figure 144. *P. wartburgi* Forel queen in lateral view of hole body.



Figure 145. *P. jacobsoni* Forel worker (syntype), head in full face view.

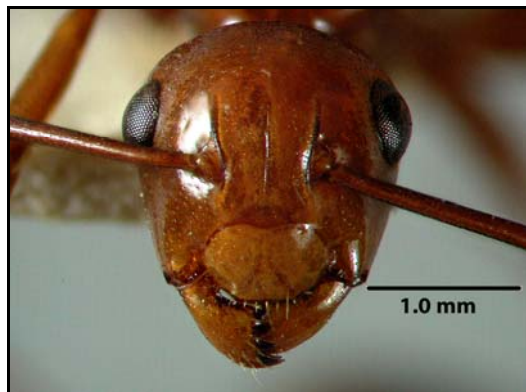


Figure 146. *P. liliana* Forel worker (syntype), head in full face view.

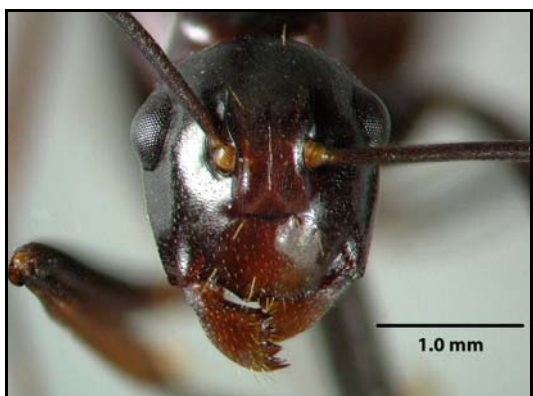


Figure 147. *P. lombokensis* Emery worker (syntype), head in full face view.

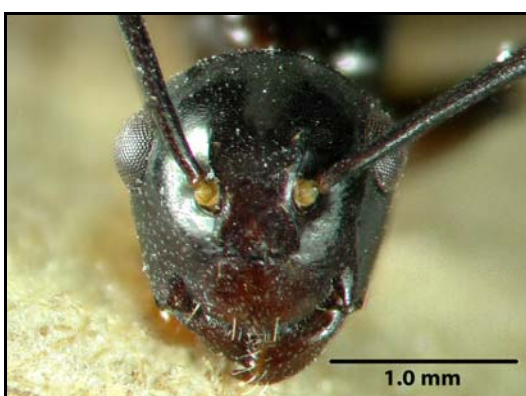


Figure 148. *P. subtridens* Emery worker (syntype), head in full face view.

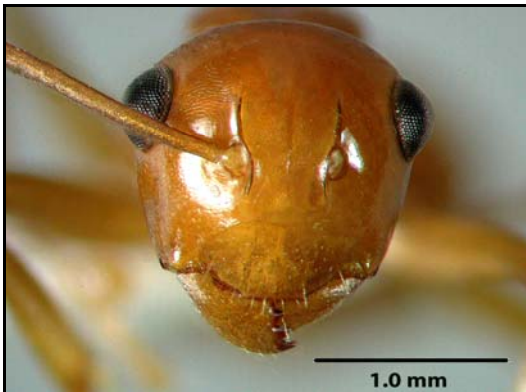


Figure 149. *P. vanispina* sp. nov. worker, head in full face view.

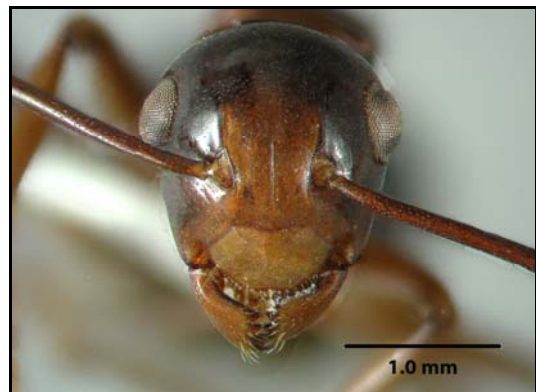


Figure 150. *P. wartburgi* Forel worker, head in full face view.



Figure 151. *P. yamanei* sp. nov. worker, head in full face view.

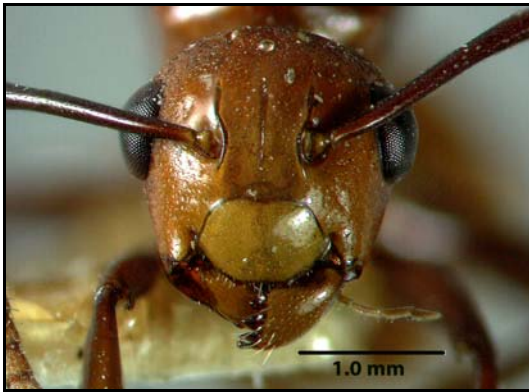


Figure 152. *P. lilianae* Forel queen (syntype), head in full face view.

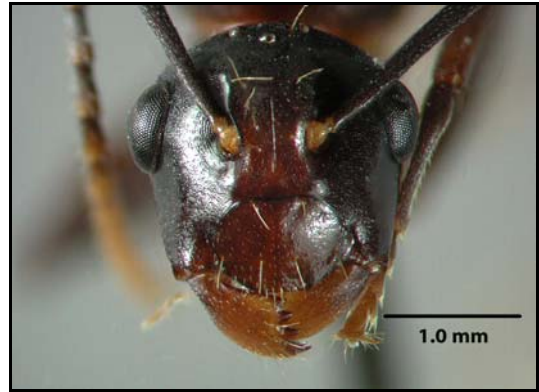


Figure 153. *P. lombokensis* Emery queen (syntype), head in full face view.

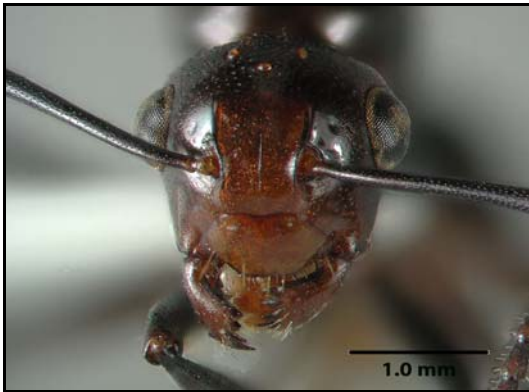


Figure 154. *P. wartburgi* Forel queen, head in full face view.

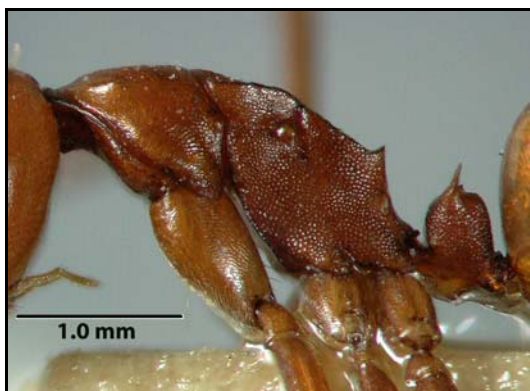


Figure 155. *P. jacobsoni* Forel worker (syntype) in lateral view of mesosoma and petiole.

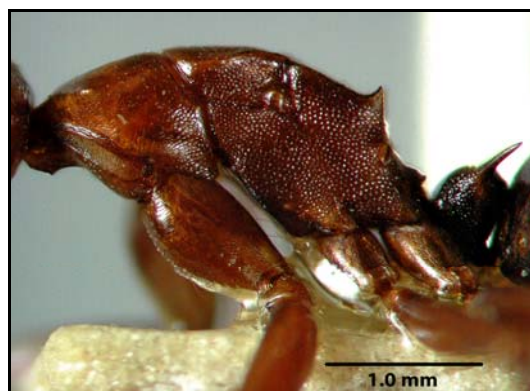


Figure 156. *P. lilianae* Forel worker (syntype) in lateral view of mesosoma and petiole.

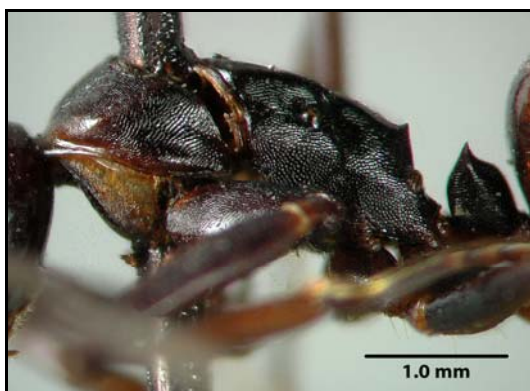


Figure 157. *P. lombokensis* Emery worker (syntype) in lateral view of mesosoma and petiole.

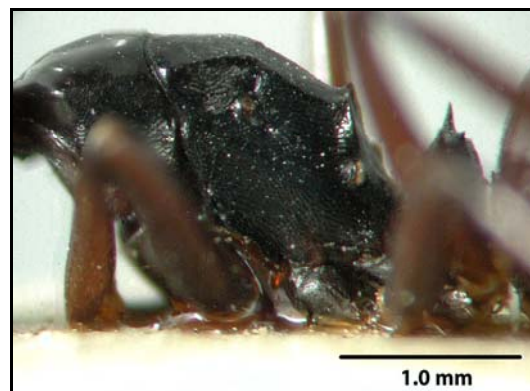


Figure 158. *P. subtridens* Emery worker (syntype) in lateral view of mesosoma and petiole.



Figure 159. *P. vanispina* sp. nov. worker in lateral view of mesosoma and petiole.



Figure 160. *P. wartburgi* Forel worker in lateral view of mesosoma and petiole.



Figure 161. *P. yamanei* sp. nov. worker in lateral view of mesosoma and petiole.



Figure 162. *P. jacobsoni* Forel queen (syntype) in lateral view of mesosoma and petiole.

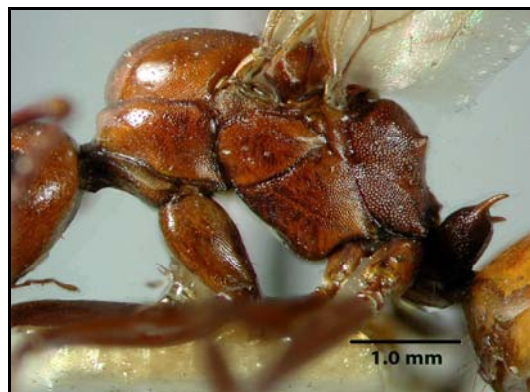


Figure 163. *P. lilianae* Forel queen (syntype) in lateral view of mesosoma and petiole.



Figure 164. *P. lombokensis* Emery queen (syntype) in lateral view of mesosoma and petiole.



Figure 165. *P. wartburgi* Forel queen in lateral view of mesosoma and petiole.

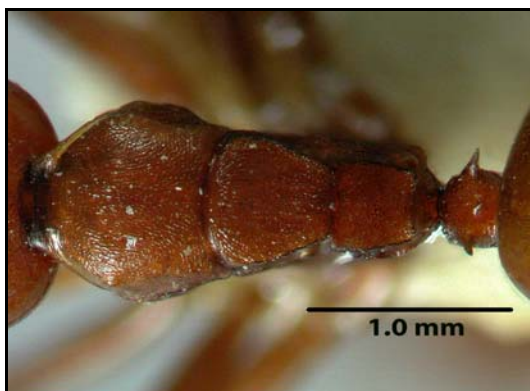


Figure 166. *P. jacobsoni* Forel worker (syntype) in dorsal view of mesosoma and petiole.

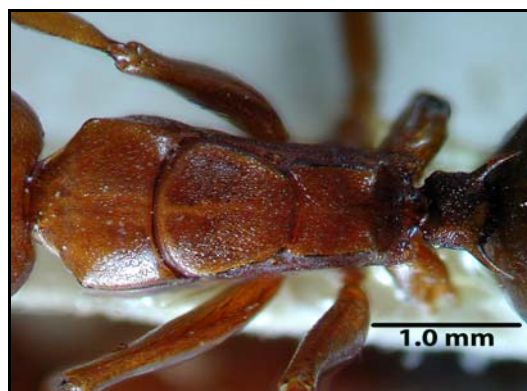


Figure 167. *P. lilianae* Forel worker (syntype) in dorsal view of mesosoma and petiole.

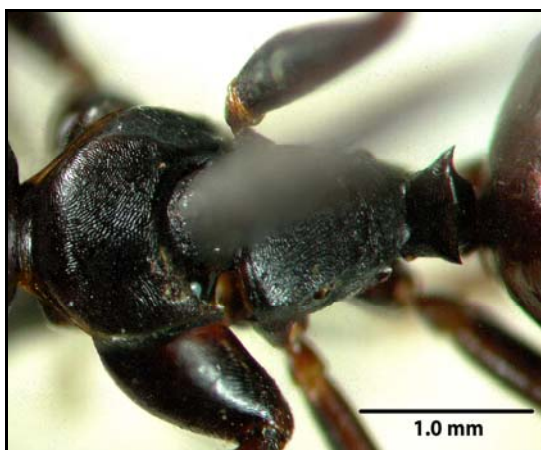


Figure 168. *P. lombokensis* Emery worker (syntype) in dorsal view of mesosoma and petiole.

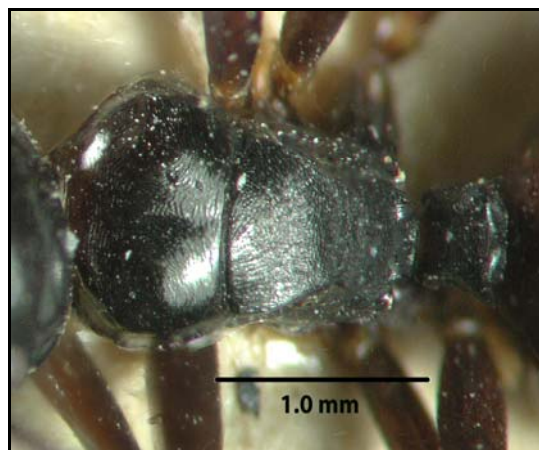


Figure 169. *P. subtridens* Emery worker (syntype) in dorsal view of mesosoma and petiole.



Figure 170. *P. vanispina* sp. nov. worker in dorsal view of mesosoma and petiole.



Figure 171. *P. wartburgi* Forel worker in dorsal view of mesosoma and petiole.

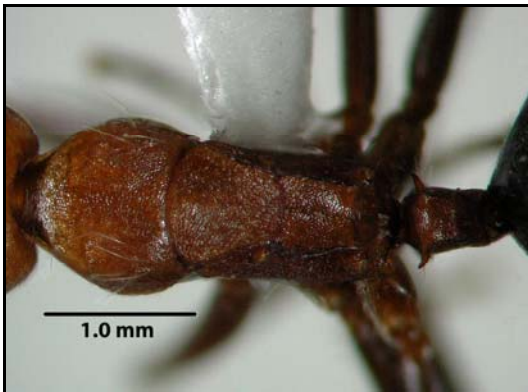


Figure 172. *P. yamanei* sp. nov. worker in dorsal view of mesosoma and petiole.

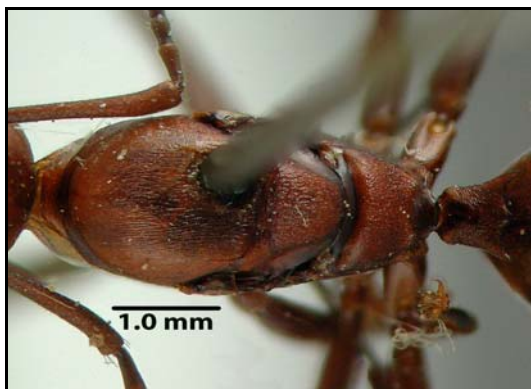


Figure 173. *P. jacobsoni* Forel queen (syntype) in dorsal view of mesosoma and petiole.



Figure 174. *P. lilianae* Forel queen (syntype) in dorsal view of mesosoma and petiole.



Figure 175. *P. lombokensis* Emery queen (syntype) in dorsal view of mesosoma and petiole.



Figure 176. *P. wartburgi* Forel queen in dorsal view of mesosoma and petiole.

2.4 Discussion

In this study, the subgenus *Myrmatopa* in the Indo-Malayan subregion was divided into four species groups (*flavicornis*, *schang*, *simillima* and *wallacei*-group) and twenty-one species were recognized on the basis of their external morphological characteristics of the workers. Besides, eleven species in three species groups, queens are known that are associated with workers, due to the limits of variation remain uncertain in species for which only a few specimens are available. In addition, the description and keys to species based on the workers and queens are provided, except key to species of the *schang*-group based on the queen has been omitted due to the limitation of the materials and absence of discriminating characteristics.

Moreover, an associated male are known for five species and these males have been omitted from this work, due to the male genitalia of *Polyrhachis* were proved to be quite similar throughout the genus (Hung, 1967) and the males associated with workers and queens are very rare.

This study differs from the first description by Emery (1925) which *Myrmatopa* was divided into the *schang*-group and *wallacei*-group. In addition, most species are known only from the type materials or only from the queen and lack of information on worker-queen association in that report (Bolton, 1995a; Dorrow, 1995; Emery, 1925). However, the latest arrangement of *Myrmatopa* was subdividing the *wallacei*-group and placing several of its species into a new *flavicornis*-group (Kohout, 2008), and is consistent with this study.

