ความหลากหลายทางชนิดของชันโรงและพืชอาหารที่เป็นแหล่งเรณู ในตำบลไหล่น่าน อำเภอเวียงสา จังหวัดน่าน

นางสาวหนึ่งฤทัย วิชัยกุล

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรมหาบัณฑิต
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SPECIES DIVERSITY OF STINGLESS BEES AND POLLEN FOOD SOURCES IN LAI NAN SUBDISTRICT, WIANG SA DISTRICT, NAN PROVINCE

Miss Nungruthai Wichaikul

A Thesis Submitted in Partial Fulfillment of the Requirements
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Thesis Title SPECIES DIVERSITY OF STINGLESS BEES AND POLLEN FOOD SOURCES IN LAI NAN SUBDISTRICT WIANG SA DISTRICT, NAN PROVINCE

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Field of study Zoology

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หนึ่งฤทัย วิชัยกุล: ความหลากหลายทางชนิดของชันโรงและพืชอาหารที่เป็นแหล่งเรณู ในตำบลไหล่น่าน อำเภอเวียงสา จังหวัดน่าน (SPECIES DIVERSITY OF STINGLESS BEES AND POLLEN FOOD SOURCES IN LAI NAN SUBDISTRICT, WAING SA DISTRICT, NAN PROVINCE) อ. ที่ปรึกษาวิทยานิพนธ์หลัก: ผศ. ดร. สุรีรัตน์ เดี่ยววาณิชย์, อ. ที่ปรึกษาวิทยานิพนธ์ร่วม: อ. ดร. ณัฐพจน์ วาฤทธิ์, 182 หน้า

ชันโรงจัดเป็นผึ้งไม่มีเหล็กใน ที่มีบทบาทสำคัญในการช่วยผสมเกสรให้กับพืช ปลูกและพืชป่า จุดประสงค์ของงานวิจัยนี้เป็นการสำรวจ จำนวนชนิดชันโรงและชนิดพืชอาหารของชันโรง บริเวณสถานีวิจัยและพื้นที่ป่าอนุรักษ์ของจุฬาลงกรณ์มหาวิทยาลัย ตำบลไหล่น่าน อำเภอเวียงสา จังหวัดน่าน เก็บตัวอย่างระหว่างเดือนกันยายน 2553 ถึงเดือนสิงหาคม 2554 พบชันโรงจำนวน 5 สกุล 6 ชนิด 145 รัง ได้แก่ *Tetragonilla collina, Tetrigona apicalis, Tetrigona melanoleuca, Homotrigona fimbriata, Lepidotrigona terminata* และ *Tetragonula pagdeni* จากค่าดัชนีความเด่นของชันโรง (C= 0.684) พบว่าชันโรง *Tetragonilla collina* มีความเด่น แต่พบค่าความหลากชนิดในพื้นที่ศึกษาน้อย (J' = 0.125) ชันโรงมีการสร้างรัง แบ่งออกเป็น 4 กลุ่ม คือ *Tetragonilla collina* พบการสร้างรังในจอมปลวกและเนินดิน ในขณะที่ *Tetrigona melanoleuca, Homotrigona fimbriata* และ *Lophotrigona terminata* เป็นกลุ่มที่สร้างรังในโพรงไม้ยืนต้นที่มีชีวิต และ *Tetrigona apicalis* พบการสร้างรังในโพรงไม้ยืนต้นที่ มีชีวิตและไม่มีชีวิต ต้นไม้ที่เป็นแหล่งที่อยู่อาศัยของชันโรงได้แก่ พลวง (*Dipterocarpus tuberculatus*) มะมื่น (*Irvingia malayana*) ประดู่ (*Pterocarpus macrocarcus*) เต็ง (*Shorea obtuse*) และรัง (*S. siamensis*) นอกจากนี้ยังพบว่ามีชันโรงสองชนิดใช้แหล่งที่อยู่อาศัยร่วมกัน ชันโรงตัวแทนศึกษาพืชอาหารที่เป็นแหล่งเรณู คือ *Tetragonilla collina* และ *Tetrigona apicalis* จากการศึกษาชนิดพืชอาหาร จากก้อนเรณูของชันโรง เปรียบเทียบกับชนิดพืชดอกในบริเวณพื้นที่ศึกษา โดยใช้วิธี acetolysis ผลการศึกษาพบพืชออกดอกทั้งปีทั้งหมด 52 ชนิด จากการวิเคราะห์พืชอาหารของชันโรงพบ 59 ชนิด 21 วงศ์ ซึ่งตรงกับพืชที่ออกดอก 25 ชนิด และอีก 34 ชนิดที่ยังระบุชนิดไม่ได้ ในจำนวนพืชอาหารที่ยังระบุชนิดไม่ได้ สามารถระบุในระดับวงศ์ได้ 9 ชนิด พืชอาหารที่เป็นแหล่งเรณู ได้แก่ Asteraceae (5 ชนิด) Caesalpinioideae (4 ชนิด) Poaceae (3 ชนิด) Convolvulaceae, Euphorbiaceae, Lythraceae, Mimosaceae (วงศ์ละ 2 ชนิด) Apiaceae, Anacardiaceae, Amaranthaceae, Apocynaceae, Bombacaceae, Boraginaceae, Hypericaceae, Malvaceae, Myrtaceae, Passifloraceae, Rosaceae, Sapindaceae, Solanaceae และ Tiliceae (วงศ์ละ 1 ชนิด) จากการศึกษาพบว่าจำนวนพืชที่พบในแต่ละเดือน มีเพียงไม่กี่ชนิดที่ชันโรง เก็บเรณูเพื่อเป็นอาหาร กล่าวได้ว่า จำนวนพืชที่ออกดอกทั้งหมด และพืชอาหารของชันโรง ไม่สัมพันธ์กัน พืชอาหารแต่ละชนิดมีปริมาณเรณูแตกต่างกัน ซึ่งชันโรง *Tetragonilla collina* พบพืชอาหารทั้งหมด 51 ชนิด และชันโรง *Tetrigona apicalis* พบพืชอาหาร 22 ชนิด

ภาควิชา ชีววิทยา ลายมือชื่อนิสิต

สาขาวิชา สัตววิทยา ลายมือชื่อ อ.ที่ปรึกษาวิทยานิพนธ์หลัก

ปีการศึกษา 2555 ลายมือชื่อ อ.ที่ปรึกษาวิทยานิพนธ์ร่วม

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KEYWORDS : STINGLESS BEES/ NESTING SITES/ POLLEN FOOD SOURCES

NUNGRUTHAI WICHAIKUL : SPECIES DIVERSITY OF STINGLESS BEES AND POLLEN FOOD SOURCES IN LAI NAN SUBDISTRICT, WAING SA DISTRICT, NAN PROVINCE. ADVISOR : ASST. PROF. SUREERAT DEOWANISH, Dr. Agr., CO - ADVISOR : NATAPOT WARRIT, Ph.D., 182 pp.