The type specimens of *P. wartburgi* are lost from the MHNG or Forel returned them to another museum and the type is not examined in this study. Although, this species was described only based on the worker by Forel (1901: 76-77), but the information on worker-queen association still unavailable. So, this species is designated and the nomenclatural stability of this species is established in accordance with article 75.3.5 of the International Code of Zoological Nomenclature (ICZN, 1999), a worker specimen as the neotype of *Polyrhachis wartburgi* Forel.

Eight new species have been found in this study and seven species have been described based on only one worker specimens, these are *P. antedoridens* sp. nov. of the *flavicornis*-group; *P. tawauensis* sp. nov. of the *schang*-group; *P. angusticlypealis* sp. nov., *P. watanasiti* sp. nov. and *P. wiwatwitayai* sp. nov. of the *simillima*-group; *P. vanispina* sp. nov. and *P. yamanei* sp. nov. of the *wallacei*-group, except for *P. kohouti* sp. nov., which the additional materials are available.

Two species are now raised to full species as they have distinct external morphological characters, these are *P. cnemidata* stat. nov. and *P. parvicella* stat. nov. of the *schang*-group.

In addition, eleven species were provided the information on worker-queen association. These are *P. constructor*, *P. varicolor* and *P. wartburgi* from the field collecting; *P. dolomedes*, *P. jacobsoni*, *P. lilianae*, *P. lumbokensis* and *P. parvicella* from the type material; and *P. flavicornis*, *P. cnemidata* and *P. solmsi* from both the field collecting and type material.

A rough distributional pattern among the *Myrmatopa* species from the Indo-Malayan subregion was recognized in three groups on the geographical data: widespread, moderate and endemic group.

The widespread group represented by *P. cnemidata*, *P. constructor* and *P. flavicornis*. These species are widely distributed in the Indo-Malayan subregion, from Indonesia, Borneo to Peninsular Thailand. Besides, *P. flavicornis* has been recorded from the Central and Eastern Thailand.

The second group occurs in two localities. These are *P. kohouti* sp. nov. (Borneo and Peninsular Thailand), *P. lilianae* (Java and Sumatra), *P. varicolor* (Singapore and Peninsular Thailand) and *P. wartburgi* (Java and Peninsular Thailand). In addition, *P. varicolor* is also known from Cambodia (Kohout, 2008).

The last group, appear to be endemic to only one locality. These are *P. dolomedes* (occurs in Seram Island); *P. lumbokensis* (occurs in Lombok Island); *P. parvicella*, *P. solmsi* and *P. jacobsoni* (occur in Java); *P. simillima* and *P. subtridens* (occur in Mentawai Island); *P. angusticlypealis* sp. nov., *P. antedoridens* sp. nov., *P. tawauensis* sp. nov., *P. vanispina* sp. nov. and *P. yamanei* sp. nov. (occur in Borneo); *P. watanasiti* sp. nov. and *P. wiwatwitayai* sp. nov. (occur in Peninsular Thailand).

The results from this study indicated that the additional species or materials examined remain undiscovered or unrecognised, especially in the *simillima*-group. Moreover, an emphasis on colony based collection or nest series which obtaining workers, queens and males are still important for expanding our knowledge of the taxonomy and systematics, including the biology, ecology and biogeography of these ants.

CHAPTER 3

NESTING HABITS

3.1 Introduction

The weaver ants that use larval silk in the construction of their nests are considered to provide one of the best illustrations of cooperation among social insects (Hölldobler & Wilson, 1990). These ants have evolved independently into at least four genera within the subfamily Formicinae: such as *Camponotus* Mayr, *Dendromyrmex* Emery, *Oecophylla* F. Smith and *Polyrhachis* F. Smith (Johnson *et al.*, 2003). A number of species of *Camponotus* Mayr and *Polyrhachis* F. Smith are claimed to occupy an intermediate level of complexity, in which the silk depositing larvae are also held by workers (Hölldobler & Wilson, 1990). Knowledge of the nesting habits of ants, not only within the genus *Polyrhachis* F. Smith, but also within other genera, clearly helps us to begin to understand the evolution of nest weaving behavior in ants (Hölldobler & Wilson, 1990; Robson & Kohout, 2004, 2005, 2007).

The taxonomic and ecological diversity of the genus *Polyrhachis* F. Smith appears to be matched by a significant diversity in nesting habits, in addition, the consistent relationship between nesting habits and the subgeneric classification was revealing, for example, species in the subgenera *Chariomyrma* Forel and *Hagiomyrma* Wheeler nest predominantly in the ground and do not include silk in their nests, species in the subgenera *Cyrtomyrma* Forel, *Myrmatopa* Forel and *Myrmothrinax* Forel are always found in arboreal sites and produce silk nests, while the subgenus *Myrmhopla* Forel demonstrates a great diversity in nesting habits (Liefke *et al.*, 1998; Robson & Kohout, 2004, 2005, 2007).

The nesting habits of the subgenus *Myrmatopa* Forel are arboreal and their nests are constructed on leaves (Hung, 1967; Robson & Kohout, 2005, 2007), but in an Australian species, the nest is made by joining together leaves of various trees and shrubs (Kohout, 1999). Moreover, many species do include silk in their nests (Robson & Kohout, 2007). However, the information on nesting habits and

socioecological characteristics of many species are still lacking, especially for the *Myrmatopa* species from the Indo-Malayan subregion which is one of the biodiversity hotspots with high concentrations of endemic species and undergoing immense habitat loss (Myers *et al.*, 2000; Sodhi *et al.*, 2004). In addition, Peninsular Thailand in the Indo-Malayan subregion, is the zoogeographical transition area between the Indochinese subregion and the Malayan subregion (Wallace's Indo-Malayan subregion) of the Oriental region (Hughes *et al.*, 2003; Woodruff, 2003). Therefore, this study aims to examine the nesting habits of the Indo-Malayan species of the subgenus *Myrmatopa*, including nesting sites, nest material and colony composition. This study concentrates on field observations on the Peninsular Thailand, and also the primary literature from other institutions and private information from other areas such as West Sumatra, Java and Borneo.

3.2 Materials and methods

3.2.1 Study area

Peninsular Thailand (Fig. 176) lies between 6° and 12° N latitude, and this region forms a narrow peninsula flanked by the Gulf of Thailand in the East and the Andaman Sea in the West. The climate in Peninsular Thailand is influenced by both the northeast monsoon, with the wettest months being from October to December on the East, and the Southwest monsoon, with the wettest months being from May to October on the West (Geo-Informatics & Space Technology Development Agency, 2003). The LANDSAT 5 mosaic for this region shows many mountain ranges running from North to South. Peninsular Thailand is narrowest at the Kra Isthmus, with a width of only 64 km South of the Isthmus, called the Lower Peninsular region, the land comprises the southern region of Thailand and West Malaysia. On the West of the Peninsula, the Phuket mountain range extends from Ranong to Phuket Province. On the east, the Nakorn Si Thammarat mountain range stretches from Surat Thani southward to Satun Province which lies at the southern end of Thailand. On the Thai-Malay border, the Sankalakhiri mountain range stretches NW-SE along the border and then turns southward into Malaysia. The Upper Peninsular region is shared by Thailand and Myanmar, with the Tanao Si (Tenasserim)

mountain range running in a north-south direction along the border and ending at the Kra Buri river in Ranong Province (Geo-Informatics & Space Technology Development Agency, 2003).

Thirty-two sampling sites were selected as representative areas of the lowland forest that ranged in elevation from 0 to 600 m above mean sea level (msl) in the five mountain ranges (Tenasserim, Phuket, Khao Luang, Khao Banthat and Sankalakhiri) and one on Tarutao island of the Peninsular Thailand. A map of Peninsular Thailand and sampling sites is shown in Fig. 177.

3.2.2 Sampling of nests

Nests of *Myrmatopa* species were collected from the Upper and Lower Peninsular regions of Thailand along the mountain ranges. The Tenasserim mountain range represents the Upper Peninsular region while the Phuket, Khao Luang, Khao Banthat and Sankalakhiri mountain range, including Tarutao island, represent the lower Peninsular region. At least three sites were established for each mountain range and Tarutao island, and ant nests on the lower vegetation at less than 3 m above the ground during March 2004 to March 2008 were collected. The frequency of sampling at each site throughout the year was selected in order to cover both the dry and wet seasons on each side of Peninsular Thailand.

The height of nests above the ground was measured and the number of nest entrances counted in the field. All the nests were brought back to the laboratory at the Department of Biology, Faculty of Science, Prince of Songkla University for further examination of size, material of the nests, and colony composition.

From a preliminary survey of *Polyrhachis* ants in the lowland tropical rain forest of Peninsular Thailand (Noon-anant & Watanasit, 2003), *P. (Myrmatopa) flavicornis* Smith was a dominant species in terms of its spatial distribution. Therefore, plants on which *P. flavicornis* Smith had built their nests were classified into four categories: trees, shrubs, climbers and herbs, then identified to families by plant taxonomist Dr. Jarun Leeratiwong from the Department of Biology, Faculty of Science, Prince of Songkla University, Songkhla, Thailand.

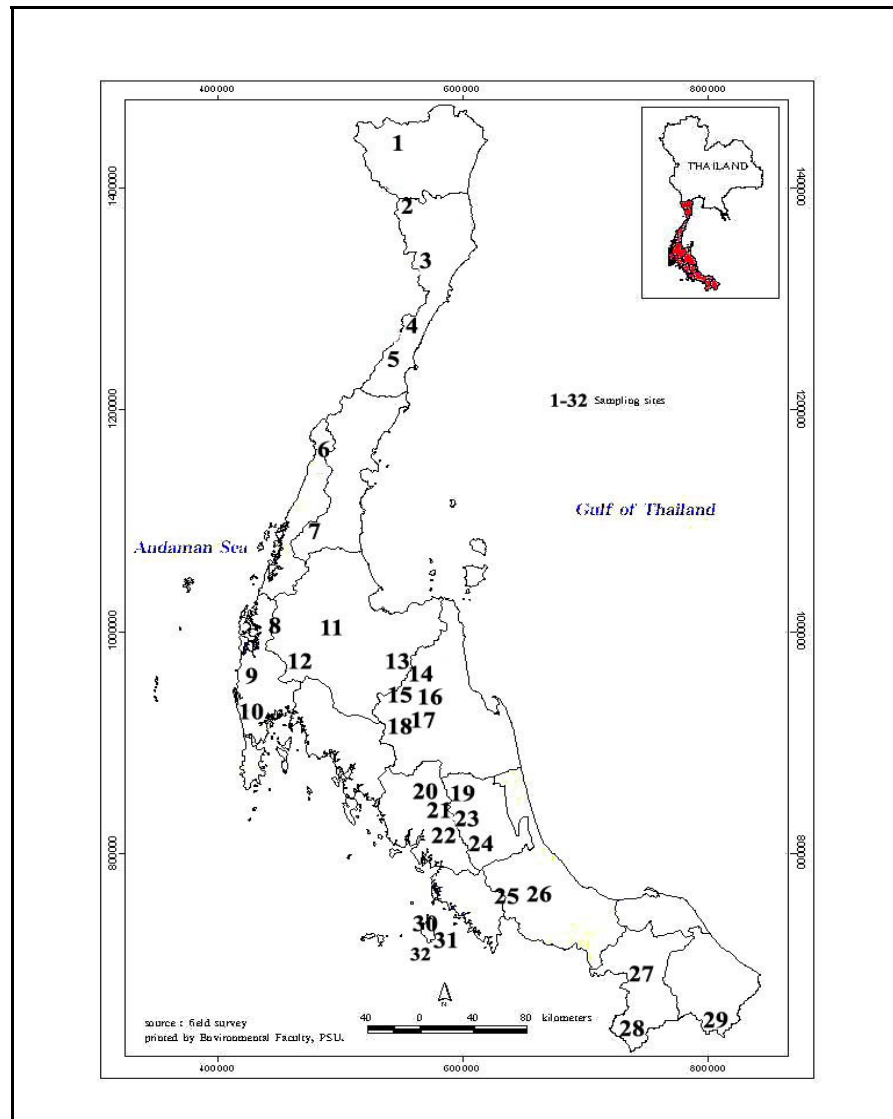


Figure 177. Map of Peninsular Thailand and its thirty-two sampling sites: 1-5 in the Tenasserim mountain range; 6-12 in the Phuket mountain range; 13-18 in the Khao Luang mountain range; 19-26 in the Khao Banthat mountain range; 27-29 in the Sankalakhiri mountain range and 30-32 in Tarutao island (modified from the Southern Remote Sensing GIS Center, Prince of Songkla University 2008).

The maximum height, width, and depth of each nest was measured in and the linear measurements are given in centimeters (Fig. 178). The nest materials were randomly sampled from nests of different colonies and location sites, and examined using a scanning electron microscope (JSM-5800LV, JEOL) at the Scientific Equipment Center, Prince of Songkla University, Songkhla, Thailand. The nest material was classified and modified from Robson & Kohout (2005, 2007) as silk (typically flat sheets thought to arise from larval silk), carton (fine and coarse particulate plant material) and other material (plant tissue fragments and silk from the unknown sources).

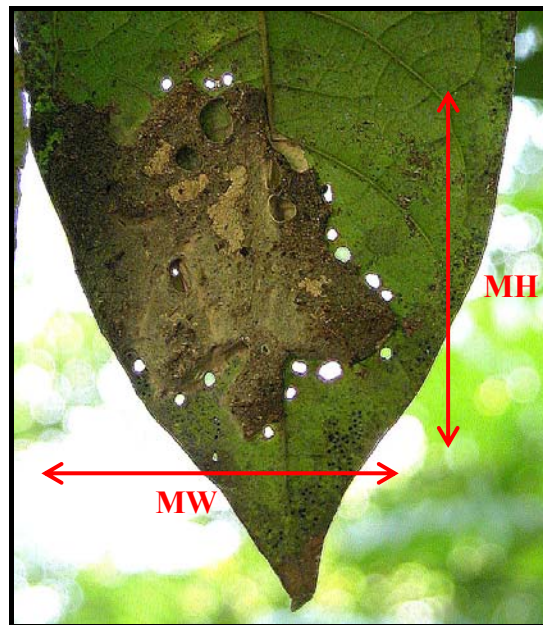


Figure 178. Measurements in the maximum height and width of nest: MH = the maximum height of nest, MW = the maximum width of nest.

The colony composition was obtained by counting the numbers of workers, dealate queens, winged queens and males. Colonies of most *Polyrhachis* species are known to be polydomous, where a single colony has more than one nest and the subgenus *Myrmatopa* are arboreal nesting ants. (Dorow & Maschwitz, 1990; Liefke *et al.*, 1998; Schellerich-Kaaden *et al.*, 1997; Schultz & Alonso, 2000). In the present study it was difficult to delimit colony boundaries in the field because multiple nests found on the same tree or closely located to each other were inferred to constitute one colony. In addition, if workers were observed moving between nests or

the transfer of workers between nests did not express aggressive interactions these nests were thought to constitute one colony. Moreover, polygyny was inferred if a few dealate queen was observed in a single nest, while monogyny was inferred if only one dealate queen was observed in a single nest.

3.2.3 Data analysis

One-way ANOVA was used to compare mean values for the nest size as represented by height, width, depth and nest location (height above ground), among the mountain ranges and one island, including among the different species, when variances were homogeneous. In addition, the Kruskal-Wallis test was used when variances were heterogeneous. In all cases, the Tukey HSD was used for post hoc multiple comparisons, and Mann-Whitney U-test for comparisons of heterogenic subsets (Zar, 1996).

The independent-Sample T-Test was used to compare mean values for the nest size (height, width, depth) and nest location above ground, between the nests from two mountain ranges, and the nests from Peninsular Thailand and West Sumatra.

The Pearson Chi-square test with exact method was used to analyze the proportion of *P. flavicornis* Smith nests and colonies between different categories and families of plant.

Analyses were performed using the SPSS version 14.0 for Windows. In all cases, a P-value of 0.05 or less was considered statistically significant.

3.3 Results

The nesting sites and nest material of the four *Myrmatopa* species, *P. cnemidata* Emery, *P. constructor* Smith, *P. flavicornis* Smith and *P. varicolor* Viehmeyer were found and examined. In addition, the colony composition of *P. wartburgi* Forel was also examined.

3.3.1 Nesting sites

3.3.1.1 Nesting sites of *Polyrhachis cnemidata* Emery

Nests of *P. cnemidata* Emery were found on the underside of plant leaves. A total of 14 nests were measured for their size: height 1.93–9.23 cm (mean 4.61 ± 0.52 cm), width 1.55–4.78 cm (mean 2.56 ± 0.23 cm) and depth 0.14–1.72 cm (mean 0.81 ± 0.14 cm) while the number of entrances per nest ranged from 1 to 5 (n=14) (Table 1). They were located at 105.00-280.00 cm (mean 211.42 ± 7.99 cm, n = 31) from the ground (Table 2).