Stingless bees are pollinators that play an important role in the pollination of many crops and endemic plants. This study determined the species diversity and pollen food sources of stingless bees in the Chulalongkorn University Forest and Research Station at Lai Nan subdistrict, Wiang Sa district, Nan province. Stingless bees were collected from September 2010 to August 2011 in deciduous and deciduous - dipterocarp forests. Five genera and six species of stingless bees from the total of 145 nests were found: *Tetragonilla collina, Tetrigona apicalis, Tetrigona melanoleuca, Homotrigona fimbriata, Lepidotrigona terminata* and *Tetragonula pagdeni.* Species diversity of stingless bees was low (J' = 0.125). *Tetragonilla collina* was the dominant species in this area (C= 0.684). Stingless bees were found in four different types of nesting sites. *Tetragonilla collina* was found nesting in termite nests and underground, whereas *Tetrigona melanoleuca, Homotrigona fimbriata* and *Lophotrigona terminata* nested in live tree hollows. *Tetrigona apicalis* built their nests in live tree hollows, dead trees and wooden poles. *Dipterocarpus tuberculatus, Irvingia malayana*, *Pterocarpus macrocarcus*, *Shorea obtuse* and *S. siamensis* were nested by stingless bees. In some cases two species were found sharing the same nesting site. The pollen samples collected by two species of *Tetragonilla collina* and *Tetrigona apicalis* were acetolyzed and the pollen types were identified. A total of 59 pollen types were identified in the samples, with the represented 21 families being: Asteraceae (5 pollen types), Caesalpinioideae (4 pollen types), Poaceae (3 pollen types), Convolvulaceae, Euphorbiaceae, Lythraceae, Malvaceae, Mimosaceae (two pollen types each), Apiaceae, Anacardiaceae, Amaranthaceae, Apocynaceae, Bombacaceae, Boraginaceae, Hypericaceae, Myrtaceae, Passifloraceae, Rosaceae, Sapindaceae, Solanaceae, Tiliceae (one type each). Twenty - five pollen types could be identifield and thirty - four pollen types could not be identifield. The number of pollen types and number of flowering plants were not related. The number of pollen food sources collected by *Tetragonilla collina* and *Tetrigona apicalis* were 51 and 22, respectively.

Department : Biology Student's Signature ....

Field of Study : Zoology Advisor's Signature ....

Academic Year : 2012 Co-advisor's Signature ....

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CHAPTER I

INTRODUCTION

Stingless bees belong to the family Apidae (Meliponini) are eusocial insects that are perennial (Wille, 1983). Most stingless bees build their nests in tree hollows and crack building. They are very diverse, with approximately 500 species occur throughout the tropical and subtropical parts of the world. In Thailand, thirty-three species and ten genera of stingless bees are recognized and are wildly distributed throughout the region (Klakasikorn *et al*., 2005; Inson, 2006; Boontop *et al*., 2008; Rasmussen, 2008).

Stingless bees have polylectic habit in which they can harvest pollen and nectar from many floral. In general, they collect more pollen than nectar because pollens are the main food source for stingless bees which consist of proteins, lipids, vitamins, minerals and carbohydrates (Grogan and Hunt, 1979). They collect pollen and keep in nest for the propose of feeding their larva. They are pollinators that play an important role in the pollination of many crops and endemic plants (Wille, 1993; Heard, 1999).

Stingless bees are docile to human and can be domesticated. They were easily threatened by human. Many people exploit natural products of stingless bee in which destroy the nesting habitats causing the colony and population to decline which reduce the pollination efficiency on crops and endemic plants.

Nan province, only two stingless bee species, *Tetragonilla collina* and *Tetragonula laeviceps* were recorded from this area. This report contains less species number than in other provinces in the northern regions of Thailand (Klakasikorn *et al*., 2005).

The deciduous and deciduous-dipterocarp forests in Chulalongkorn University Forest and Research Station, Nan province covers with importance value index of plants, for example *Dipterocarpus obtusifolius*., *D. tuberculatus*, *Terminalia alata*, *T. bellirica*, *Shorea obtuse*, *S. siamensis*, *Mammea siamensis*, *Irvingia malayana*, and

Pterocarpus spp. (Dumrongrojwatthana, 2004). These plants may be food sources of stingless bees.

The conservation, management and propagation of stingless bees are depended on the basic knowledge of the species diversity and pollen food sources. This research is aimed to determine the pollen harvested from the stingless bee foragers using acetolysis method to examine the pollen morphology (Juntawong and Pechhacker, 1991; Kaewkaw *et al.*, 2005).

Diversity of stingless bees in Thailand has been studied in many regions, but they are poorly documented from Nan province. Thus, Nan province is a suitable study site to investigate species diversity and pollen food sources of stingless bees that could contribute to the conservation of biodiversity and populations of these bees. The results from this research will provide basic information essential for the advancement of the meliponiculture.

1.1 Objectives

1. To study the diversity of stingless bees in Lai Nan subdistrict, Wiang Sa district, Nan province.
2. To study the pollen food sources of stingless bees *Tetrigona apicalis* and *Tetragonilla collina*.
3. To evaluate the quantity of pollen types of *Tetrigona apicalis* and *Tetragonilla collina*.

CHAPTER II

LITERATURE REVIEW

2.1 Taxonomy and Biology of stingless bees

The stingless bees (tribe Meliponini, family Apidae) are part of the corbiculate bees. There are four tribes of the corbiculate bees, the orchid bees (Euglossini), the bumble bees (Bombini), the honey bees (Apini) and the stingless bees. Stingless bees are eusocial insects living in perennial colonies. The colonies of stingless bees are usually comprises of three castes with a queen, few hundred drones, and several hundred up to thousand workers (Wille,1983). The body of a stingless bee consists of three main parts (Figure 2.1): head, thorax and abdomen. Head consists of two compound eyes and simple eyes and chewing mouth. Thorax consists of three segments. The prothorax comprises of front legs, mesothorax has the middle legs, which on the dorsal area have one pair of fore wings. Below the metathorax, there are hind legs that have a structure called corbiculate or pollen basket for pollen transporting, on the dorsal part of the metathorax has one pair of hind wings, smaller than the species are specific fore wings (Wille, 1983; Velthusis, 1997). They can build nests in many habitats such as tree hollows, underground cavities, rock crevices, and wall cavities (Eltz *et al*., 2003). Some species live in ants or termites (Jongjitvimol and Wattanachaiyingcharoen, 2007). Stingless bees construct their nests with wax and plant resins (propolis). Nest entrances of the stingless bees are species specific (Figure 2.2).

Stingless bees are closely related to the honey bees. However, many morphology and behaviors of stingless bees can easily be distinguished from the honey bees by the following characters (Wille,1983):

1. The stingless bees are smaller in size than the honeybees.
2. The workers of stingless bees do not have sting as honey bees possess this morphology, but will defend by biting if their nest is disturbed.
3. The wing venations are reduced and weak in the stingless bees.

4. The stingless bee nest is made with horizontal brood combs while the honey bees nest constantly build vertical hanging wax combs.
5. The foraging range of most stingless bee species are not as wide as the honey bees, which may increase the foraging competence in limited spaces (Visscher and Seeley, 1982; Slaa *et al*., 2006).

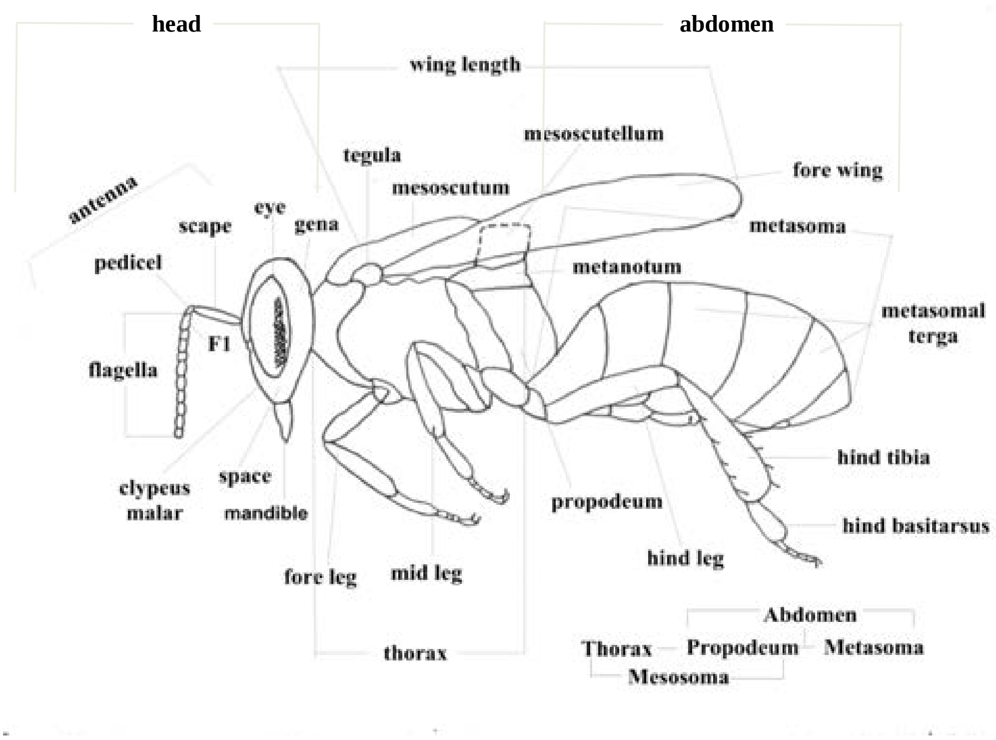

Figure 2.1 Morphological structures of a stingless bee (adapted from Schwarz, 1939).

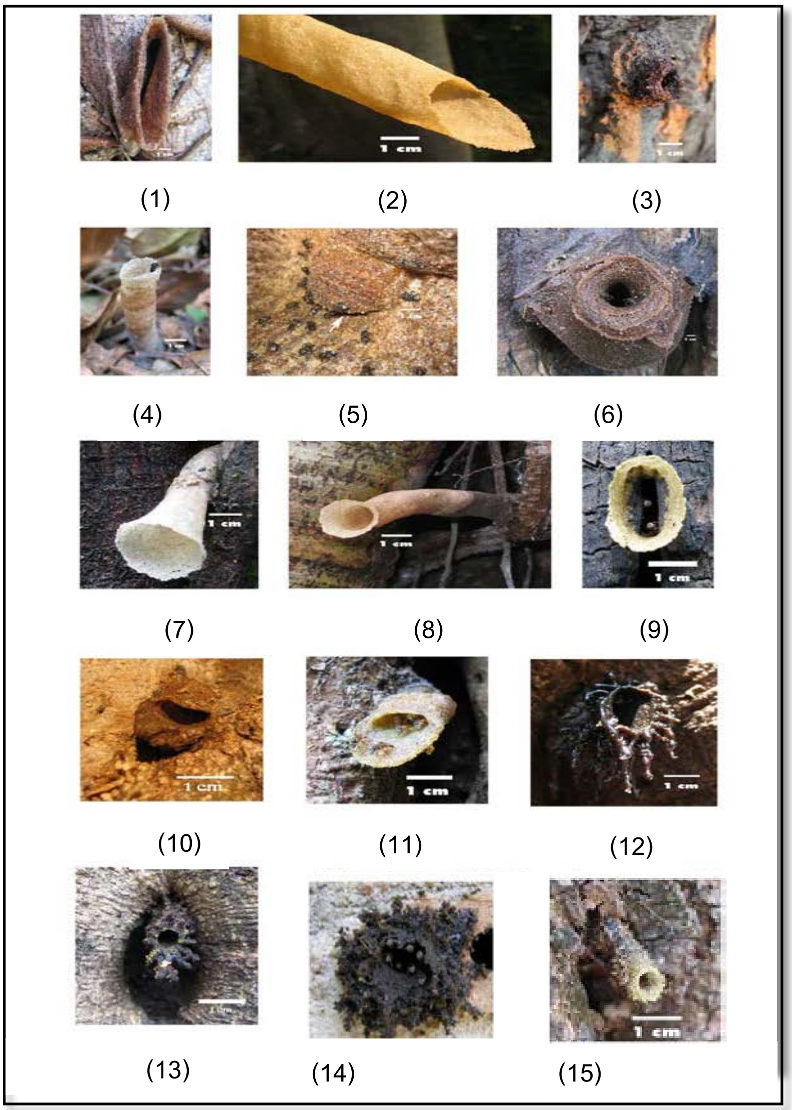

Figure 2.2 Nest entrances of stingless bees in Thailand (adapted from Inson, 2006; Jinarite, 2006).

(1) *Tetrigona apicalis* (2)*Tetrigona melanoleuca* (3) *Tetrigona peninsularis*

(4)*Tetragonilla collina* (5)*Lophotrigona canifrons* (6)*Geniotrigona thoracica*

(7) *Lepidotrigona terminata* (8) *Lepidotrigona ventalis* (9) *Lepidotrigona flavibasis*

(10-12) *Tetragonula iridipennis* variety 1,2,3 (13) *Lisotrigona scintillans*

(14) *Tetragonula pagdeni* (15) *Pariotrigona pendleburyi*

2.2 Diversity and distribution of stingless bees

Stingless bees have a wide distributions in the tropical and subtropical parts of South and Central America, Africa, Australia and Asia. They are highly diverse, with approximately about 500 species world wide (Figure 2.3).