The mean values for nest size (height, width, depth) among the mountain ranges and Tarutao island were compared and the results of one-way ANOVA shows that no significant differences were detected among the three mountain ranges (Tenasserim, Khao Luang, Khao Banthat) and Tarutao island for nest size in their height (F = 0.75, df = 12, $P > 0.05$), width (F = 1.06, df = 12, $P > 0.05$) and depth (F = 1.52, df = 12, $P > 0.05$). However, the ANOVA test was not performed for their nest size (height, width, depth) in the Phuket mountain range because this group had fewer than two cases.

The mean values for nest location above ground among the mountain ranges and Tarutao island were compared and the results of one-way ANOVA showed that no significant differences were detected among the five mountain ranges (Tenasserim, Phuket, Khao Luang, Khao Banthat, Sunkalakhiri) and one island for nest location above ground (F = 2.39, df = 30, $P > 0.05$).

Table 1. Size of the nests and the number of entrances per nest for *P. cnemidata* Emery in Peninsular Thailand (Note: n = total number of nests).

Nest Structure	Mountain range				Tarutao island	Total
	Tenasserim (n=3)	Phuket (n=1)	Khao Luang (n=3)	Khao Banthat (n=5)		
Height (cm.)						
Range	3.23-4.92	-	2.35-9.23	3.48-6.16	2.52-4.76	1.93-9.23
Mean ± SE	3.93 ± 0.51	1.93	5.54 ± 2.00	5.38 ± 0.51	3.64 ± 1.12	4.61 ± 0.52
Width (cm.)						
Range	1.79-2.45	-	2.57-3.43	1.64-4.78	1.55-2.37	1.55-4.78
Mean ± SE	2.20 ± 0.21	1.78	2.98 ± 0.25	2.91 ± 0.52	1.96 ± 0.41	2.56 ± 0.23
Depth (cm.)						
Range	0.14-0.55	-	0.35-1.45	0.50-1.72	0.44-0.52	0.14-1.72
Mean ± SE	0.41 ± 0.13	1.62	0.75 ± 0.35	1.05 ± 0.23	0.48 ± 0.04	0.81 ± 0.14
No. of nest entrance (hole)						
Range	1-2	1	1-2	1-5	1-2	1-5

Table 2. Location of the nests above ground for *P. cnemidata* Emery in Peninsular Thailand (Note: n = total number of nests).

Nest location above ground (cm.)	Mountain range					Tarutao island	Total
	Tenasserim (n=6)	Phuket (n=7)	Khao Luang (n=5)	Khao Banthat (n=8)	Sunkala khiri (n=3)		
Range	215.00	105.00	120.00	180.00	185.00	165.00	105.00
	-280.00	-250.00	-245.00	-240.00	-250.00	-210.00	-280.00
Mean ± SE	255.00	192.86	184.40	212.75	225.00	187.50	211.42
	± 12.52	± 21.93	± 21.51	± 6.74	± 20.21	± 22.50	± 7.99

3.3.1.2 Nesting sites of *Polyrhachis constructor* Smith

Nests of *P. constructor* Smith were found on the underside of plant leaves or between leaves. They were located at 159.00-280.00 cm (mean 218.25 ± 14.49 cm, $n = 8$) from the ground. A total of 7 nests were measured for their size: height 1.74–10.53 cm (mean 5.85 ± 1.49 cm), width 1.51–5.66 cm (mean 3.50 ± 0.66 cm) and depth 0.22–0.95 cm (mean 0.51 ± 0.09 cm) while the number of entrances per nest in all cases was only one ($n=8$) (Table 3).

The mean values for nest size (height, width, depth) and nest location above ground among the mountain ranges were compared and the results of the independent-Sample T-Test showed that no significant differences were detected between the Tenasserim and Khao Banthat mountain range for nest size in their height ($F = 2.88$, $t = -2.18$, $df = 5$, $P > 0.05$), width ($F = 1.75$, $t = -2.03$, $df = 5$, $P > 0.05$), depth ($F = 1.70$, $t = -0.53$, $df = 5$, $P > 0.05$), and nest location above ground ($F = 2.87$, $t = 0.42$, $df = 5$, $P > 0.05$). Comparisons of the mean values for nest size (height, width, depth) and nest location above ground among the three mountain ranges (Tenasserim, Phuket, Khao Banthat) were not performed because the Phuket mountain range had fewer than two cases.

Table 3. Size and location of the nests, and the number of entrances per nest for *P. constructor* Smith in Peninsular Thailand (Note: n = total number of nests).

Nest structure and location	Mountain range			Total
	Tenasserim	Phuket	Khao Banthat	
Height (cm.)	(n=2)	-	(n=5)	(n=7)
Range	-	-	1.74-10.53	1.74-10.53
Mean \pm SE	1.82 \pm 0.00	-	7.46 \pm 1.55	5.85 \pm 1.49
Width (cm.)	(n=2)	-	(n=5)	(n=7)
Range	1.74-1.85	-	1.51-5.66	1.51-5.66
Mean \pm SE	1.80 \pm 0.04	-	4.18 \pm 0.70	3.50 \pm 0.66
Depth (cm.)	(n=2)	-	(n=5)	(n=7)
Range	0.37-0.48	-	0.22-0.95	0.22-0.95
Mean \pm SE	0.43 \pm 0.04	-	0.54 \pm 0.13	0.51 \pm 0.09
Location above ground (cm.)	(n=2)	(n=1)	(n=5)	(n=8)
Range	180.00-280.00	-	159.00-250.00	159.00-280.00
Mean \pm SE	230.00 \pm 35.36	220.00	213.20 \pm 17.83	218.25 \pm 14.49
No. of nest entrance (hole)	(n=2)	(n=1)	(n=5)	(n=8)
Range	1	1	1	1

3.3.1.3 Nesting sites of *Polyrhachis flavicornis* Smith

3.3.1.3.1 Nesting sites, categories and families of plants used for nesting in Peninsular Thailand

Nests of *P. flavicornis* Smith were found on the underside of plant leaves or between leaves. They were located at 58.00–271.00 cm (mean 171.00 ± 6.00 cm, $n = 65$) from the ground. A total of 64 nests were measured for their size: height 1.16–10.89 cm (mean 4.05 ± 0.23 cm), width 0.88–5.08 cm (mean 2.31 ± 0.11 cm) and depth 0.14–0.78 cm (mean 0.14 ± 0.78 cm). The number of entrances per nest ranged from 1 to 7 ($n=55$) (Table 4).

The mean values for nest size (height, width, depth) and nest location above ground among the mountain ranges were compared and the results of one-way ANOVA showed that no significant differences were detected among the four mountain ranges (Tenasserim, Phuket, Khao Luang, Khao Banthat) for nest size in their height ($F = 1.41$, $df = 64$, $P > 0.05$), width ($F = 1.97$, $df = 64$, $P > 0.05$), depth ($F = 1.17$, $df = 64$, $P > 0.05$), and nest location above ground ($F = 2.37$, $df = 64$, $P > 0.05$).

In this study, the most preferred plant type for nesting was in shrubs (43 nests, 32 colonies), followed by trees (15 nests, 14 colonies), climbers (6 nests, 5 colonies) and herb (1 nest, 1 colony) (Table 5). The Pearson Chi-square test showed that no differences were seen in the proportion of nests and colonies in each plant category among the four mountain ranges ($\chi^2_{0.05, 9} = 0.69, 0.53$, $P > 0.05$).

The frequency of *P. flavicornis* Smith nests and colonies on different plant families are shown in Table 6. The nests ($n = 65$) and forty-five colonies were found on 17 families of plants, but some plant samples could not be identified to the family level (Unknown spp.). The majority of nests and colonies were found on Euphorbiaceae spp. (24 nests, 19 colonies), followed by Rubiaceae (6 nests, 6 colonies), Annonaceae (5 nests, 4 colonies), Myrtaceae (4 nests, 3 colonies) and Fabaceae (3 nests, 3 colonies). With other plant families only one or two nests and colonies were found. The Pearson Chi-square test (Unknown plant spp. were excluded from the analyses) showed that no differences were seen in the proportion of nests and colonies in each host plant family among the four mountain ranges ($\chi^2_{0.05, 48} = 0.08, 0.17$, $P > 0.05$).

Table 4. Size, location of the nests, and the number of entrances per nest for *P. flavicornis* Smith in Peninsular Thailand (Note: n = total number of nests).

Nest structure and location	Mountain range				Total
	Tenasserim	Phuket	Khao Luang	Khao Banthat	
Height (cm.)	(n=11)	(n=6)	(n=13)	(n=34)	(n=64)
Range	2.49-6.85	1.66-4.79	1.66-6.09	1.16-10.89	1.16-10.89
Mean \pm SE	4.24 \pm 0.41	3.04 \pm 0.49	4.18 \pm 0.32	4.13 \pm 0.39	4.05 \pm 0.23
Width (cm.)	(n=11)	(n=6)	(n=13)	(n=34)	(n=64)
Range	1.04-3.96	0.96-3.85	1.18-4.28	0.88-5.08	0.88-5.08
Mean \pm SE	2.51 \pm 0.28	2.02 \pm 0.41	2.62 \pm 0.24	2.18 \pm 0.13	2.31 \pm 0.11
Depth (cm.)	(n=11)	(n=6)	(n=13)	(n=34)	(n=64)
Range	0.26-0.63	0.23-0.77	0.14-0.56	0.23-0.78	0.14-0.78
Mean \pm SE	0.43 \pm 0.03	0.50 \pm 0.08	0.36 \pm 0.04	0.44 \pm 0.02	0.43 \pm 0.02
Location above ground (cm.)	(n=11)	(n=7)	(n=13)	(n=34)	(n=65)
Range	98.00- 230.00	105.00- 220.00	58.00- 250.00	119.00- 270.00	58.00- 271.00
Mean \pm SE	155.00 \pm 12.00	163.00 \pm 15.00	154.00 \pm 16.00	185.00 \pm 7.00	171.00 \pm 6.00
No. of nest entrance (hole)	(n=7)	(n=3)	(n=11)	(n=34)	(n=55)
Range	2-3	1-3	1-6	1-7	1-7

Table 5. The frequency of *P. flavicornis* Smith nests and colonies on different plant categories in Peninsular Thailand (Note: Ne = nest, Co = colony and n = total number of nests).

Plant categories	Mountain range								Total	
	Tenasserim		Phuket		Khao Luang		Khao Banthat		Ne	Co
	Ne (n=11)	Co (n=9)	Ne (n=7)	Co (n=7)	Ne (n=13)	Co (n=7)	Ne (n=34)	Co (n=22)		
Shrub	10	8	4	3	8	6	21	15	43	32
Tree	1	1	3	4	3	3	8	6	15	14
Climber	-	-	-	-	2	2	4	3	6	5
Herb	-	-	-	-	-	-	1	1	1	1

In the same locality, colonies located near each other were often found on different plant categories (shrub, tree, climber and herb) and families. For example, in the Khao Banthat mountain range, some colonies were found both on shrubs and climbers, and on Euphorbiaceae and Fabaceae, respectively.

Overall, there were 3 colonies found in two plant categories; shrub and tree (2 colonies), shrub and climber (1 colony), and 2 colonies in three plant categories (shrub, climber and herb; shrub, tree and climber). Additionally, 9 colonies were found in more than one plant family (Euphorbiaceae and Rubiaceae; Euphorbiaceae and Fabaceae; Euphorbiaceae and Anacardiaceae; Euphorbiaceae and Unknown spp.; Rubiaceae and Fabaceae; Annonaceae and Unknown spp.; Dipterocarpaceae, Myrtaceae and Myrsinaceae; Annonaceae, Euphorbiaceae and Menispermaceae; Marattiaceae, Myrtaceae, Sterculiaceae and Unknown spp.).

Table 6. The frequency of *P. flavicornis* Smith nests and colonies on different plant families in Peninsular Thailand (Note: Ne = nest, Co = colony and n = total number of nests).

Plant family	Mountain range								Total	
	Tenasserim		Phuket		Khao Luang		Khao Banthat		Ne	Co
	Ne (n=11)	Co (n=9)	Ne (n=7)	Co (n=7)	Ne (n=13)	Co (n=7)	Ne (n=34)	Co (n=22)		
1. Euphorbia- ceae	5	4	1	1	4	4	14	10	24	19
2. Rubiaceae	1	1	1	1	-	-	4	4	6	6
3. Annonaceae	2	2	-	-	2	1	1	1	5	4
4. Myrtaceae	-	-	-	-	1	1	3	2	4	3
5. Fabaceae	-	-	-	-	-	-	3	3	3	3
6. Dipterocar- paceae	-	-	-	-	2	2	-	-	2	2
7. Flacourtiaceae	-	-	-	-	-	-	2	2	2	2
8. Myristicaceae	-	-	1	1	-	-	1	1	2	2
9. Anacardia- ceae	-	-	-	-	1	1	-	-	1	1
10. Areaceae	-	-	1	1	-	-	-	-	1	1
11. Clusiaceae	-	-	-	-	-	-	1	1	1	1
12. Ebenaceae	-	-	1	1	-	-	-	-	1	1
13. Marattia- ceae	-	-	-	-	-	-	1	1	1	1
14. Melastoma- taceae	-	-	-	-	1	1	-	-	1	1
15. Menisper- maceae	-	-	-	-	1	1	-	-	1	1
16. Myrsinaceae	-	-	-	-	1	1	-	-	1	1
17. Sterculiaceae	-	-	-	-	-	-	1	1	1	1
18. Unknown spp.	3	3	2	2	-	-	3	3	8	8

3.3.1.3.2 Comparison of nesting sites between Peninsular Thailand and West Sumatra, Indonesia

Nests of *P. flavicornis* Smith in West Sumatra, Indonesia were found on the underside of plant leaves. They were located at 120.00-235.00 cm (mean 185.00 ± 22.00 cm, $n = 5$) from the ground (Table 7).

The mean values for nest location above ground between the Peninsular Thailand and West Sumatra, Indonesia was compared and the results of Independent-Sample T-Test shows that no significant difference was detected between the Peninsular Thailand and West Sumatra for nest location above ground ($F = 0.152$, $t = -0.67$, $df = 68$, $P > 0.05$).

Table 7. Location of the nests above ground for *P. flavicornis* Smith in Peninsular Thailand and West Sumatra, Indonesia (Note: n = total number of nests).

Nest location above ground (cm.)	Peninsular Thailand ($n=65$)	West Sumatra ($n=5$)	Total ($n=70$)
Range	58.00-271.00	120.00-235.00	58.00-271.00
Mean \pm SE	171.00 ± 6.00	185.00 ± 22.00	172.00 ± 5.00

3.3.1.4 Nesting sites of *Polyrhachis varicolor* Viehmeyer

Nests of *P. varicolor* Viehmeyer were found on the underside of plant leaves or between leaves. They were located at 137.00-280.00 cm (mean 204.62 ± 12.80 cm, $n = 13$) from the ground. A total of 8 nests were measured for their size: height 2.64–12.13 cm (mean 5.74 ± 1.12 cm), width 1.73–3.07 cm (mean 2.40 ± 0.16 cm) and depth 0.25–1.45 cm (mean 0.77 ± 0.17 cm). The number of entrances per nest ranged from 1 to 5 ($n=8$) (Table 8).

The mean values for nest size (height, width, depth) and nest location above ground among the mountain ranges were compared and the results of Independent-Sample T-Test shows that no significant differences were detected between the Tenasserim and Khao Banthat mountain range for nest size in their height ($F = 3.55$, $t = 0.34$, $df = 5$, $P > 0.05$), width ($F = 0.01$, $t = 0.21$, $df = 5$, $P > 0.05$), depth ($F = 5.41$, $t = 0.50$, $df = 5$, $P > 0.05$), and nest location above ground ($F = 3.02$, $t = 1.30$, $df = 10$, $P > 0.05$). Comparison of the mean values for nest size (height, width, depth) and nest location above ground among the three mountain ranges (Tenasserim, Khao Luang, Khao Banthat) were not performed because the Khao Luang mountain range has fewer than two cases.

Table 8. Size, location of the nests, and the number of entrances per nest for *P. varicolor* Viehmeyer in Peninsular Thailand (Note: n = total number of nests).

Nest structure and location	Mountain range			Total
	Tenasserim	Khao Luang	Khao Banthat	
Height (cm.)	(n=5)	(n=1)	(n=2)	(n=8)
Range	2.64-12.13	-	3.94-6.29	2.64-12.13
Mean \pm SE	6.16 \pm 1.81	4.92	5.12 \pm 1.18	5.74 \pm 1.12
Width (cm.)	(n=5)	(n=1)	(n=2)	(n=8)
Range	1.73-3.07	-	1.94-2.68	1.73-3.07
Mean \pm SE	2.40 \pm 0.23	2.54	2.31 \pm 0.37	2.40 \pm 0.16
Depth (cm.)	(n=5)	(n=1)	(n=2)	(n=8)
Range	0.25-1.45	-	0.36-0.74	0.25-1.45
Mean \pm SE	0.76 \pm 0.25	1.28	0.55 \pm 0.19	0.77 \pm 0.17
Location above ground (cm.)	(n=9)	(n=1)	(n=3)	(n=13)
Range	138.00-280.00	-	164.00-200.00	137.00-280.00
Mean \pm SE	219.33 \pm 15.36	137.00	183.00 \pm 10.44	204.62 \pm 12.80
No. of nest entrance (hole)	(n=5)	(n=1)	(n=2)	(n=8)
Range	2-5	1	1-2	1-5

3.3.1.5 Comparison of nesting sites among the different species of *Myrmatopa*

The mean values for nest size (height, width, depth) and the number of entrances per nest among the different species were compared (Table 9A) and the results of one-way ANOVA shows that no significant differences were detected among the four species (*P. cnemidata* Emery, *P. constructor* Smith, *P. flavicornis* Smith, *P. varicolor* Viehmeyer) for nest size in their height ($F=2.57$, $df = 92$, $P>0.05$). On the other hand, there were significant differences among these four species for nest size in their width ($F=3.65$, $df = 92$, $P<0.05$) and depth ($F=9.87$, $df = 92$, $P<0.05$). In addition, the number of entrances per nest overlapped in their range.