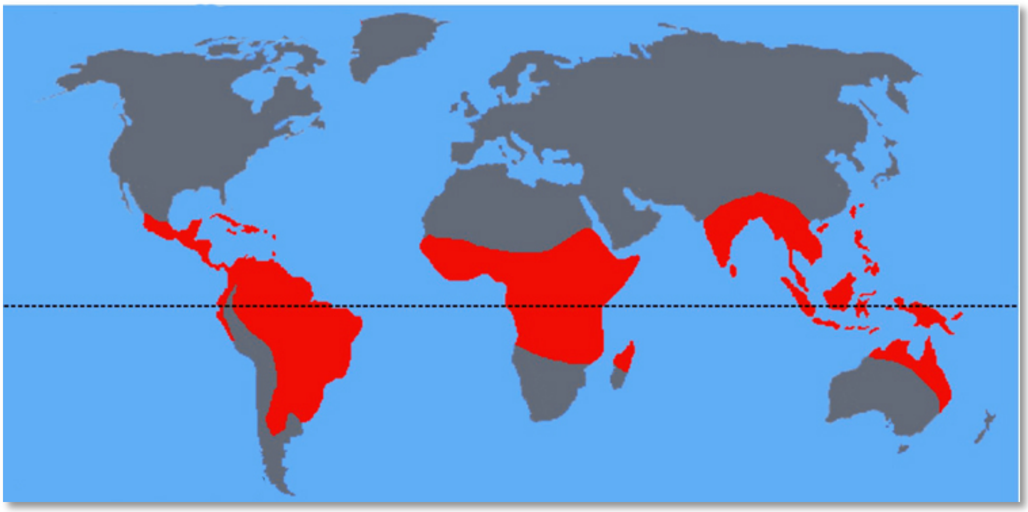

Figure 2.3 Distribution of stingless bees (adapted from Sakagami, 1982).

In Thailand, there are about thirty-three species and ten genera, as shown in Table 2.1: *Geniotrigona, Heterotrigona, Homotrigona, Lepidotrigona, Lisotrigona, Lophotrigona, Pariotrigona, Tetragonilla, Tetragonula* and *Tetrigona* that distributed all over the country (Klakasikorn *et al*., 2005; Inson, 2006; Boontep *et al*., 2008 and Rasmussen, 2008).

Table 2.1 Species of stingless bees described in Thailand (adapted from Klakasikorn *et al*., 2005).

Species of stingless bees	Schwarz (1939)	Sakagami *et al*. (1985)	Rajitparinya *et al*. (2000)	Michener and Boongrird (2004)	Klakasikorn *et al*. (2005)	Inson (2006)
Geniotrigona thoracica Smith, 1857	/	/			/	/
Heterotrigona itama Cockerell, 1918	/	/				
Homotrigona aliceae Cockerell, 1929	/					
Homotrigona ferrea Cockerell, 1929	/					
Homotrigona fimbriata Smith, 1857		/	/		/	
Lepidotrigona terminata Smith, 1857	/	/	/		/	/
Lepidotrigona doipaensis Schwarz, 1939	/				/	
Lepidotrigona flavibasis Cockerell, 1929	/					/
Lepidotrigona nitidiventris Smith, 1857		/				
Lepidotrigona ventalis Smith, 1857	/	/	/			/
Lisotrigona scintillans Cockerell, 1920	/	/	/			/

Table 2.1 Species of stingless bees described in Thailand (adapted from Klakasikorn *et al*., 2005) (continued).

Species of stingless bees	Schwarz (1939)	Sakagami *et al*. (1985)	Rajitparinya *et al*. (2000)	Michener and Boongrird (2004)	Klakasikorn *et al*. (2005)	Inson (2006)
Lophotrigona canifrons Smith, 1857	/	/				/
Pariotrigona pendleburyi Schwarz, 1939						/
Tetragonilla atripes Smith,1857		/				
Tetragonilla collina Smith,1857	/	/	/		/	/
Tetragonilla fuscibasis Cockerell, 1920		/				
Tetragonula fuscobalteata Cameron, 1908	/	/			/	
Tetragonula geissleri Cockerell, 1918	/	/				
Tetragonula hirashimai Schwarz,1939		/				
Tetragonula iridipennis Smith, 1854	/					/
Tetragonula laeviceps Smith,1857		/	/		/	
Tetragonula latigenalis Cockerell, 1969		/				
Tetragonula melina Gribodo, 1893	/	/				
Tetragonula minor Sakagami, 1978					/	

Table 2.1 Species of stingless bees described in Thailand (adapted from Klakasikorn *et al*., 2005) (continued).

Species of stingless bees	Schwarz (1939)	Sakagami *et al*. (1985)	Rajitparinya *et al*. (2000)	Michener and Boongrird (2004)	Klakasikorn *et al*. (2005)	Inson (2006)
Tetragonula pagdeni Schwarz,1939	/	/				
Tetragonula pagdeniformis Sakagami, 1978		/				
Tetragonula sarawakensis Schwarz,1937	/					
Tetragonula sirindhornae Michener and Boongird, 2004				/		
Tetragonula valdezi Cockerell, 1918	/					
Tetrigona apicalis Smith,1857	/	/	/		/	/
Tetrigona binghami Schwarz,1939					/	
Tetrigona melanoleuca Cockerell, 1929	/	/	/			/
Tetrigona peninsularis Cockerell, 1929	/	/				
Total	21	22	8	1	10	11

2.3 Foraging behaviors of stingless bees

Workers of stingless bees harvested pollen and resin of plants on their hind tibial cobiculae on their foraging flights (Hilario and Fonseca, 2009). The foraging behavior of sitngless bees were mostly influenced by environmental factors (Roubik, 1989). The flight distance foraging range correlated to the body size of the foragers. There are reports of flight range of 300 m. for small stingless bees (3 to 4 mm), 600 m. for medium sized stingless bees (5 mm), 800 m. for large stingless bees (10 mm) and 2 km. for very large stingless bees (13-15 mm) (Wille, 1983 and Araujo *et al*., 2004). In Thailand, there has been a report of flight range from the nest of about 300 m. for stingless bees (Visit Thanooarg, Interview, 24 June 2010). The foraging behavior of *Homotrigona fimbriata*, *Tetrigona apicalis* and *Tetragonilla collina* were recorded with the highest pollen loads between 6.00 - 8.30 a.m., 8.00 - 9.30 a.m. and 9.30 - 11.30 a.m., respectively (Jongjitvimol and Wattanachaiyingcharoen, 2006).

2.4 Importances of stingless bees

Momose *et al*. 1998 reported that social bees are the main pollinators in a lowland dipterocarp forest of Sarawak, Malaysia. They found that some floral characters (flowering time of day and floral shape) are significantly related to the pollination systems (Momose *et al*., 1998).

In a mixed deciduous forest in Phayao Province, Northern Thailand, the most important insect pollinators of teak (*Tectona grandis*) are stingless bees and small carpenter bees particularly *Tetragonilla collina* (Tangmitcharoen *et al*.,2005).

Stingless bees are considered to be good pollinators of many crops and wild plants. Many characteristics of stingless bees that influence their efficiency as pollinators are described as follows (Heard, 1999).

1. They can collect pollen and nectar from many plant species (polylecty).
2. Stingless bees have a floral constancy, one plant species is visited by a

worker on a trip. They usually find food source in the location not far from the nest. In Brazil, 97% of the pollen foragers of nine species of the stingless bees visited only one floral resource on each trip, because evidenced by the pure

pollen loads in their corbiculae (Ramalho *et al*., 1994).

3. The species of stingless bees have been managed in hives(domestication) for pollination assistance. Colonies can be easily propagated and keep individual hive for long life cycle of time (about 7 month and up to 60 years) than most others insect pollinators (Slaa *et al*., 2006). This makes them specially appropriate for pollinations of crop. Hives can also be transferred to places that are required for crop pollination.
4. Stingless bees forage throughout the year. They stroed many food in their nests.
5. Stingless bees are endemic insect pollinatorin Asian, thus are used to pollinate native plants.

2.5 Crop pollination by stingless bees

Pollination is the transfer of pollen from anthers of a flower to the stigma of the similar or different flowers. Several insects visit flowers to accumulate nectar and pollen as food while they pollinate the flowers. The main pollinating vector of many plants are self-pollinated, wind or insects (Free, 1993). However, many previous studies have determined that insects have a major role as pollinators (Buchmann and Nabhan, 1996; Momose *et al*., 1998; Tasen, 2009). Among insects, stingless bees are the mainly important and effective pollinators for crop pollinations (Heard, 1999; Slaa *et al*., 2006).

Kakutani *et al*. (1993) studied the foraging and pollination efficiencies of *Trigona minangkabau*, and the honey bee, *Apis mellifera*, on strawberry under greenhouses conditions in the campus of Shimane University, Matsue, Shimane Prefecture, Japan. They found that the stingless bee can pollinate strawberry also the honey bees.

Heard and Exley (1994) and Heard (1999) reported that the honey bees and *Trigona* spp. are the most important visitors in Macadamia, *Macadamia integrifolia* in Australia and Costa Rica.

Rambutan, *Nephelium lappaceum*, a native crop species to Southeast Asia, is visited by some species of stingless bees, that are potential pollinators (Heard, 1999).

In many tropical countries, one of the most important crops for agriculture are *Coffea arabica* and *C. canephora*. Klein *et al*. (2003a,b) reported that stingless bees, *Lepidotrigona terminata*, are the most efficient insect pollinator for these plants.

The avocado (*Persea americana*) is a major crop in South Africa and is native to tropical of America. In central America, Mexico, stingless bees and honey bees are regular visitors and able pollinators of avocado flowers (Can-Alonso *et al*., 2005).

Solange *et al*. (2008) investigated the cucumber pollinated, *Cucumis sativus*, by the stingless bees *Scaptotrigona* aff. *Depilis*. Moure and *Nannotrigona testaceicornis* in the greenhouses in Brazil. The results shown the yield of cucumbers is highest with stingless bees pollinating.

In Thailand, several plants are pollinated and increased yield by stingless bees. For instance, the stingless bee, *Tetragonula laeviceps*, play and inportant role in the pollination of durian, *Durio zibethinus* L. (Boongrid, 1992) and pollination of dragon fruits (Namwong, 2003). According to Jinarite (2006), Lychi pollination by stingless bees was conducted in Thong Pha Phum district, Kanchanaburi province. Therefore, stingless bees could be important insect pollinators for plants.

2.6 Meliponiculture

Stingless beekeeping is well-known as meliponiculture (Laurino, 2006), which is mostly developed in Central and South America. Stingless bees can simply be harvested in their natural habitats. Ones that nest mostly in tree hollows, can be moved and kept in artificial wooden hives.

Chinajariyawong and Saiboon (2001) studied the culturing method of *Tetragonula laeviceps* in Songkla province, southern of Thailand. They found that stingless bee could be cultured in old bamboo stem and cement hollow block. They tried to culture this species in two types of wooden boxes, vertical and horizontal types. They reported that *Tetragonula laeviceps* could be best cultured in the vertical wooden boxes.

Culture of stingless bee, *Tetragonula pagdeni*, was cultured and propagated in the wooden boxes in orchard for pollination, honey and propolis collecting by agriculturists in Chanthaburi province, eastern Thailand (Visit Thanooarg, Interview, 24 June 2010).

2.7 Pollen food sources of stingless bees

In 1988, Laurino and Ramalho reported on pollens harvested by *Trigona spinipes* in a botanical garden in Brazil. Pollen samples were collected from storage pots in a colony expending 13 months period. *Eucalyptus* spp. (Myrtaceae), *Aloe* sp. (Liliaceae) *Archontophoenix* sp. (Palmae) were collected by this species of stingless bees, while Myrtaceae is the main prefer flowers. Pollen foraging bees were examined on the flowers of 207 species of plants, associated with 56 plant families at Boraceia Biological Station in Sao Paulo, Brazil. The significant food sources for highly eusocial bee colonies are *Milkania* and *Verninia* (Asteraceae), *Myrcia* and *Eugenia* (Myrtaceae), *Bathysa* and *Psychotria* (Rubiaceae) (Wilms *et al*., 1996). Wilms and Wiechers (1997) reported that native *Melipona* stingless bees and the introduced Aficanized honey bee in Brazilia rain forest have a floral resources partitioning.

Eltz *et al*. (2001) investigated the diversity of pollen diets on stingless bees. Three colonies of *Tetragonilla collina* and a colony of *Tetragonilla collina*, *T. Melina* and *T. melanocephala* in lowland tropical rain forest in Sabah, Malaysia were analysed by pollen analysis method. They found pollen grains consisted of 74 different types. The most quantity of 32 pollen types are found in *T. Melina*.

In Thailand, Dejtisakdi (2005) studied pollens from the stingless bees, *Tetragonilla collina*, in a deciduous forest of Doi Mon Long, Queen Sirikit Botanical Garden, Mae Rim, Chiang Mai Province. They found 78 flowering species, while the number of plant species visited by *Tetragonilla collina* were 19 types.

Jongjitvimol and Wattanachaiyingcharoen (2006) observed pollen food sources of stingless bees *Tetrigona apicalis*, *Tetragonilla collina* and *Homotrigona fimbriata* at the Phisanulok Wildlife Conservation Development by acetolysis method. A total of 29 plant species of 18 families were recorded. *Tetragonilla collina* collecting 29 plant species, while *Tetrigona apicalis* collected 20 plant species and 16 plant species for *Homotrigona fimbriata*. Among these three species, they conclude that *Tetragonilla collina* is the most important pollinator in this forest.

2.8 Study of pollen morphology

Many studies of pollen food sources were prepared by acetolysis method (Erdtman, 1960). The pollen morphologies were investigated by light microscopy (LM) and scanning electron microscopy (SEM).

CHAPTER III

SPECIES DIVERSITY OF STINGLESS BEES IN LAI NAN SUBDISTRICT WIANG SA DISTRICT, NAN PROVINCE

3.1 Methodology

Study sites

The study sites is located in the Chulalongkorn University Forest and Research Station at Lai Nan sub-district, Wiang Sa district, Nan province (UTM zone 47Q: N2051960-2054260 and E688400-690360) (Figure 3.1) with a surface area of 3.07 km^2. This area consists of deciduous and deciduous-dipterocarp forests (Figure. 3.2).