The mean values for nest location above ground among the different species was compared (Table 9A) and the results of one-way ANOVA found significant differences among the four species (*P. cnemidata* Emery, *P. constructor* Smith, *P. flavicornis* Smith, *P. varicolor* Viehmeyer) for nest location above ground ($F=7.82$, $df = 116$, $P<0.05$). The ANOVA test was not performed for their nest location above ground for *P. wartburgi* Forel because this group had fewer than two cases.

The results of post hoc multiple comparisons test are shown in Table 9B. The mean values of nest width for *P. constructor* Smith was higher than for *P. flavicornis* Smith (Tukey HSD, $P<0.05$), while the mean values of nest depth for *P. cnemidata* Emery and *P. varicolor* Viehmeyer was higher than for *P. flavicornis* Smith (Tukey HSD, $P<0.05$). Moreover, the mean values of nest location above ground for *P. cnemidata* Emery and *P. constructor* Smith was higher than for *P. flavicornis* Smith (Tukey HSD, $P<0.05$).

Table 9 (A-B). Size, location of the nests, the number of entrances per nest and multiple comparisons tests among the different species of *Myrmatopa* in Peninsular Thailand (Note: n = total number of nests).

Table 9A. Size, location of the nests and the number of entrances per nest among the different species of *Myrmatopa*.

Nest structure and location	Species				
	<i>P. cnemidata</i> Emery (n=14)	<i>P. constructor</i> Smith (n=7)	<i>P. flavicornis</i> Smith (n=64)	<i>P. varicolor</i> Viehmeyer (n=8)	<i>P. wartburgi</i> Forel (n=1)
Height (cm.)					-
Range	1.93-9.23	1.74-10.53	1.16-10.89	2.64-12.13	-
Mean ± SE	4.61 ± 0.52	5.85 ± 1.49	4.05 ± 0.23	5.74 ± 1.12	-
Width (cm.)					-
Range	1.55-4.78	1.51-5.66	0.88-5.08	1.73-3.07	-
Mean ± SE	2.56 ± 0.23	3.50 ± 0.66	2.31 ± 0.11	2.40 ± 0.16	-
Depth (cm.)					-
Range	0.14-1.72	0.22-0.95	0.14-0.78	0.25-1.45	-
Mean ± SE	0.81 ± 0.14	0.51 ± 0.09	0.43 ± 0.02	0.77 ± 0.17	-
Location above ground (cm.)	(n=31)	(n=8)	(n=65)	(n=13)	(n=1)
Range	105.00- 280.00	159.00 -280.00	58.00 -271.00	137.00- 280.00	-
Mean ± SE	211.42 ± 7.99	218.25 ± 14.49	171.00 ± 6.00	204.62 ± 12.80	120.00
No. of nest entrance (hole)	(n=14)	(n=8)	(n=55)	(n=8)	-
Range	1-5	1	1-7	1-5	-

Table 9B. Multiple comparisons tests among the different species of *Myrmatopa* for nest size (width, depth) and nest location above ground.

Nest structure and location	Comparison	Mean diff	P
Width	<i>P. constructor</i> Smith vs <i>P. flavicornis</i> Smith	1.19	<0.05
Depth	<i>P. cnemidata</i> Emery vs <i>P. flavicornis</i> Smith	0.38	<0.05
	<i>P. varicolor</i> Viehmeyer vs <i>P. flavicornis</i> Smith	0.35	<0.05
Location above ground	<i>P. cnemidata</i> Emery vs <i>P. flavicornis</i> Smith	40.27	<0.05
	<i>P. constructor</i> Smith vs <i>P. flavicornis</i> Smith	47.10	<0.05

3.3.2 Nest Material

All four species of *Myrmatopa* in Peninsular Thailand have arboreal nests, and the nest material was randomly sampled from nests on different colonies and localities. In all samples (17 nests) of the four species, the nest material (wall) was ‘carton’ and other material (Table 10). The ‘carton’ material was made up from fine and coarse particulate material, while the other material was plant tissue fragments and silk from unknown sources. Silk sheets composed of thin layers of similarly sized silk strands, were found in the nest wall structure of *P. constructor* Smith (Fig. 180: A-F), *P. flavicornis* Smith (Fig. 181: A-F) and *P. varicolor* Viehmeyer (Fig. 182: A-F), with one exception. There was no evidence for silk strands in the nest wall structure of *P. cnemidata* Emery (Fig. 179: A-F) (Table 12). In general there were no distinct differences observed among the nest wall structures of each species from different colonies and localities (Fig. 179-182).

Table 10. Nest material among the different *species*-groups and species of *Myrmatopa* in Peninsular Thailand (Note: n = number of randomly sampled nests, + = present and - = absent).

Nest material	<i>flavicornis</i> -group		<i>schang</i> -group	<i>wallacei</i> -group
	<i>P. constructor</i> Smith (n=3)	<i>P. flavicornis</i> Smith (n=7)	<i>P. cnemidata</i> Emery (n=4)	<i>P. varicolor</i> Viehmeyer (n=3)
Silk sheets	+	+	-	+
Carton material	+	+	+	+
Other material	+	+	+	+

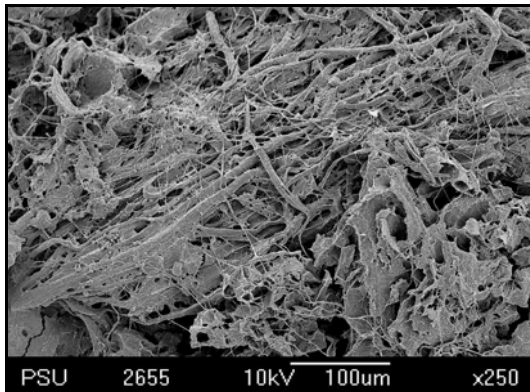


Figure 179: A

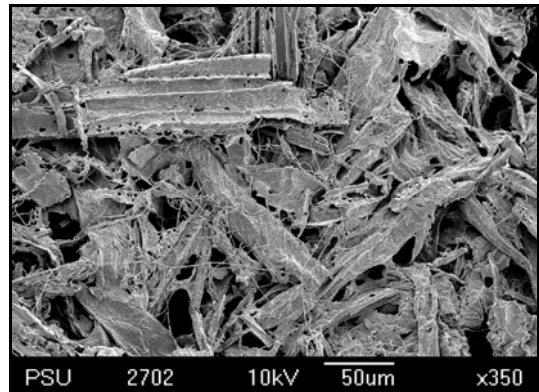


Figure 179: B

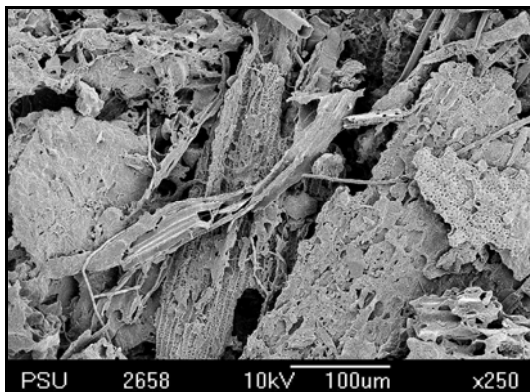


Figure 179: C

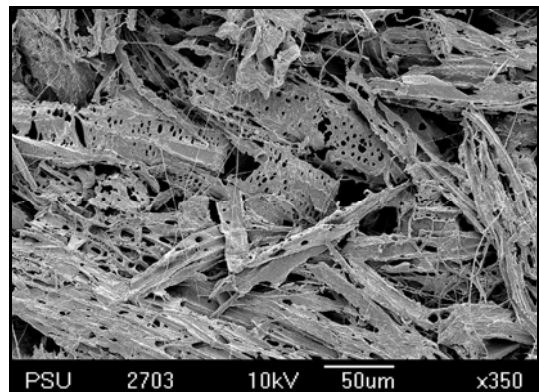


Figure 179: D

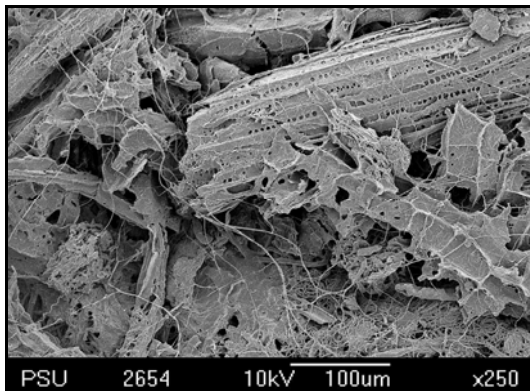


Figure 179: E

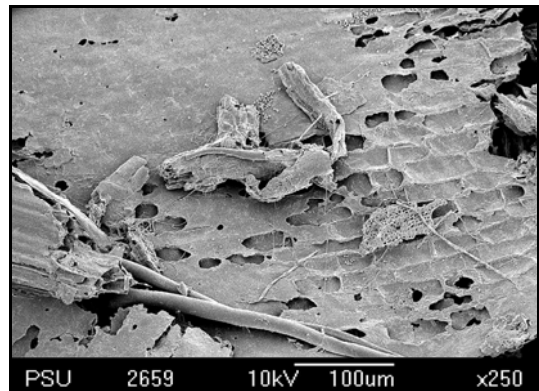


Figure 179: F

Figure 179. The nest wall structure of *P. cnemidata* Emery.

(A)-(F) Carton material (fine and coarse particulate material) and other material (plant tissue fragments and silk from an unknown source).

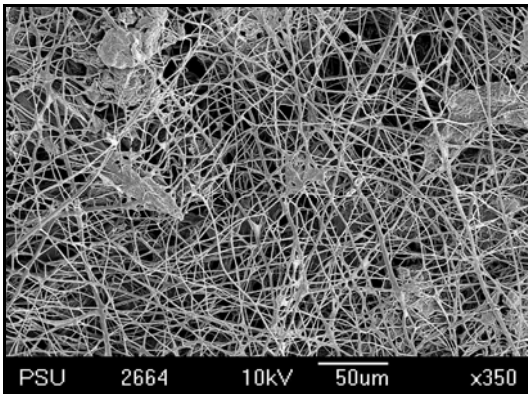


Figure 180: A

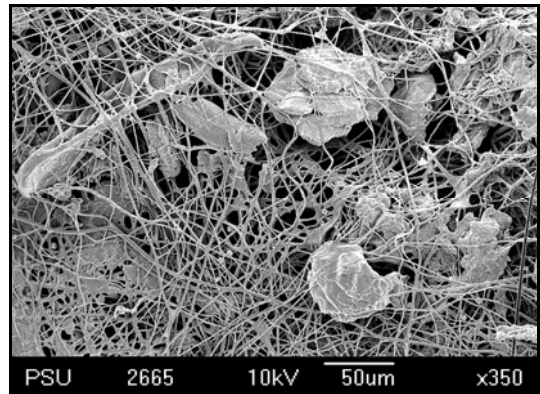


Figure 180: B

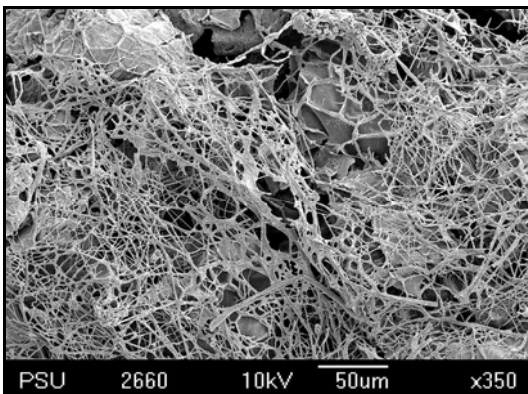


Figure 180: C

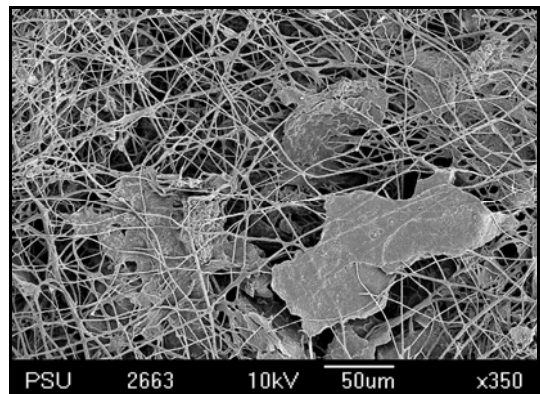


Figure 180: D

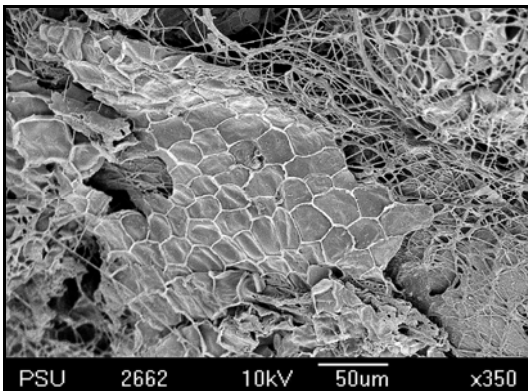


Figure 180: E

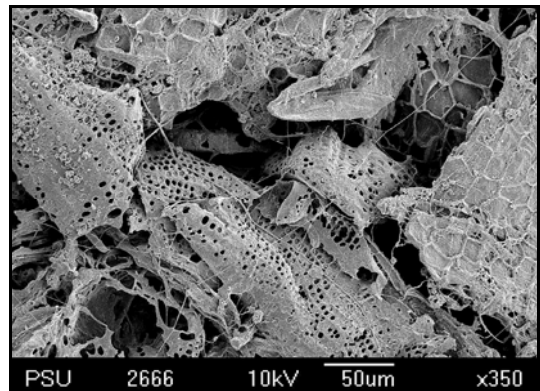


Figure 180: F

Figure 180. The nest wall structure of *P. constructor* Smith.

(A) Silk sheet (thin layers of similarly sized silk strands) and carton material (fine and coarse particulate material).

(B)-(F) Silk sheet, carton and other material covering the silk sheet.

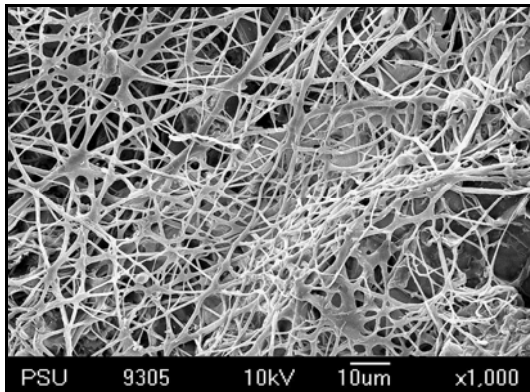


Figure 181: A

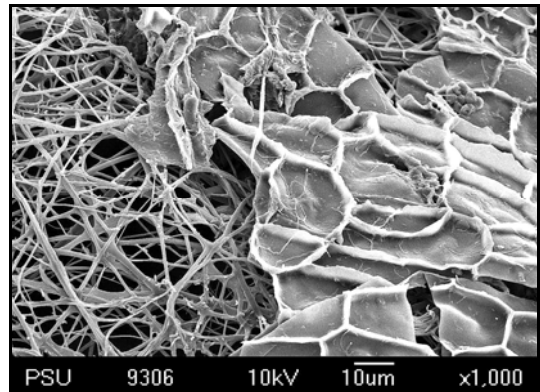


Figure 181: B

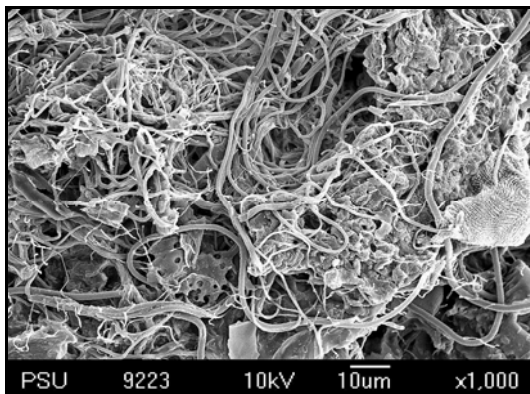


Figure 181: C

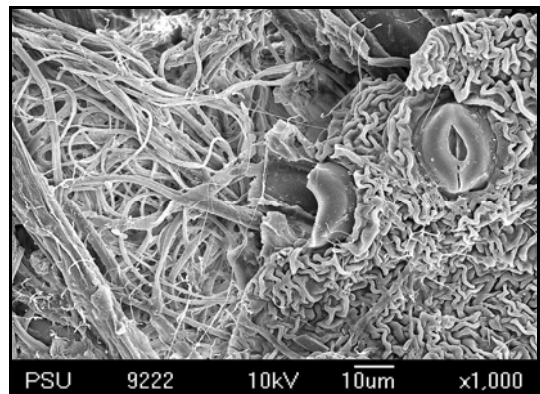


Figure 181: D

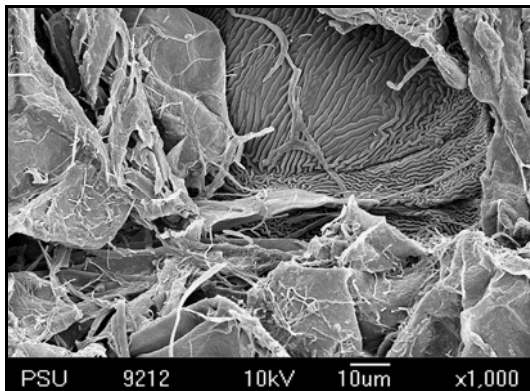


Figure 181: E

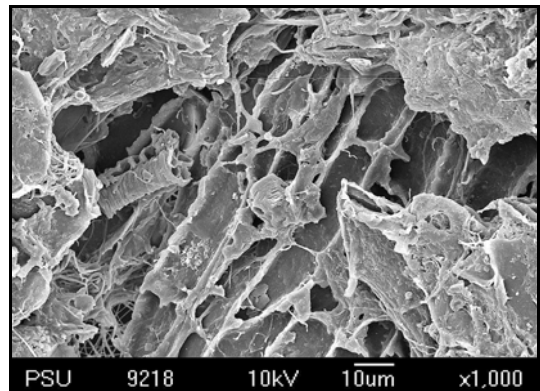


Figure 181: F

Figure 181. The nest wall structure of *P. flavicornis* Smith.

(A) Silk sheet (thin layers of similarly sized silk strands). (B) Carton material covering the silk sheet. (C)-(F) Carton (fine and coarse particulate material) and other material covering the silk sheet.

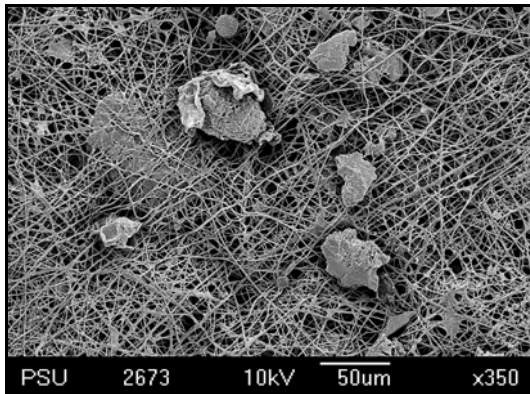


Figure 182: A

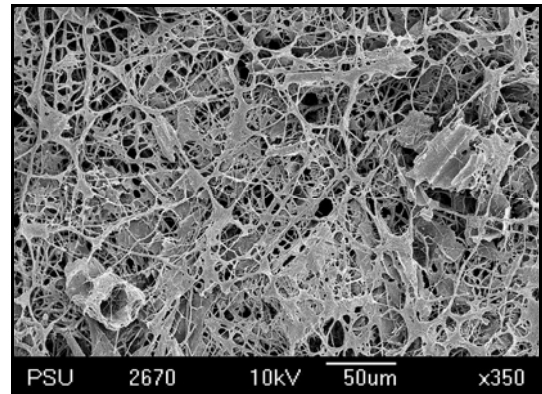


Figure 182: B

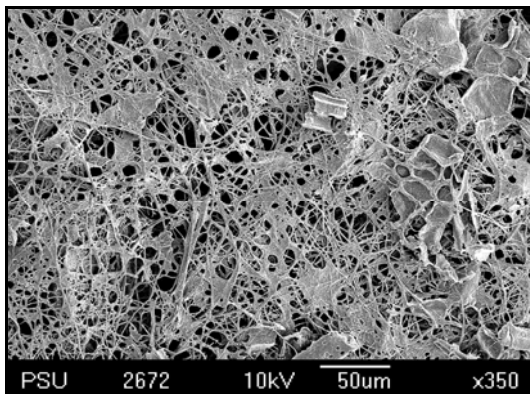


Figure 182: C

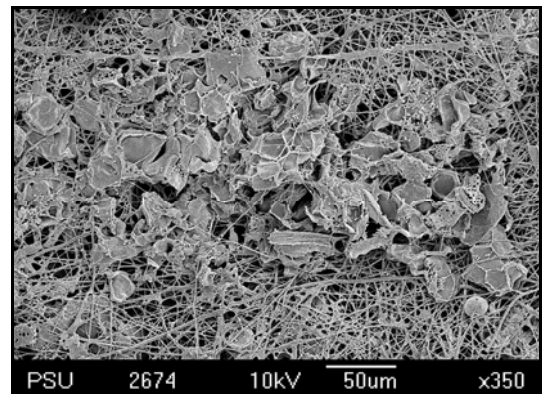


Figure 182: D

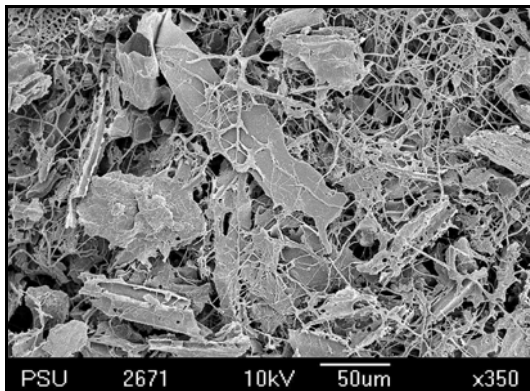


Figure 182: E

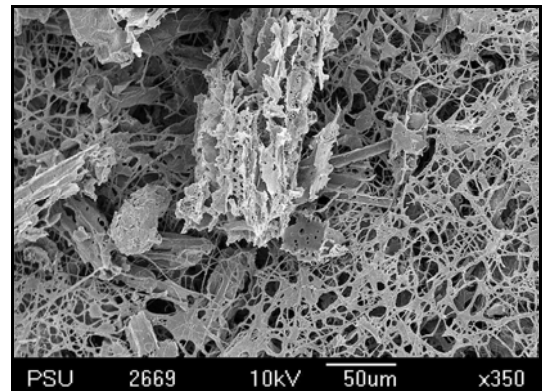


Figure 182: F

Figure 182. The nest wall structure of *P. varicolor* Viehmeyer

(A)-(F) Silk sheet (thin layers of similarly sized silk strands), carton (fine and coarse particulate material), and other material (plant tissue fragments and silk from an unknown source) covering the silk sheet.

3.3.3 Colony Composition

3.3.3.1 Colony composition of *Polyrhachis cnemidata* Emery

The colony composition of *P. cnemidata* Emery from each mountain range of the Peninsular Thailand and on Tarutao island is shown in Table 11. Observations on 27 nests (26 colonies) showed that each colony consisted of 1-2 nests and that the numbers of different castes were distributed over several nests of a colony. The number of dealate queens per colony was 0-1, thus indicating that each colony of this species is generally monogynous. The colonies were relatively small and the number of workers present ranged from 1 to 170. Winged queens and males were found in 9 and 12 colonies and ranged from 0 to 140 and 0 to 19, respectively.

Table 11. Colony composition of *P. cnemidata* Emery from Peninsular Thailand
(Note: n = total number of colonies).

Nests and adults of different castes	Numbers per colony						Total range (n =26)
	Tenasserim (n =6)	Phuket (n =5)	Khao Luang (n =5)	Khao Banthat (n=5)	Sunkala khiri (n =3)	Tarutao island (n =2)	
Nests	1	1-2	1	1	1	1	1-2
Dealate queens	0-1	0-1	0-1	0-1	1	0-1	0-1
Winged queens	0-2	0-140	0-2	0-45	0-5	0-9	0-140
Males	0-2	0-19	0-12	0-10	0-13	0-13	0-19
Workers	6-48	15-159	1-170	2-110	28-63	17-85	1-170

3.3.3.2 Colony composition of *Polyrhachis constructor* Smith

The colony composition of *P. constructor* Smith from each mountain range of Peninsular Thailand is shown in Table 12. Observations on 8 nests (8 colonies) showed that each colony consisted of one nest and that the numbers of different castes were distributed over one nest of a colony. The number of dealate queens per colony was 0-1, thus indicating that the colony of this species is generally monogynous. The colonies were relatively small and the number of workers present ranged from 2 to 86. Winged queens and males were found in 2 and 1 colonies, and ranged from 0 to 7 and 0 to 24, respectively.

Table 12. Colony composition of *P. constructor* Smith from Peninsular Thailand
(Note: n = total number of colonies).

Nests and adults of different castes	Numbers per colony			
	Tenasserim (n =2)	Phuket (n=1)	Khao Banthat (n=5)	Total range (n=8)
Nests	1	1	1	1
Dealate queens	1	1	0-1	0-1
Winged queens	0-1	0	0-7	0-7
Males	0	0	0-24	0-24
Workers	2-4	2	2-86	2-86

3.3.3.3 Colony composition of *Polyrhachis flavicornis* Smith

The colony composition of *P. flavicornis* Smith from each mountain range of Peninsular Thailand and from West Sumatra, Indonesia is shown in Table 13. Observations on the 65 nests (45 colonies) from Peninsular Thailand and the 5 nests (4 colonies) from West Sumatra, showed that each colony consisted of 1-5 and 1-2 nests, respectively, and that members of different castes were distributed over several nests of a colony. The number of dealate queens per colony was 0-1 from both locations, thus indicating that the colony of this species is generally monogynous. The colonies were relatively small and the number of workers present ranged from 2 to 307. Winged queens and males were found in 7 and 4 colonies, and ranged from 0 to 39 and 0 to 8, respectively from the colonies in Peninsular Thailand. In addition, winged queens and males were found in 4 and 1 colonies, and ranged from 1 to 8 and 0 to 1, respectively from the colonies in West Sumatra, Indonesia.

Table 13. Colony composition of *P. flavicornis* Smith from Peninsular Thailand and West Sumatra, Indonesia (Note: n = total number of colonies).

Nests and adults of different castes	Numbers per colony				
	Peninsular Thailand (n=45)				West Sumatra (n=4)
	Tenasserim (n=9)	Phuket (n=7)	Khao Luang (n=7)	Khao Banthat (n=22)	
Nests	1-2	1	1-4	1-5	1-2
Dealate queens	0-1	0-1	0-1	0-1	0-1
Winged queens	0-6	0	0-39	0-24	1-8
Males	0-2	0	0-4	0-8	0-1
Workers	31-156	2-30	26-185	2-307	25-69

3.3.3.4 Colony composition of *Polyrhachis varicolor* Viehmeyer

The colony composition of *P. varicolor* Viehmeyer from each mountain range of Peninsular Thailand is shown in Table 14. Observations on the 14 nests (11 colonies) showed that each colony consisted of 1-3 nests and that numbers of different castes were distributed over several nests of a colony. The number of dealate queens per colony was 0-1, thus indicating that the colony of this species is generally monogynous. The colonies were relatively small and the number of workers present ranged from 1 to 251. Both winged queens and males were found in only one colony, and ranged from 0 to 6 and 0 to 8, respectively.

Table 14. Colony composition of *P. varicolor* Viehmeyer from Peninsular Thailand
(Note: n = total number of colonies).

Nests and adults of different castes	Numbers per colony			
	Tenasserim (n =6)	Khao Luang (n=2)	Khao Banthat (n=3)	Total range (n=11)
Nests	1-3	1	1	1-3
Dealate queens	0-1	0-1	0-1	0-1
Winged queens	0	0	0-6	0-6
Males	0	0	0-8	0-8
Workers	31-251	1-146	39-151	1-251

3.3.3.5 Colony composition of *Polyrhachis wartburgi* Forel

There was only one colony of *P. wartburgi* Forel found in the Khao Bantat mountain range of Peninsular Thailand and its composition is shown in Table 15. There was one dealate queen in the colony. The colony was relatively small and the number of workers present was 391, while the number of winged queens and males were 4 and 34, respectively.

Table 15. Colony composition of *P. wartburgi* Forel from Peninsular Thailand (Note: n = total number of colonies).

Nests and adults of different castes	Numbers per colony (n=1)
Nests	1
Dealate queens	1
Winged queens	4
Males	34
Workers	391

3.3.3.6 Colony composition among the different species of *Myrmatopa*

The colony composition among the five different species of *Myrmatopa* in Peninsular Thailand is shown in Table 16. Observations on the 114 nests (91 colonies) showed that each species consisted of at least one nest and that the numbers of different castes were distributed over several nests of a colony. In addition, the number of dealate queens per colony, indicated that the colonies of four of the five species (not including *P. wartburgi* Forel) is generally monogynous. The number of workers and males was higher in the *P. wartburgi* Forel colony than in the other four *Myrmatopa* species. However, the highest number of winged queens per colony was in the *P. cnemidata* Emery colonies.

Table 16. Colony composition among the different species of *Myrmatopa* from Peninsular Thailand (Note: n = total number of colonies).

Nests and adults of different castes	Numbers per colony				
	<i>P. cnemidata</i> Emery (n=26)	<i>P. constructor</i> Smith (n=8)	<i>P. flavicornis</i> Smith (n=45)	<i>P. varicolor</i> Viehmeyer (n=11)	<i>P. wartburgi</i> Forel (n=1)
Nests	1-2	1	1-5	1-3	1
Dealate queens	0-1	0-1	0-1	0-1	1
Winged queens	0-140	0-7	0-39	0-6	4
Males	0-19	0-24	0-8	0-8	34
Workers	1-170	2-86	2-307	1-251	391

3.4 Discussion

3.4.1 Nesting sites

This study indicated that five *Myrmatopa* species (*P. cnemidata* Emery, *P. constructor* Smith, *P. flavicornis* Smith, *P. wartburgi* Forel and *P. varicolor* Viehmeyer) were similar in that in the lowland tropical rain forest they nested on the lower vegetation using plant leaves. However, many species with the exception of one species, *P. constructor* Smith, were all collected by canopy fogging in Peninsular Thailand (Noon-anant & Watanasit, 2003). Consequently, the nesting sites of *P. cnemidata* Emery, *P. flavicornis* Smith, *P. wartburgi* Forel and *P. varicolor* Viehmeyer might also be found in the tree canopies, just as are the other five *Myrmatopa* species from the Indo-Malayan subregion (*P. dolomedes* Smith, *P. lombokensis* Emery, *P. schang* Forel, *P. solmsi* Emery and *P. subtridens* Emery) that do make arboreal nests (Robson & Kohout, 2007).

Various types of plants and plant families were used for the nests of *P. flavicornis* Smith in Peninsular Thailand, not only in different localities but also in the same locality. In addition, some colonies were found in more than one plant type and family. This indicates that *P. flavicornis* Smith has no obligate association with any particular plant. However, the majority of nests were collected from the plant families Euphorbiaceae, Rubiaceae and Annonaceae. This is not surprising as these families are invariably among the ten most species rich families in all regions of the tropical rain forests in the world (Whitmore, 1998).

The nests of *P. flavicornis* Smith in West Sumatra, Indonesia and Peninsular Thailand were located at similar distances from the ground with no statistical difference in their mean values. As mentioned by Wilson (1959), nesting space in the tropical rain forest is regarded as a limited resource for ants. The *Myrmatopa* species in the Indo-Malayan subregion, may have become specialized in building their nests in this finely partitioned niche of the lower vegetation, in order to reduce the competition from other arboreal ants.

In this study, the mean values of nest width for *P. constructor* Smith was higher than for *P. flavicornis* Smith, while *P. cnemidata* Emery and *P. varicolor* Viehmeyer were different from *P. flavicornis* Smith in their mean values of nest depth. Moreover, the mean values of nest location above ground for *P. cnemidata* Emery and *P. constructor* Smith was higher than for *P. flavicornis* Smith. On the other hand, the nest size (height, width, depth), nest location above ground and the number of entrances per nest, overlapped in their range among the five species. As a result, this study indicated that there was a remarkable difference in nest width, nest depth and the distance of the nest above ground among three species (*P. cnemidata* Emery, *P. constructor* Smith, *P. flavicornis* Smith). It indicated that *P. constructor* Smith might be restricted to the lower vegetation for its nesting and foraging sites. On the other hand, *P. cnemidata* Emery and *P. flavicornis* Smith might be found in more than one stratum of the vertical forest structure for their nesting and foraging sites, as well as, *P. varicolor* Viehmeyer and *P. wartburgi* Forel, that were collected from the canopy using fogging and the lower vegetation in Peninsular Thailand (Noon-anant & Watanasit, 2003). Moreover, *P. flavicornis* Smith might prefer a broad vertical distribution range for its nesting and foraging sites from the lower vegetation to the

canopy, than did *P. cnemidata* Emery. At the same time, the nest size (height, width and depth), and the number of entrances per nest, including the colony size and structure, might also depend on the different stages of the colony life cycle and the habitat preference such as, the vertical forest structure, disturbances and microclimate.