Stingless bees survey

Stingless bees were collected from September 2010 - August 2011. The strip transect method was used in the survey. The distant between main transect was 100 m with lateral areas surveyed on left and right sides of 10 m throughout the transect. The geographical position and altitude of the stingless bee nests were recorded using a GPS (Garmin VISTA HCx).

The ecological data were recorded as follows:

1. Nesting sites
2. Number of nests in each location
3. Length and width of the nest entrance
4. Color of the nest entrance

Stingless bees were identified *in situ* at the research stations. For each species, a samples of 10 stingless bees were collected using arial net and preserved in 70 % ethanol. In the laboratory at Center of Excellence in Entomology: Bee Biology, Biodiversity of insect and mites at chulalongkorn university, stingless bee specimens were dried in an incubator (50 °C) for a week and were identified using identification key by Schwarz (1939) under light microscopy (LM).

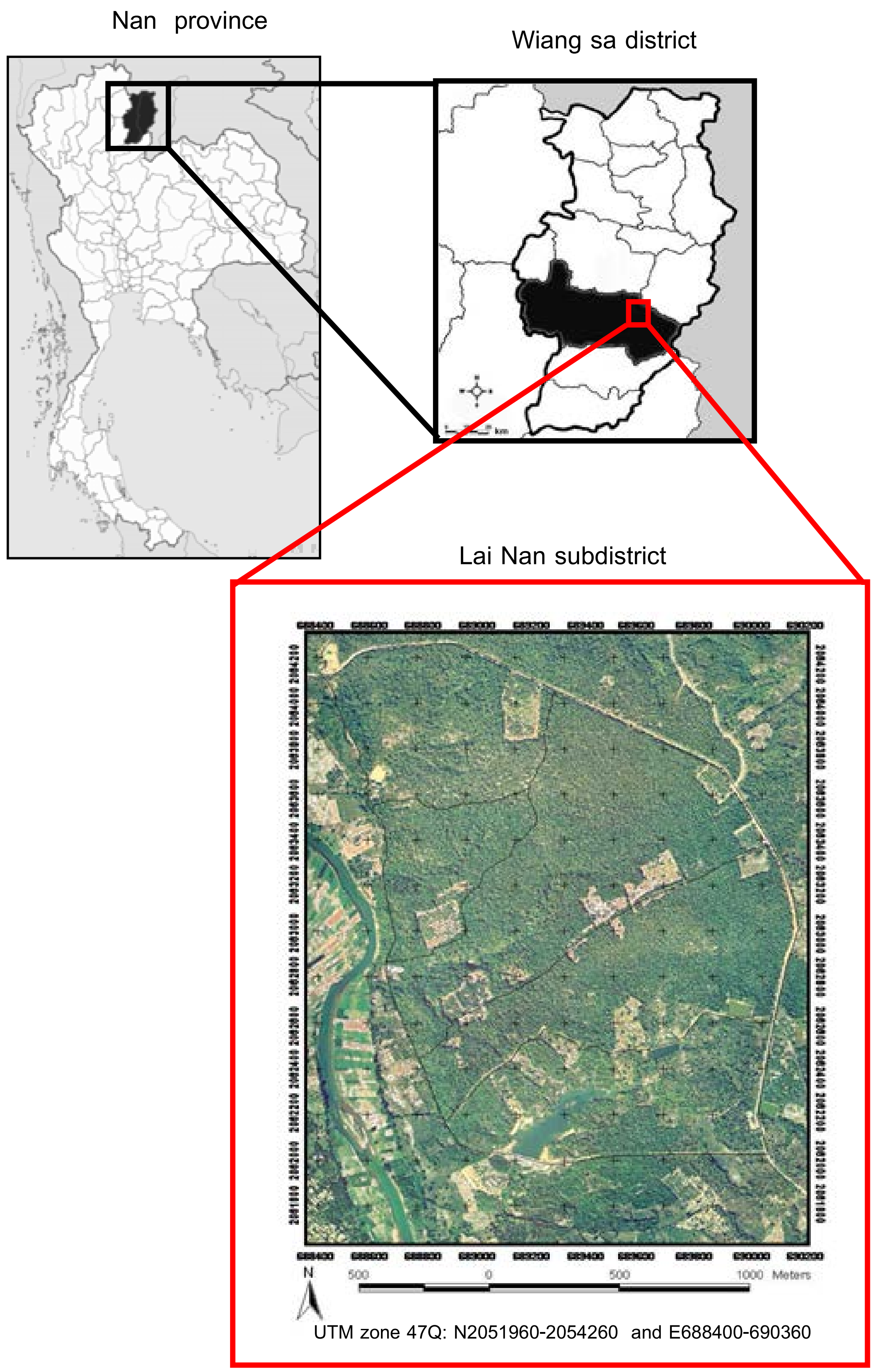

Figure 3.1 Chulalongkorn University Forest and Research Station at Lai Nan subdistrict, Wiang Sa district, Nan province. (UTM zone 47Q: N2051960-2054260 and E688400-690360).

Figure 3.2 Study sites; deciduous and deciduous-dipterocarp forests in the Chulalongkorn University Forest and Research Station at Lai Nan subdistrict, Wiang Sa district, Nan province.

A, B deciduous

C, D deciduous-dipterocarp

Data analysis

Species diversity and species dominant indices were analyzed using Shannon-Weiner index (Shannon and Weiner, 1949) compared with Colwell and Futuyma (1971) and Dominant index (Kreb, 1999).

The formula of Shannon- Weiner index (Shannon and Weiner, 1949) compared with Colwell and Futuyma (1971) are described as follow:

$$H' = -\sum_{i=1}^{S} (P_i)(\ln P_i)$$

Where, H' = Index of species diversity

S = the number of the species

P_i = the proportion of number of stingless bee nests of each species and total number of stingless bee nests

$$J' = H' / \ln N$$

J' = the standard of species diversity index

N = Total number of stingless bees nest

The formula of species dominant index as follow:

$$C = \sum (n_i / N)^2$$

Where, C = Dominant index

n_i = the number of stingless bee nest

N = the total number of stingless bees nest

3.2 Results

3.2.1 Species diversity and nesting sites of stingless bees

All stingless bees nests collected in this study can be identified to the species level. A total of 145 nests including five genera and six species of stingless bees were identified in the study site (Figure 3.3): 118 nests of *Tetragonilla collina*, 21 nests of *Tetrigona apicalis*, 3 nests of *Homotrigona fimbriata*, 2 nests of *Lepidotrigona terminata*, 1 nest of *Tetrigona melanoleuca*. Nest of *Tetragonula pagdeni* was not collected, though specimens of this species were collected using aerial nest in the study site. The majority of nests are of *Tetragonilla collina*. Figure 3.3 shows the distribution and positions of the stingless bees species in this study. Nests were collected in the rang of 200–250 m above sea level. Species diversity of stingless bees in this area is low (J'= 0.125) and the dominant species can be detected (C= 0.684).