3.4.2 Nest Material

The nest material of the four *Myrmatopa* species (*P. cnemidata* Emery, *P. constructor* Smith, *P. flavicornis* Smith and *P. varicolor* Viehmeyer) in the lowland tropical rain forest of Peninsular Thailand contained ‘carton’ material composed of both coarse and finely particulate material, while the silk sheets were incorporated into the nest wall structure, with the exception of only a single species, *P. cnemidata* Emery. Most literature sources have shown that many species within the subgenus *Myrmatopa* can include silk in their nests by such as: *P. dolomedes* Smith, *P. lombokensis* Emery, *P. solmsi* Emery and *P. subtridens* Emery, but the single species, *P. schang* Forel which is very similar to *P. cnemidata* Emery in terms of the morphological characteristics of their workers, did not (Robson & Kohout, 2007).

This study provides the first record of the composition of the nests of *Myrmatopa* species from continental Asia, and is consistent with both the previous descriptions from other regions and the primary literature on the incorporation of flat sheets of larval silk into their nests. Not only do other species of *Myrmatopa*, not found in the continental Asia, such as *P. osae* Mann and *P. ulyssees* Forel, incorporate flat silk sheets into their nests but so do other subgenera of *Polyrhachis* distributed in the Peninsular Thailand, for example, *P. (Hemioptica) boltoni* Dorow & Kohout, *P. (Myrmholpa) armata* (LeGuillou) and *P. (Myrmhopla) muelleri* Forel (Bolton, 1995b; Noon-anant & Watanasit 2003; Robson & Kohout, 2005, 2007). On the other hand, there is no evidence that the two predominantly ground nesting subgenera, *Chariomyrma* and *Hagiomyrma*, such as *P. (Hagiomyrma) thusnelda* Forel incorporate flat sheets of larval silk into their nest structure. Their nest material is composed entirely of ‘carton’ material (Robson & Kohout, 2004, 2007). Additionally, spider silk has been found in the nests of at least four *Polyrhachis* species, for example, *P. (Cyrtomyrma) australis* Mayr, *P. (Cyrtomyrma) pilosa* Donisthorpe, *P.*

(*Myrma*) *laboriosa* Smith, and *P. (Hedomyrma) turneri* Forel construct their entire nests from spider silk (Robson & Kohout, 2007).

The construction of nests with flat sheets of larval silk is common and has been found in representatives from seven of the nine ant subgenera *Cyrtomyrma*, *Hemioptica*, *Myrma*, *Myrmatopa*, *Myrmhopla*, *Myrmothrinax* and *Polyrhachis* (Robson & Kohout, 2005, 2007). However, it was difficult to clearly distinguish between *Myrmatopa* and the other arboreal nesting subgenera, such as, *Myrmhopla* and *Myrmothrinax* based only on their nest material because the nests of these species and the four *Myrmatopa* species are covered with carton material (Robson & Kohout, 2005, 2007). As claimed by Hung (1967) and Robson & Kohout (2005, 2007), the use of larval silk and other materials, such as coarse or finely particulate material, for nest construction might have evolved independently within the genus *Polyrhachis*.

3.4.3 Colony Composition

In this study we found that *P. cnemidata* Emery, *P. constructor* Smith, *P. flavicornis* Smith and *P. varicolor* Viehmeyer have a polydomous colony structure, with colony members being distributed over several nests, and they are generally monogynous, as in *P. (Myrmatopa) lombokensis* Forel (Robson & Kohout, 2007) and the other arboreal species of *Polyrhachis*, distributed in the lowland tropical rain forest of Peninsular Thailand and West Malaysia, such as *P. (Hemioptica) boltoni* Dorrow & Kohout, *P. (Myrma) nigropilosa* Mayr, *P. (Myrmhopla) bicolor* F. Smith, *P. (Myrmhopla) furcata* Smith and *P. (Myrmhopla) muelleri* Forel (Dorow & Kohout 1995; Liefke *et al.*, 1998; Robson & Kohout, 2007). The situation differs from that of the polygynous colonies of a single species of the subgenus *Myrmatopa*, *P. osae* Mann, found in the Solomon islands (Mann, 1919), the polydomous nests and multiple queen colonies of a single arboreal species of *Polyrhachis* we found in the lowland tropical rain forest of Peninsular Thailand and West Malaysia, *P. (Myrmhopla) dives* Smith (Liefke *et al.*, 1998; Noon-anant & Watanasit 2003; Robson & Kohout, 2007), and the polydomous *Myrmicaria* species found on the lower vegetation (Yamane & Bakhtiar, pers. com.). Although the one *P. wartburgi* Forel

colony we found in this study, had a dealate queen we cannot make predictions based on only one nest.

One possible explanation for the finding that *Myrmatopa* species and other arboreal species of *Polyrhachis*, have a polydomous colony structure, is that it may reduce the distances between foraging sites and their nests. Sudd & Franks (1987) and Hölldobler & Wilson (1990) concluded that polydomous ants like *Oecophylla longinoda* (Latreille) catch their food and bring it back to a central place before they distribute the foodstuffs to the nearby nests. Thus, having a polydomous colony structure, where the colony members were distributed over several nests, might favor the arboreal *Polyrhachis* species, giving them more advantages and allowing for a larger foraging range in the lowland tropical rain forests of the Indo-Malayan subregion.

Studies on the nesting habits and socioecology of most *Myrmatopa* species of the Indo-Malayan subregion are extremely limited especially of the species with a small colony in the lower vegetation and canopy. However, the information provided in this study adds useful knowledge to the socioecology of the subgenus *Myrmatopa*, and facilitates an understanding of the socioecology and phylogeny of the genus *Polyrhachis*.

CHAPTER 4

CONCLUSIONS AND FUTURE PERSPECTIVES

A total of 21 *Myrmatopa* species are recognized from the Indo-Malayan subregion based on the external morphological characteristics of the workers, belonging to four species-groups: *flavicornis*-group (*P. antedoridens* sp. nov., *P. constructor* F. Smith, *P. flavicornis* F. Smith, *P. kohouti* sp. nov. and *P. varicolor* Viehmeyer); *schang*-group (*P. cnemidata* Emery stat. nov., *P. dolomedes* F. Smith, *P. parvicella* Forel stat. nov., *P. solmsi* Emery and *P. tawauensis* sp. nov.); *simillima*-group (*P. angusticlypealis* sp. nov., *P. simillima* Emery, *P. watanasiti* sp. nov. and *P. wiwatwitayai* sp. nov.) and *wallacei*-group (*P. jacobsoni* Forel, *P. lilianae* Forel, *P. lombokensis* Emery, *P. subtridens* Emery, *P. vanispina* sp. nov., *P. wartburgi* Forel and *P. yamanei* sp. nov.). The neotype for *P. wartburgi* Forel is designated. Description and information on geographical distribution and bionomics are given for each species. In addition, keys to species-groups and species are provided for identification of workers.

For 11 *Myrmatopa* species in three species-groups queens are known that are associated with workers: *flavicornis*-group (*P. constructor* F. Smith, *P. flavicornis* F. Smith and *P. varicolor* Viehmeyer); *schang*-group (*P. cnemidata* Emery stat. nov., *P. dolomedes* F. Smith, *P. parvicella* Forel stat. nov. and *P. solmsi* Emery) and *wallacei*-group (*P. jacobsoni* Forel, *P. lilianae* Forel, *P. lombokensis* Emery and *P. wartburgi* Forel). A provisional key is proposed to species-groups and species for which the worker-queen association was available. Key to species of the *schang*-group has been omitted due to the limitation of the material and absence of discriminating characteristics.

There was a remarkable difference in nest width, nest depth and nest location above ground among three *Myrmatopa* species (*P. cnemidata* Emery, *P. constructor* Smith and *P. flavicornis* Smith). However, the nest size of nest (height, width, depth), nest location above ground and the number of entrances per nest, were

overlapping among the five species (*P. cnemidata* Emery, *P. constructor* Smith *P. flavicornis* Smith, *P. varicolor* Viehmeyer and *P. wartburgi* Forel) in their range.

Seventeen sampled nests of the four *Myrmatopa* species (*P. cnemidata* Emery, *P. constructor* Smith, *P. flavicornis* Smith and *P. varicolor* Viehmeyer), contained ‘carton’ material composed of both coarse and finely particulate material, while the silk sheets were incorporated into the nest wall structure, with the exception of only a single species, *P. cnemidata* Emery. The sources of silk in the construction of silk nests have not yet been confirmed; multiple sources of silk are expected such as fungi, lichen and unknown material.

The colony composition of the five four *Myrmatopa* species indicates that *P. cnemidata* Emery, *P. constructor* Smith, *P. flavicornis* Smith and *P. varicolor* Viehmeyer are polydomous and generally monogynous. For *P. wartburgi* Forel it was not possible to be specific because only one nest with a dealate queen was found.

The following seven *Myrmatopa* species were original described based on the morphological characters of single worker: *flavicornis*-group (*P. antedoridensis* sp. nov.); *schang*-group (*P. tawauensis* sp. nov.); *simillima*-group (*P. angusticlypealis* sp. nov., *P. watanasiti* sp. nov. and *P. wiwatwitayai* sp. nov.) and *wallacei*-group (*P. vanispina* sp. nov. and *P. yamanei* sp. nov.). Furthermore, some other species were described based on a few specimens (*P. simillima* Emery and *P. kohouti* sp. nov.), and many of these taxa have been known only from one or two localities, and also from a single microhabitat (canopy or lower vegetation). It is highly likely that not a few species remain unrecognized or undiscovered, especially in the *P. simillima*-group. Therefore, colony based sampling which often enables to collect all the castes and sexes in a colony of the rain forest canopy, and the vertical distribution pattern are highly recommended for the taxonomic, systematics and bionomics studies of *Polyrhachis*, and other arboreal ants in tropical rain forest.

The establishment and development of local multipurpose reference collections of ants are indispensable and given the first priority in the study of ants in Thailand because without the correct identification of species it is difficult to conduct surveys of any field of myrmecology. Additionally, the cooperation among local people, neighboring countries and researches of different countries are necessary for biodiversity conservation.

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APPENDIX



Figure 183. Nest of *P. cnemidata* Emery from Tarutao I., Tarutao N.P., Peninsular Thailand.



Figure 184. Nest of *P. flavicornis* F. Smith from Ka Oon Waterfall, Peninsular Thailand.



Figure 185. Nest of *P. varicolor* Viehmeyer from Ka Oon Waterfall, Peninsular Thailand.



Figure 186. Nest of *P. varicolor* Viehmeyer from Khiriwong Village, Peninsular Thailand.

Table 17. Nest structure and location of the nests for *P. cnemidata* Emery in the Tenasserim mountain range.

	Colony No.						Total	
	I	II	III	IV	V	VI	Mean ± SE	Range
Location	Prajuab Khiri Khan Prov., Ka Oon Waterfall 100-200 m	Prajuab Khiri Khan Prov., Pala-U Waterfall 220-350 m	Prajuab Khiri Khan Prov., Ka Oon Waterfall 100-200 m	Prajuab Khiri Khan Prov., Ka Oon Waterfall 100-200 m	Prajuab Khiri Khan Prov., Ka Oon Waterfall 100-200 m	Prajuab Khiri Khan Prov., Ka Oon Waterfall 100-200 m		
Date	28 Dec. 05	29 Jan. 07	9 Feb. 07	10 Feb. 07	10 Feb. 07	10 Feb. 07		
Nest No.	1	2	3	4	5	6		
Height (cm.)	-	-	4.92	-	3.63	3.23	3.93 ± 0.51	3.23 -4.92
Width (cm.)	-	-	2.45	-	2.35	1.79	2.20 ± 0.21	1.79 -2.45
Depth (cm.)	-	-	0.53	-	0.55	0.14	0.41 ± 0.13	0.14 -0.55
Location above ground (cm.)	215.00	255.00	280.00	220.00	280.00	280.00	255.00 ± 12.52	215.00 -280.00
No. of nest entrance (hole)	-	-	2	-	1	2	-	1-2
No. of dealate queens	0	0	0	1	0	1	-	0-1
No. of winged queens	0	0	2	0	0	0	-	0-2
No. of males	0	0	0	0	2	0	-	0-2
No. of workers	47	25	33	6	48	41	-	6-48

Table 18. Nest structure and location of the nests for *P. cnemidata* Emery in the Phuket mountain range.

	Colony No.						Total		
	I	II	III	IV	IV	V	VI	Mean ± SE	Range
Location	Phangnga Prov., Sri Phang Nga N.P. 100-300 m	Ranong Prov., Haew Loam Waterfall 0-200 m	Ranong Prov., Tung Raya Nasak W.S. 0-300 m	Phangnga Prov., Lumru Waterfall 0-100 m	Phangnga Prov., Lumru Waterfall 0-100 m	Phangnga Prov., Lumru Waterfall 0-100 m	Surat Thani Prov., Khao Sok N.P. 0-200 m		
Date	25 Oct. 04	23 Mar. 05	24 Mar. 05	20 April. 05	20 April. 05	20 April. 05	11 Mar. 06		
Nest No.	1	2	3	4	5	6	7		
Height (cm.)	1.93	-	-	-	-	-	-	1.93	-
Width (cm.)	1.78	-	-	-	-	-	-	1.78	-
Depth (cm.)	1.62	-	-	-	-	-	-	1.62	-
Location above ground (cm.)	200.00	180.00	235.00	130.00	105.00	250.00	250.00	192.86 ± 21.93	105.00 -250.00
No. of nest entrance (hole)	1	-	-	-	-	-	-	-	1
No. of dealate queens	1	0	0	0	1	1	0	-	0-1
No. of winged queens	0	0	140	0	0	0	0	-	0-140
No. of males	0	3	19	0	0	0	0	-	0-19
No. of workers	15	67	60	54	105	37	0	-	15-159

Table 19. Nest structure and location of the nests for *P. cnemidata* Emery in the Khao Luang mountain range.

	Colony No.					Total	
	I	II	III	IV	V	Mean ± SE	Range
Location	Nakorn Sri Thammarat Prov., Khao Luang N.P. 100-300 m	Nakorn Sri Thammarat Prov., Pa Pra, Khao Nun N.P. 200-400 m	Nakorn Sri Thammarat Prov., Pa Pra, Khao Nun N.P. 200-400 m	Nakorn Sri Thammarat Prov., Pa Pra, Khao Nun N.P. 200-400 m	Nakorn Sri Thammarat Prov., Khao Luang N.P. 100-500 m		
Date	15 April. 05	14 Mar. 07	9 Nov. 07	10 Nov. 07	20 Mar. 08		
Nest No.	1	2	3	4	5		
Height (cm.)	-	9.23	-	5.05	2.35	5.54 ± 2.00	2.35 -9.23
Width (cm.)	-	3.43	-	2.95	2.57	2.98 ± 0.25	2.57 -3.43
Depth (cm.)	-	1.45	-	0.35	0.46	0.75 ± 0.35	0.35 -1.45
Location above ground (cm.)	245.00	190.00	120.00	157.00	210.00	184.40 ± 21.51	120.00 -245.00
No. of nest entrance (hole)	-	1	-	1	2	-	1-2
No. of dealate queens	0	1	1	0	1	-	0-1
No. of winged queens	2	0	0	0	0	-	0-2
No. of males	7	1	0	12	4	-	0-12
No. of workers	62	170	1	12	34	-	1-170

Table 20. Nest structure and location of the nests for *P. cnemidata* Emery in the Khao Banthat mountain range.

	Colony No.									Total	
	I	II				III	IV		V	Mean ± SE	Range
Location	Phatthalung Prov., Lan Mom Juy Waterfall 0-200 m	Phatthalung Prov., Lan Mom Juy Waterfall 0-200 m	Phatthalung Prov., Lan Mom Juy Waterfall 0-200 m	Phatthalung Prov., Lan Mom Juy Waterfall 0-200 m	Phatthalung Prov., Lan Mom Juy Waterfall 0-200 m	Trang Prov., Pak Jam Waterfall 100-200 m	Phatthalung Prov., Khao Pu Khao Ya N.P. 0-200 m	Trang Prov., Pak Jam Waterfall 100-200 m	Phatthalung Prov., Lan Mom Juy Waterfall 0-200 m		
Date	4 Sep 04	4 Oct. 04	5 Oct. 04	3 Dec. 04	3 Dec. 04	8 Nov. 05	24 Jan. 06	28 Feb. 06	8 Sep. 07		
Nest No.	1	2	3	4	5	6	7	8	9		
Height (cm.)	-	6.08	3.48	5.99	5.18	-	-	6.16	-	5.38 ± 0.51	3.48 -6.16
Width (cm.)	-	2.61	2.50	4.78	1.64	-	-	3.03	-	2.91 ± 0.52	1.64 -4.78
Depth (cm.)	-	0.99	0.50	1.72	1.42	-	-	0.64	-	1.05 ± 0.23	0.50 -1.72
Location above ground (cm.)	200.00	180.00	212.00	220.00	230.00	200.00	-	240.00	220.00	212.75 ± 6.74	180.00 -240.00
No. of nest entrance (hole)	-	1	3	5	-	-	-	2	-	-	1-5
No. of dealate queens	1	0	0	0	0	0	0	1	0	-	0-1
No. of winged queens	0	0	0	0	0	3	1	45	0	-	0-45
No. of males	1	0	0	0	0	10	0	0	0	-	0-10
No. of workers	2	0	0	0	0	110	64	65	21	-	2-110

Table 21. Nest structure and location of the nests for *P. cnemidata* Emery in the Sunkalakhiri mountain range.

	Colony No.			Total	
	I	II	III	Mean ± SE	Range
Location	Yala Prov., Tan To Waterfall, Bang Lang N.P. 0-300 m	Yala Prov., Tan To Waterfall, Bang Lang N.P. 0-300 m	Yala Prov., Julaporn 10, Betong 500-600 m		
Date	1 April. 05	1 April. 05	9 Feb. 06		
Nest No.	1	2	3		
Height (cm.)	-	-	-	-	-
Width (cm.)	-	-	-	-	-
Depth (cm.)	-	-	-	-	-
Location above ground (cm.)	250.00	185.00	240.00	225.00 ± 20.21	185.00 -250.00
No. of nest entrance (hole)	-	-	-	-	-
No. of dealate queens	1	1	1	-	1
No. of winged queens	0	5	5	-	0-5
No. of males	10	13	0	-	0-13
No. of workers	28	51	63	-	28-63

Table 22. Nest structure and location of the nests for *P. cnemidata* Emery in the Tarutao island.

	Colony No.		Mean ± SE	Total Range
	I	II		
Location	Satun Prov., Taloudung Nature trail, Tarutao N.P. 0-150 m	Satun Prov., Talowow, Tarutao N.P. 0-150 m		
Date	5 Mar. 08	7 Mar. 08		
Nest No.	1	2		
Height (cm.)	4.76	2.52	3.64 ± 1.12	2.52 -4.76
Width (cm.)	2.37	1.55	1.96 ± 0.41	1.55 -2.37
Depth (cm.)	0.52	0.44	0.48 ± 0.04	0.44 -0.52
Location above ground (cm.)	165.00	210.00	187.50 ± 22.50	165.00 -210.00
No. of nest entrance (hole)	2	1	-	1-2
No. of dealate queens	1	0	-	0-1
No. of winged queens	9	0	-	0-9
No. of males	13	0	-	0-13
No. of workers	85	17	-	17-85

Table 23. Nest structure and location of the nests for *P. constructor* Smith in the Tenasserim mountain range.

	Colony No.		Total	
	I	II	Mean ± SE	Range
Location	Prajuab Khiri Khan Prov., Pala U Waterfall 220-350 m	Prajuab Khiri Khan Prov., Pala U Waterfall 220-350 m		
Date	29 Jan.07	30 Jan.07		
Nest No.	1	2		
Height (cm.)	1.82	1.82	1.82	-
Width (cm.)	1.85	1.74	1.80 ± 0.04	1.74 -1.85
Depth (cm.)	0.37	0.48	0.43 ± 0.04	0.37 -0.48
Location above ground (cm.)	180.00	280.00	230.00 ± 35.36	180.00 -280.00
No. of nest entrance (hole)	1	1	-	1
No. of dealate queens	1	1	-	1
No. of winged queens	1	0	-	0-1
No. of males	0	0	-	0
No. of workers	2	4	-	2-4

Table 24. Nest structure and location of the nests for *P. constructor* Smith in the Phuket mountain range.

	Colony No.		Total
	I	Mean ± SE	Range
Location	Phangnga Prov., Lumpee Waterfall 0-100 m		
Date	19 Sep. 05		
Nest No.	1		
Height (cm.)	-	-	-
Width (cm.)	-	-	-
Depth (cm.)	-	-	-
Location above ground (cm.)	220.00	220.00	-
No. of nest entrance (hole)	1	-	1
No. of dealate queens	1	-	1
No. of winged queens	0	-	0
No. of males	0	-	0
No. of workers	2	-	2

Table 25. Nest structure and location of the nests for *P. constructor* Smith in the Khao Banthat mountain range.

	Colony No.					Total	
	I	II	III	IV	V	Mean ± SE	Range
Location	Songkhla Prov., Ton Nga Chang W.S. 100-300 m	Songkhla Prov., Ton Nga Chang W.S. 100-300 m	Trang Prov., Pak Jam Waterfall 100-200 m	Phatthalung Prov., Lan Mom Juy Waterfall 0-200 m	Trang Prov., Pak Jam Waterfall 100-200 m		
Date	22 May. 04	20 June. 04	28 Feb. 06	8 Sep. 07	22 Mar. 08		
Nest No.	1	2	3	4	5		
Height (cm.)	10.53	9.03	6.86	1.74	9.14	7.46 ± 1.55	1.74 -10.53
Width (cm.)	4.30	4.70	5.66	1.51	4.74	4.18 ± 0.70	1.51 -5.66
Depth (cm.)	0.63	0.95	0.22	0.33	0.56	0.54 ± 0.13	0.22 -0.95
Location above ground (cm.)	240.00	234.00	183.00	250.00	159.00	213.20 ± 17.83	159.00 -250.00
No. of nest entrance (hole)	1	1	1	1	1	-	1
No. of dealate queens	0	1	0	1	0	-	0-1
No. of winged queens	0	0	0	0	7	-	0-7
No. of males	0	0	0	0	24	-	0-24
No. of workers	86	59	71	2	51	-	2-86

Table 26. Nest structure and location of the nests for *P. flavicornis* Smith in the Tenasserim mountain range.

	Colony No.						
	I	II	III	IV	V	VI	VI
Location	Prajuab Khiri Khan Prov., Ka Oon Waterfall 100-200 m	Prajuab Khiri Khan Prov., Ka Oon Waterfall 100-200 m	Prajuab Khiri Kuy Buri N.P. 100-200 m	Prajuab Khiri Kuy Buri N.P. 100-200 m	Prajuab Khiri Kuy Buri N.P. 100-200 m	Prajuab Khiri Kuy Buri N.P. 100-200 m	Prajuab Khiri Kuy Buri N.P. 100-200 m
Date	29 May. 05	29 May. 05	29 May. 05	29 May. 05	29 May. 05	30 May. 05	30 May. 05
Nest No.	1	2	3	4	5	6	7
Height (cm.)	6.85	4.85	5.52	3.49	2.77	4.44	2.49
Width (cm.)	2.54	3.96	1.82	1.45	2.48	3.14	2.14
Depth (cm.)	0.42	0.39	0.63	0.43	0.46	0.41	0.35
Location above ground (cm.)	137.00	195.00	170.00	155.00	125.00	193.00	98.00
No. of nest entrance (hole)	3	3	3	2	2	2	-
Plant category	Shrub	Shrub	Shrub	Shrub	Tree	Shrub	Shrub
Plant family	Rubiaceae	Euphorbiaceae	Unknown spp.	Unknown spp.	Euphorbiaceae	Euphorbiaceae	Euphorbiaceae
No. of dealate queens	0	0	0	0	0	1	0
No. of winged queens	0	0	0	0	0	0	0
No. of males	0	0	0	0	0	0	0
No. of workers	156	90	33	31	60	76	20

Table 26 (Continued). Nest structure and location of the nests for *P. flavicornis* Smith in the Tenasserim mountain range.

Location	Colony No.				Overall Total	
	VII	VIII	VIII	IX	Mean ± SE	Range
	Prajuab Khiri Kuy Buri N.P. 100-200 m	Phetchburi Prov. Kangkrachan N.P. 0-300 m	Phetchburi Prov. Kangkrachan N.P. 0-300 m	Phetchburi Prov. Kangkrachan N.P. 0-300 m		
Date	30 May. 05	30 May. 05	30 May. 05	31 May. 05		
Nest No.	8	9	10	11		
Height (cm.)	2.50	4.75	4.25	4.74	4.24 ± 0.41	2.49 -6.85
Width (cm.)	3.13	3.72	1.04	2.14	2.51 ± 0.28	1.04 -3.96
Depth (cm.)	0.44	0.57	0.42	0.26	0.43 ± 0.03	0.26 -0.63
Location above ground (cm.)	152.00	134.00	230.00	117.00	155.00 ± 12.00	98.00 -230.00
No. of nest entrance (hole)	2	-	3	-	-	2-3
Plant category	Shrub	Shrub	Shrub	Shrub	-	-
Plant family	Euphorbiaceae	Unknown spp.	Annonaceae	Annonaceae	-	-
No. of dealate queens	1	0	0	1	-	0-1
No. of winged queens	0	0	6	1	-	0-6
No. of males	0	0	2	0	-	0-2
No. of workers	40	112	32	56	-	31-156

Table 27. Nest structure and location of the nests for *P. flavicornis* Smith in the Phuket mountain range.

	Colony No.							Total	
	I	II	III	IV	V	VI	VII	Mean ± SE	Range
Location	Ranong Prov., Bokroy Waterfall 100-300 m	Ranong Prov., Bokroy Waterfall 100-300 m	Ranong Prov., Bokroy Waterfall 100-300 m	Phangnga Prov., Lumpe Waterfall 0-100 m	Surat Thani Prov., Wipavadee Waterfall 0-300 m	Surat Thani Prov., Wipavadee Waterfall 0-300 m	Surat Thani Prov., Wipavadee Waterfall 0-300 m		
Date	24 Mar. 05	24 Mar. 05	24 Mar. 05	19 April. 05	26 May. 05	26 May. 05	26 May. 05		
Nest No.	1	2	3	4	5	6	7		
Height (cm.)	3.73	2.54	4.79	1.94	3.56	-	1.66	3.04 ± 0.49	1.66 -4.79
Width (cm.)	2.20	0.96	1.82	1.28	3.85	-	2.03	2.02 ± 0.41	0.96 -3.85
Depth (cm.)	0.41	0.65	0.48	0.45	0.77	-	0.23	0.50 ± 0.08	0.23 -0.77
Location above ground (cm.)	105.00	150.00	182.00	220.00	133.00	200.00	154.00	163.00 ± 15.00	105.00 -220.00
No. of nest entrance (hole)	3	1	-	1	-	-	-	-	1-3
Plant category	Shrub	Shrub	Tree	Tree	Shrub	Tree	Tree	-	-
Plant family	Euphorbiaceae	Arecaceae	Myristicaceae	Ebenaceae	Rubiaceae	Unknown spp.	Unknown spp.	-	-
No. of dealate queens	0	1	0	1	0	0	1	-	0-1
No. of winged queens	0	0	0	0	0	0	0	-	0
No. of males	0	0	0	0	0	0	0	-	0
No. of workers	26	25	30	2	24	18	27	-	2-30

Table 28. Nest structure and location of the nests for *P. flavicornis* Smith in the Khao Luang mountain range.

	Colony No.						
	I	I	I	II	III	IV	IV
Location	Nakorn Sri Thammarat Prov., Khao Nun N.P. 100-500 m	Nakorn Sri Thammarat Prov., Khao Nun N.P. 100-500 m	Nakorn Sri Thammarat Prov., Khao Nun N.P. 100-500 m	Nakorn Sri Thammarat Prov., Khao Nun N.P. 100-500 m	Surat Thani Prov., Tai Rom Yen N.P. 300-500 m	Surat Thani Prov., Tai Rom Yen N.P. 300-500 m	Surat Thani Prov., Tai Rom Yen N.P. 300-500 m
Date	16 April. 05	16 April. 05	16 April. 05	16 April. 05	17 April. 05	31 July. 05	31 July. 05
Nest No.	1	2	3	4	5	6	7
Height (cm.)	3.72	1.66	3.57	4.82	5.25	5.22	4.54
Width (cm.)	3.20	1.20	1.18	3.57	2.42	1.73	2.64
Depth (cm.)	0.37	0.17	0.16	0.25	0.55	0.56	0.14
Location above ground (cm.)	115.00	235.00	133.00	115.00	175.00	225.00	100.00
No. of nest entrance (hole)	3	1	1	3	4	3	-
Plant category	Shrub	Tree	Shrub	Shrub	Climber	Climber	Shrub
Plant family	Dipterocarpaceae	Myrtaceae	Myrsinaceae	Dipterocarpaceae	Melastomataceae	Menispermaceae	Annonaceae
No. of dealate queens	0	1	0	0	0	0	0
No. of winged queens	0	0	0	0	0	0	0
No. of males	0	0	0	0	0	0	0
No. of workers	16	5	32	49	26	41	60

Table 28 (Continued). Nest structure and location of the nests for *P. flavicornis* Smith in the Khao Luang mountain range.

	Colony No.						Overall Total	
	IV	V	VI	VI	VII	IV	Mean ± SE	Range
Location	Surat Thani Prov., Tai Rom Yen N.P. 300-500 m	Surat Thani Prov., Tai Rom Yen N.P. 300-500 m	Surat Thani Prov., Tai Rom Yen N.P. 300-500 m	Surat Thani Prov., Tai Rom Yen N.P. 300-500 m	Surat Thani Prov., Tai Rom Yen N.P. 300-500 m	Surat Thani Prov., Tai Rom Yen N.P. 300-500 m		
Date	31 July. 05	31 July. 05	31 July. 05	31 July. 05	31 July. 05	31 July. 05		
Nest No.	8	9	10	11	12	13		
Height (cm.)	3.53	6.09	3.25	4.36	4.87	3.42	4.18 ± 0.32	1.66 -6.09
Width (cm.)	4.28	2.76	2.86	2.84	2.72	2.65	2.62 ± 0.24	1.18 -4.28
Depth (cm.)	0.55	0.44	0.36	0.34	0.28	0.45	0.36 ± 0.04	0.14 -0.56
Location above ground (cm.)	250.00	58.00	132.00	172.00	149.00	142.00	154.00 ± 16.00	58.00 -250.00
No. of nest entrance (hole)	3	4	1	6	-	3	-	1-6
Plant category	Tree	Shrub	Shrub	Tree	Shrub	Shrub	-	-
Plant family	Euphorbiaceae	Euphorbiaceae	Euphorbiaceae	Anacardiaceae	Euphorbiaceae	Annonaceae	-	-
No. of dealate queens	1	1	0	1	1	0	-	0-1
No. of winged queens	25	18	0	0	0	14	-	0-39
No. of males	0	0	0	0	4	1	-	0-4
No. of workers	57	65	20	77	115	27	-	26-185

Table 29. Nest structure and location of the nests for *P. flavicornis* Smith in the Khao Banthat mountain range.

	Colony No.						
	I	I	I	I	II	III	IV
Location	Songkhla Prov., Ton Nga Chang W.S. 100-300 m	Songkhla Prov., Ton Nga Chang W.S. 100-300 m	Songkhla Prov., Ton Nga Chang W.S. 100-300 m	Songkhla Prov., Ton Nga Chang W.S. 100-300 m	Songkhla Prov., Ton Nga Chang W.S. 100-300 m	Songkhla Prov., Ton Nga Chang W.S. 100-300 m	Songkhla Prov., Ton Nga Chang W.S. 100-300 m
Date	14 Mar. 04	14 Mar. 04	14 Mar. 04	14 Mar. 04	14 Mar. 04	14 Mar. 04	14 Mar. 04
Nest No.	1	2	3	4	5	6	7
Height (cm.)	2.36	2.54	3.87	2.30	2.94	3.02	10.89
Width (cm.)	2.70	2.49	2.75	1.47	2.83	1.26	1.52
Depth (cm.)	0.78	0.28	0.43	0.50	0.43	0.45	0.44
Location above ground (cm.)	203.00	270.00	138.00	152.00	266.00	153.00	245.00
No. of nest entrance (hole)	2	2	2	1	4	1	6
Plant category	Shrub	Climber	Shrub	Shrub	Shrub	Shrub	Shrub
Plant family	Euphorbiaceae	Fabaceae	Euphorbiaceae	Euphorbiaceae	Euphorbiaceae	Euphorbiaceae	Unknown spp.
No. of dealate queens	0	0	0	0	1	1	1
No. of winged queens	0	0	0	0	0	0	0
No. of males	0	0	0	0	0	0	0
No. of workers	35	41	27	7	51	29	87

Table 29 (Continued). Nest structure and location of the nests for *P. flavicornis* Smith in the Khao Banthat mountain range.

	Colony No.						
	IV	V	VI	VII	VIII	IX	IX
Location	Songkhla Prov., Ton Nga Chang W.S. 100-300 m	Songkhla Prov., Ton Nga Chang W.S. 100-300 m	Songkhla Prov., Ton Nga Chang W.S. 100-300 m	Songkhla Prov., Ton Nga Chang W.S. 100-300 m	Songkhla Prov., Ton Nga Chang W.S. 100-300 m	Songkhla Prov., Ton Nga Chang W.S. 100-300 m	Songkhla Prov., Ton Nga Chang W.S. 100-300 m
Date	14 Mar. 04	14 Mar. 04	27 Mar. 04	27 Mar. 04	27 Mar. 04	27 Mar. 04	27 Mar. 04
Nest No.	8	9	10	11	12	13	14
Height (cm.)	2.61	1.33	4.28	2.68	4.20	3.24	4.20
Width (cm.)	1.56	1.19	0.88	2.92	5.08	2.04	2.21
Depth (cm.)	0.41	0.35	0.59	0.73	0.53	0.36	0.40
Location above ground (cm.)	177.00	209.00	152.00	185.00	196.00	134.00	214.00
No. of nest entrance (hole)	1	1	3	2	6	6	3
Plant category	Shrub	Tree	Shrub	Shrub	Shrub	Tree	Tree
Plant family	Euphorbiaceae	Euphorbiaceae	Myrtaceae	Rubiaceae	Clusiaceae	Euphorbiaceae	Euphorbiaceae
No. of dealate queens	0	1	0	0	1	1	0
No. of winged queens	0	0	0	0	0	0	0
No. of males	0	0	0	0	0	0	0
No. of workers	14	8	33	39	126	32	35

Table 29 (Continued). Nest structure and location of the nests for *P. flavicornis* Smith in the Khao Banthat mountain range.