Nesting sites of stingless bees found in the study are highly variable. They can be arbitrarily categorized into four groups (Table 3.1). 1) nesting underground 2) nesting in the termite mounds 3) nesting in live-tree hollows and 4) nesting in dead trees and wooden poles. *Tetrigona melanoleuca*, *Homotrigona fimbriata* and *Lepidotrigona terminata* were found nesting in live-tree hollows (Figure 3.4), whereas *Tetrigona apicalis* built their nest in live-tree hollows, dead trees and wooden poles (Figure 3.5). Nests of *Tetragonilla collina* were found in termite mounds and underground (Figure 3.6 and Figure 3.7).

Tetragonilla collina, that nests in termite mound are the most common nesting sites, accounting for 77 nests of all collected nests and 44 nests were found underground. Number of the nests in live tree hollows are represented of 26 nests and 1 nest was found in dead tree hollow (Table 3.1).

Table 3.2 shows the number of nests and tree species of each stingless bee species for nesting sites. Twenty-one nests of *Tetrigona apicalis* built their nests in 5 tree species: *Dipterocarpus tuberculatus, Irvingia malayana*, *Pterocarpus macrocarcus*, *Shorea obtuse* and *S. siamensis*. The most preferred nests tree are *I. malayana, P. macrocarcus*, *D. tuberculatus*, *S. obtuse* and *S. siamensis*. Three nests of *Homotrigona fimbriata* built their 2 nests in *P. macrocarcus* and 1 nest in *D. tuberculatus*. Two nests of *Lepidotrigona terminata* their built their nest in *I. malayana* and *S. obtuse*. Only *P. macrocarcus* is the nesting site of *Tetrigona melanoleuca* (Figure 3.8).

Nests of *Tetragonilla collina* have nesting sites aggregation with another nest of *Tetragonilla collina* in the same underground and the same termite mound. Some nests of *Tetrigona apicalis* have nesting sites aggregations with another nest of *Tetragonilla collina* in the same area. Some nests of *Tetrigona apicalis* have nesting sites aggregations with another nest of *Tetrigona melanoleuca* in the same plant (Table 3.3).

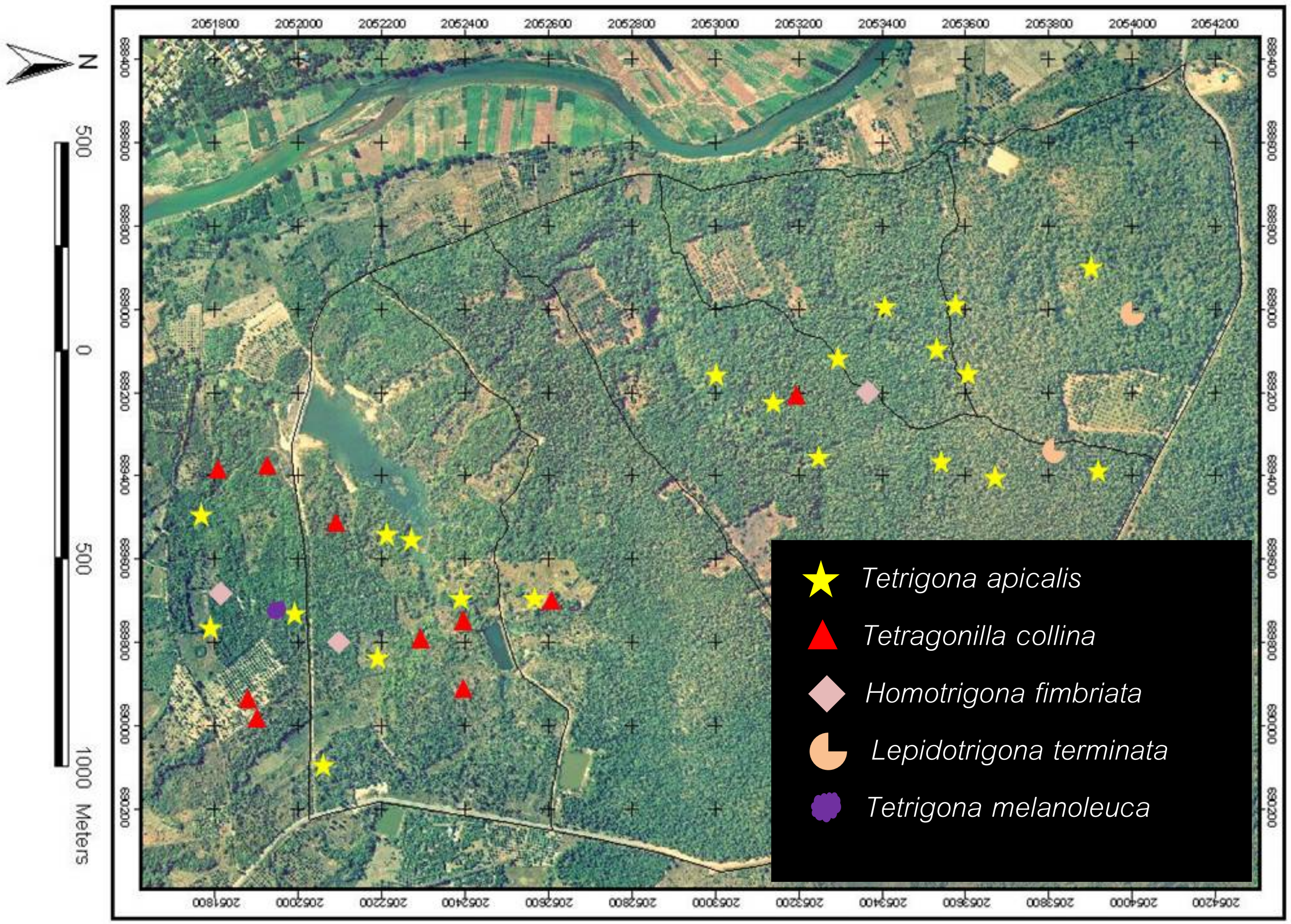

Figure 3.3 Collecting localities of the stingless bees in the Chulalongkorn University Forest and Research Station at Lai Nan subdistric Wiang Sa district, Nan province.

Table 3.1 Nesting sites of stingless bees in Chulalongkorn University Forest and Research Station at Lai Nan sub-district, Wiang Sa district, Nan province.

Species	No. of nest	Nesting sites			
		underground	termite mounds	live tree hollows	dead trees and wooden poles
Tetragonilla collina	118	41	77	-	-
Tetrigona apicalis	21	-	-	20	1
Homotrigona fimbriata	3	-	-	3	-
Lepidotrigona terminata	2	-	-	2	-
Tetrigona melanoleuca	1	-	-	1	-
Tetragonula pagdeni *	-	-	-	-	-

* nest was not found

Figure 3.4 Nesting sites of stingless bees in live tree hollow.

A. *Tetrigona apicalis* B. *Tetrigona melanoleuca*

C. *Lepidotrigona terminata* D. *Homotrigona fimbriata*

Figure 3.5 Nesting site of stingless bees *Tetrigona apicalis* in dead trees and wooden poles.