	Colony No.						
	IX	X	XI	XII	XII	XIII	XIV
Location	Songkhla Prov., Ton Nga Chang W.S. 100-300 m	Songkhla Prov., Ton Nga Chang W.S. 100-300 m	Songkhla Prov., Ton Nga Chang W.S. 100-300 m	Songkhla Prov., Ton Nga Chang W.S. 100-300 m	Songkhla Prov., Ton Nga Chang W.S. 100-300 m	Songkhla Prov., Ton Nga Chang W.S. 100-300 m	Songkhla Prov., Ton Nga Chang W.S. 100-300 m
Date	27 Mar. 04	27 Mar. 04	27 Mar. 04	27 Mar. 04	27 Mar. 04	27 Mar. 04	27 Mar. 04
Nest No.	15	16	17	18	19	20	21
Height (cm.)	4.20	9.39	2.78	6.16	3.15	1.16	9.90
Width (cm.)	2.33	2.86	1.65	2.14	1.23	1.00	2.06
Depth (cm.)	0.61	0.55	0.38	0.44	0.36	0.44	0.63
Location above ground (cm.)	260.00	165.00	154.00	119.00	164.00	244.00	146.00
No. of nest entrance (hole)	3	7	2	4	2	1	6
Plant category	Tree	Climber	Shrub	Shrub	Shrub	Tree	Shrub
Plant family	Rubiaceae	Fabaceae	Euphorbiaceae	Fabaceae	Rubiaceae	Flacourtiaceae	Euphorbiaceae
No. of dealate queens	0	1	1	0	1	1	1
No. of winged queens	0	0	0	0	0	0	0
No. of males	0	0	0	0	0	0	0
No. of workers	47	307	51	72	31	2	137

Table 29 (Continued). Nest structure and location of the nests for *P. flavicornis* Smith in the Khao Banthat mountain range.

	Colony No.						
	XV	XV	XVI	XVII	XVIII	XVIII	XVIII
Location	Trang Prov., Kachong, Khao Bunthat W.S. 100-300 m	Trang Prov., Kachong, Khao Bunthat W.S. 100-300 m	Trang Prov., Kachong, Khao Bunthat W.S. 100-300 m	Songkhla Prov., Ton Nga Chang W.S. 100-300 m	Songkhla Prov., Ton Nga Chang W.S. 100-300 m	Songkhla Prov., Ton Nga Chang W.S. 100-300 m	Songkhla Prov., Ton Nga Chang W.S. 100-300 m
Date	18 April. 04	18 April. 04	18 April. 04	10 July. 04	10 July. 04	25 July. 04	25 July. 04
Nest No.	22	23	24	25	26	27	28
Height (cm.)	3.44	4.13	3.58	6.00	3.55	6.35	4.83
Width (cm.)	2.24	2.54	3.28	2.07	2.06	2.19	2.89
Depth (cm.)	0.34	0.42	0.38	0.45	0.46	0.38	0.37
Location above ground (cm.)	185.00	180.00	170.00	142.00	200.00	170.00	220.00
No. of nest entrance (hole)	1	5	4	4	2	4	6
Plant category	Shrub	Shrub	Shrub	Tree	Tree	Shrub	Shrub
Plant family	Euphorbiaceae	Euphorbiaceae	Rubiaceae	Unknown spp.	Flacourtiaceae	Annonaceae	Myristicaceae
No. of dealate queens	1	0	1	1	1	1	1
No. of winged queens	0	0	0	12	0	11	24
No. of males	0	0	0	0	0	0	8
No. of workers	87	62	69	19	79	62	33

Table 29 (Continued). Nest structure and location of the nests for *P. flavicornis* Smith in the Khao Banthat mountain range.

Location	Colony No.						Overall Total	
	XIXII	XIXII	XIXII	XIXII	XIXII	XXII	Mean ± SE	Range
	Phatthalung Prov., Ton Pra Tong Waterfall 0-300 m	Phatthalung Prov., Ton Pra Tong Waterfall 0-300 m	Phatthalung Prov., Ton Pra Tong Waterfall 0-300 m	Phatthalung Prov., Ton Pra Tong Waterfall 0-300 m	Phatthalung Prov., Ton Pra Tong Waterfall 0-300 m	Phatthalung Prov., Ton Pra Tong Waterfall 0-300 m		
Date	19 Mar. 05	19 Mar. 05	19 Mar. 05	19 Mar. 05	19 Mar. 05	19 Mar. 05		
Nest No.	29	30	31	32	33	34		
Height (cm.)	3.14	3.31	2.35	2.44	6.59	3.34	4.13 ± 0.39	1.16 -10.89
Width (cm.)	2.23	1.95	1.83	2.34	1.93	2.44	2.18 ± 0.13	0.88 -5.08
Depth (cm.)	0.30	0.36	0.27	0.46	0.49	0.23	0.44 ± 0.02	0.23 -0.78
Location above ground (cm.)	197.00	160.00	210.00	163.00	166.00	165.00	185.00 ± 7.00	119.00 -270.00
No. of nest entrance (hole)	3	-	1	2	4	5	-	1-7
Plant category	Climber	Climber	Shrub	Shrub	Herb	Tree	-	-
Plant family	Myrtaceae	Myrtaceae	Sterculiaceae	Unknown spp.	Marattiaceae	Euphorbiaceae	-	-
No. of dealate queens	0	0	0	0	0	0	-	0-1
No. of winged queens	0	0	0	0	0	0	-	0-24
No. of males	0	0	0	0	0	0	-	0-8
No. of workers	54	37	48	18	92	67	-	2-307

Table 30. Nest structure and location of the nests for *P. flavicornis* Smith in West Sumatra, Indonesia.

Location	Colony No.					Total	
	I	II	III	III	IV	Mean ± SE	Range
	Jambi, Undisturb area 0-600 m	Jambi, Undisturb area 0-600 m	Jambi, Undisturb area 0-600 m	Jambi, Undisturb area 0-600 m	Jambi, Undisturb area 0-600 m		
Date	5 Nov. 06	5 Nov. 06	7 Nov. 06	7 Nov. 06	7 Nov. 06		
Nest No.	1	2	3	4	5		
Height (cm.)	-	-	-	-	-	-	-
Width (cm.)	-	-	-	-	-	-	-
Depth (cm.)	-	-	-	-	-	-	-
Location above ground (cm.)	220.00	200.00	150.00	235.00	120.00	185.00 ± 22.00	120.00 -235.00
No. of nest entrance (hole)	-	-	-	-	-	-	-
No. of dealate queens	1	0	0	1	1	-	0-1
No. of winged queens	5	2	5	3	1	-	1-8
No. of males	0	0	1	0	0	-	0-1
No. of workers	48	32	21	48	25	-	25-69

Table 31. Nest structure and location of the nests for *P. varicolor* Viehmeier in the Tenasserim mountain range.

Location	Colony No.									Total		
	I	II	II	III	IV	V	VI	VI	VI	Mean ± SE	Range	
	Prajuab Khiri Khan Prov., Huay Yang N.P. 0-200 m	Prajuab Khiri Khan Prov., Ka Oon Waterfall 100-200 m	Prajuab Khiri Khan Prov., Ka Oon Waterfall 100-200 m	Prajuab Khiri Khan Prov., Ka Oon Waterfall 100-200 m	Prajuab Khiri Khan Prov., Ka Oon Waterfall 100-200 m	Prajuab Khiri Khan Prov., Ka Oon Waterfall 100-200 m	Prajuab Khiri Khan Prov., Ka Oon Waterfall 100-200 m	Prajuab Khiri Khan Prov., Ka Oon Waterfall 100-200 m	Prajuab Khiri Khan Prov., Ka Oon Waterfall 100-200 m	Prajuab Khiri Khan Prov., Ka Oon Waterfall 100-200 m		
Date	28 May. 05	28 Dec. 05	28 Dec. 05	8 Mar. 06	9 Feb. 07	9 Feb. 07	9 Feb. 07	9 Feb. 07	9 Feb. 07	9 Feb. 07		
Nest No.	1	2	3	4	5	6	7	8	9			
Height (cm.)	-	-	3.93	-	-	12.13	8.57	2.64	3.53	6.16 ± 1.81	2.64 -12.13	
Width (cm.)	-	-	2.71	-	-	2.37	3.07	2.13	1.73	2.40 ± 0.23	1.73 -3.07	
Depth (cm.)	-	-	0.52	-	-	0.25	0.34	1.25	1.45	0.76 ± 0.25	0.25 -1.45	
Location above ground (cm.)	210.00	188.00	138.00	255.00	260.00	230.00	173.00	280.00	240.00	219.33 ± 15.36	138.00 -280.00	
No. of nest entrance (hole)	-	-	2	-	-	3	5	4	2	-	2-5	
No. of dealate queens	0	1	0	1	1	1	1	0	0	-	0-1	
No. of winged queens	0	0	0	0	0	0	0	0	0	-	0	
No. of males	0	0	0	0	0	0	0	0	0	-	0	
No. of workers	61	75	107	171	31	172	151	55	45	-	31-251	

Table 32. Nest structure and location of the nests for *P. varicolor* Viehmeyer in the Khao Luang and Khao Banthat mountain range.

	Colony No. in the Khao Luang mountain range		Total		Colony No. in the Khao Banthat mountain range			Total	
	I	II	Mean ± SE	Range	I	II	III	Mean ± SE	Range
Location	Nakorn Sri Thammarat Prov., Khiriwong Vill. 100-400 m	Nakorn Sri Thammarat Prov., Khiriwong Vill. 100-400 m			Trang Prov., Sayrung Waterfall 0-300 m	Phatthalung Prov., Khao Pu-Khao Ya N.P. 0-200 m	Songkhla Prov., PSU, Kuan Mod Dang 0-100 m		
Date	21 Mar. 08	21 Mar. 08			22 Oct. 04	4 April. 06	17 July. 07		
Nest No.	1	2			1	2	3		
Height (cm.)	4.92	-	4.92	-	6.29	-	3.94	5.12 ± 1.18	3.94 -6.29
Width (cm.)	2.54	-	2.54	-	2.68	-	1.94	2.31 ± 0.37	1.94 -2.68
Depth (cm.)	1.28	-	1.28	-	0.36	-	0.74	0.55 ± 0.19	0.36 -0.74
Location above ground (cm.)	137.00	-	137.00	-	164.00	200.00	185.00	183.00 ± 10.44	164.00 -200.00
No. of nest entrance (hole)	1	-	-	1	2	-	1	-	1-2
No. of dealate queens	0	1	-	0-1	1	1	0	-	0-1
No. of winged queens	0	0	-	0	0	0	6	-	0-6
No. of males	0	0	-	0	8	0	0	-	0-8
No. of workers	146	1	-	1-146	69	151	39	-	39-151

Table 33. The Pearson Chi-square test showed the proportion of *P. flavicornis* Smith nests on different plant categories in Peninsular Thailand.

Plant categories		Mountain range				Total
		Tenasserim	Phuket	Khao Luang	Banthat	
Shrub	Observed	10	4	8	21	43
	Expected	7.3	4.6	8.6	22.5	43.0
Tree	Observed	1	3	3	8	15
	Expected	2.5	1.6	3.0	7.8	15.0
Climber	Observed	0	0	2	4	6
	Expected	1.0	0.6	1.2	3.1	6.0
Herb	Observed	0	0	0	1	1
	Expected	0.2	0.1	0.2	0.5	1.0
Total	Observed	11	7	13	34	65
	Expected	11.0	7.0	13.0	34.0	65.0

Table 34. The Pearson Chi-square test showed the proportion of *P. flavicornis* Smith colonies on different plant categories in Peninsular Thailand.

Plant categories		Mountain range				Total
		Tenasserim	Phuket	Khao Luang	Banthat	
Shrub	Observed	8	3	6	15	32
	Expected	5.5	4.3	6.8	15.4	32.0
Tree	Observed	1	4	3	6	14
	Expected	2.4	1.9	3.0	6.7	14.0
Climber	Observed	0	0	2	3	5
	Expected	0.9	0.7	1.1	2.4	5.0
Herb	Observed	0	0	0	1	1
	Expected	0.2	0.1	0.2	0.5	1.0
Total	Observed	9	7	11	25	52
	Expected	9.0	7.0	11.0	25.0	52.0

Table 35. The Pearson Chi-square test showed the proportion of *P. flavicornis* Smith nests on different host plant families in Peninsular Thailand.

Plant family		Mountain range				Total
		Tenasserim	Phuket	Khao Luang	Banthat	
Euphorbiaceae	Observed	5	1	4	14	24
	Expected	3.4	2.1	5.5	13.1	24.0
Rubiaceae	Observed	1	1	0	4	6
	Expected	0.8	0.5	1.4	3.3	6.0
Annonaceae	Observed	2	0	2	1	5
	Expected	0.7	0.4	1.1	2.7	5.0
Myrtaceae	Observed	0	0	1	3	4
	Expected	0.6	0.4	0.9	2.2	4.0
Fabaceae	Observed	0	0	0	3	3
	Expected	0.4	0.3	0.7	1.6	3.0
Dipterocarpaceae	Observed	0	0	2	0	2
	Expected	0.3	0.2	0.5	1.1	2.0
Flacourtiaceae	Observed	0	0	0	2	2
	Expected	0.3	0.2	0.5	1.1	2.0
Myristicaceae	Observed	0	1	0	1	2
	Expected	0.3	0.2	0.5	1.1	2.0
Anacardiaceae	Observed	0	0	1	0	1
	Expected	0.1	0.1	0.2	0.5	1.0
Arecaceae	Observed	0	1	0	0	1
	Expected	0.1	0.1	0.2	0.5	1.0
Clusiaceae	Observed	0	0	0	1	1
	Expected	0.1	0.1	0.2	0.5	1.0
Ebenaceae	Observed	0	1	0	0	1
	Expected	0.1	0.1	0.2	0.5	1.0
Marattiaceae	Observed	0	0	0	1	1
	Expected	0.1	0.1	0.2	0.5	1.0
Melastomataceae	Observed	0	0	1	0	1
	Expected	0.1	0.1	0.2	0.5	1.0
Menispermaceae	Observed	0	0	1	0	1
	Expected	0.1	0.1	0.2	0.5	1.0
Myrsinaceae	Observed	0	0	1	0	1
	Expected	0.1	0.1	0.2	0.5	1.0
Sterculiaceae	Observed	0	0	0	1	1
	Expected	0.1	0.1	0.2	0.5	1.0
Total	Observed	8	5	13	31	57
	Expected	8.0	5.0	13.0	31.0	57.0

Table 36. The Pearson Chi-square test showed the proportion of *P. flavicornis* Smith colonies on different host plant families in Peninsular Thailand.

Plant family		Mountain range				Total
		Tenasserim	Phuket	Khao Luang	Banthat	
Euphorbiaceae	Observed	4	1	4	10	19
	Expected	2.7	1.9	4.6	9.9	19.0
Rubiaceae	Observed	1	1	0	4	6
	Expected	0.8	0.6	1.4	3.1	6.0
Annonaceae	Observed	2	0	1	1	4
	Expected	0.6	0.4	1.0	2.1	4.0
Myrtaceae	Observed	0	0	1	2	3
	Expected	0.4	0.3	0.7	1.6	3.0
Fabaceae	Observed	0	0	0	3	3
	Expected	0.4	0.3	0.7	1.6	3.0
Dipterocarpaceae	Observed	0	0	2	0	2
	Expected	0.3	0.2	0.5	1.0	2.0
Flacourtiaceae	Observed	0	0	0	2	2
	Expected	0.3	0.2	0.5	1.0	2.0
Myristicaceae	Observed	0	1	0	1	2
	Expected	0.3	0.2	0.5	1.0	2.0
Anacardiaceae	Observed	0	0	1	0	1
	Expected	0.1	0.1	0.2	0.5	1.0
Arecaceae	Observed	0	1	0	0	1
	Expected	0.1	0.1	0.2	0.5	1.0
Clusiaceae	Observed	0	0	0	1	1
	Expected	0.1	0.1	0.2	0.5	1.0
Ebenaceae	Observed	0	1	0	0	1
	Expected	0.1	0.1	0.2	0.5	1.0
Marattiaceae	Observed	0	0	0	1	1
	Expected	0.1	0.1	0.2	0.5	1.0
Melastomataceae	Observed	0	0	1	0	1
	Expected	0.1	0.1	0.2	0.5	1.0
Menispermaceae	Observed	0	0	1	0	1
	Expected	0.1	0.1	0.2	0.5	1.0
Myrsinaceae	Observed	0	0	1	0	1
	Expected	0.1	0.1	0.2	0.5	1.0
Sterculiaceae	Observed	0	0	0	1	1
	Expected	0.1	0.1	0.2	0.5	1.0
Total	Observed	7	5	12	26	50
	Expected	7.0	5.0	12.0	26.0	50.0

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