Figure 3.6 Nesting site of stingless bees *Tetrgonilla collina* in termite mound.

Figure 3.7 Nesting site of stingless bees *Tetrgonilla collina* underground.

Table 3.2 Species of trees nested by stingless bees in the Chulalongkorn University Forest and Research Station at Lai Nan subdistrict, Wiang Sa district, Nan province.

Tree Species	Stingless bees species			
	Tetrigona apicalis	*Homotrigona fimbriata*	*Tetrigona melanoleuca*	*Lepidotrigona terminata*
Dipterocarpus tuberculatus	2	1	-	-
Irvingia malayana	13	-	-	1
Pterocarpus macrocarpus	4	2	1	-
Shorea obtuse	1	-	-	1
Shorea siamensia	1	-	-	-
Total number of nests	21	3	1	2

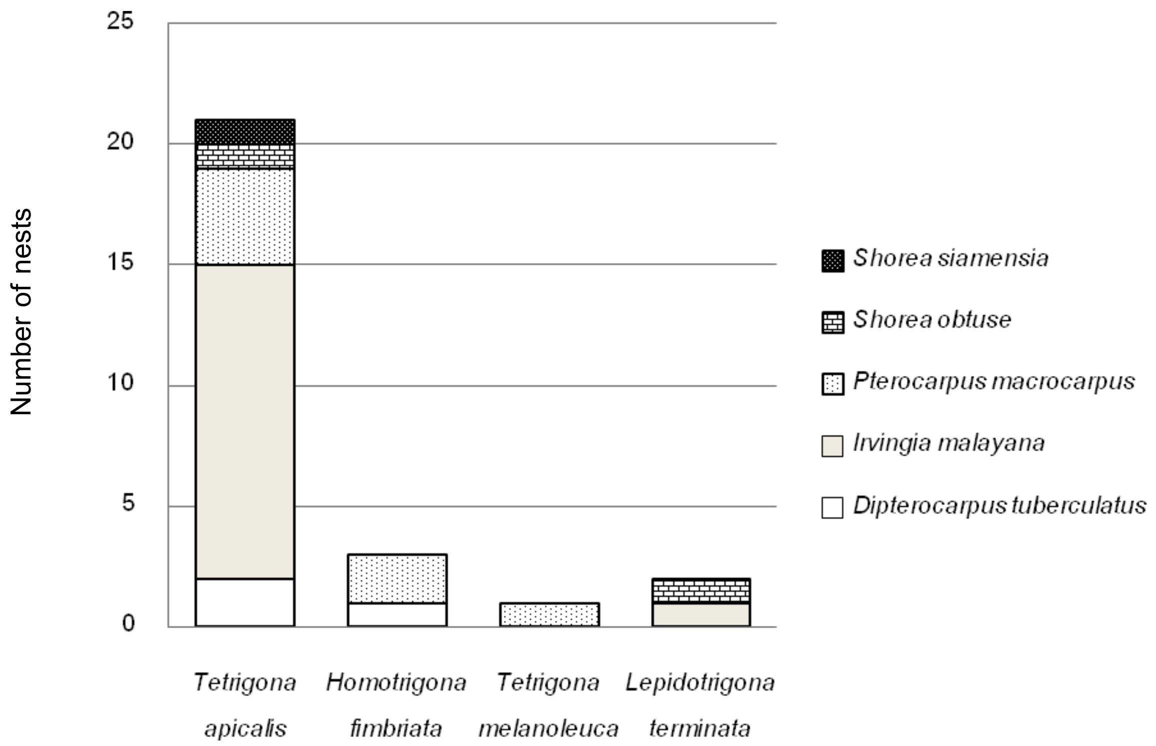

Figure 3.8 Tree preferences for nesting sites of stingless bees found in the Chulalongkorn University Forest and Research Station at Lai Nan sub-district, Wiang Sa district, Nan province.

Table 3.3 Species of stingless bees and nest aggregations in the Chulalongkorn University Forest and Research Station at Lai Nan subdistrict, Wiang Sa district, Nan province.

Species	No. of nest	No. of nests in aggregations	Nests in agrregations		Associated species
			single species	mixed	
Tetragonilla collina	118	118	112	16	*Tetrigona apicalis*
Tetrigona apicalis	21	2	-	2	*Tetragonilla collina* , *Tetrigona melanoleuca*
Homotrigona fimbriata	3	-	-	-	-
Tetrigona melanoleuca	1	1	-	1	*Tetrigona apicalis*
Lepidotrigona terminata	2	-	-	-	-
Tetragonula pagdeni	-	-	-	-	-

3.2.2 Morphological characters and nest entrance of stingless bees

Tetrigona apicalis

The nesting sites are usually found in a cavity of live tree hollows, dead trees and wooden poles. The nest entrance tubes are trumpet-shaped, extending outward 10–30 cm from the host tree, with a width between 1–3 cm, relatively thick and hard, brownish color. The apical tip of the nest entrance is elongated, resembling a funnel. The morphological characters of this species are; body and wing lengths are 6.5 and 7 mm, respectively, abdomen and leg are dark brown. Near front of nest entrance usually have 5-10 guards bee hovering (Figure 3.9).

Tetragonilla collina

Nests were found in termite mounds and underground. The nest entrance tube are typically long cylindrical shape, extending outward 5–25 cm from the termite mound, with a width between 0.8–2 cm; relatively thin and brittle; yellowish white, extending upward from the ground. The morphological characters of this speices are body and wing lengths 6 and 6.5 mm, respectively, predominantly dark, fore wings basal usually darker and different from the milky white apical half (Figure 3.10).

Homotrigona fimbriata

It is the largest species in this study area. The nesting sites are found in a cavity of live tree hollows. The nest entrance tubes are trumpet-shaped, brown , though the apex expand considerably (approximate 5 cm in width). Textures of the entrances are rough and uneven. Plant resins can be found around the entrance. The morphological characters of this speices are the body length of worker are 8.5 mm and predominantly reddish brown, whereas tibia and basitarsus are dark (Figure 3.11).

Tetrigona melanoleuca

The nest entrances are long cylindrical shape, extending downward approximately 35 cm from the host tree with 1.5 cm width, yellow, extending downward from the tree. The morphological characters of this species are body and wing lengths are 7 mm, body and legs dark black (Figure 3.12).

Lepidotrigona terminata

The nesting sites are found in the cavity of live tree hollows. The nest entrance tube is more or less trumpet-shaped, extending 8– 10 cm downward from the tree, relatively thin and soft, yellowish white. The morphological characters of this species are as followed; body and wing lengths are 6.5 and 7 mm, respectively, fore wings somewhat uniformly transparent or slightly infuscate, mesoscutal tomenta usually bright yellow brown and extending to mesoscutellum (Figure 3.13).

Tetragonula pagdeni

The nest site was not found during the collected season. The samples were collected from flower visited by the bees. Morphological characters of this species, body and wing lengths are 3.5 mm, body and legs are dark to blackish brown, and frontal hairs mainly whitish and distinctly plumose (Figure 3.14).

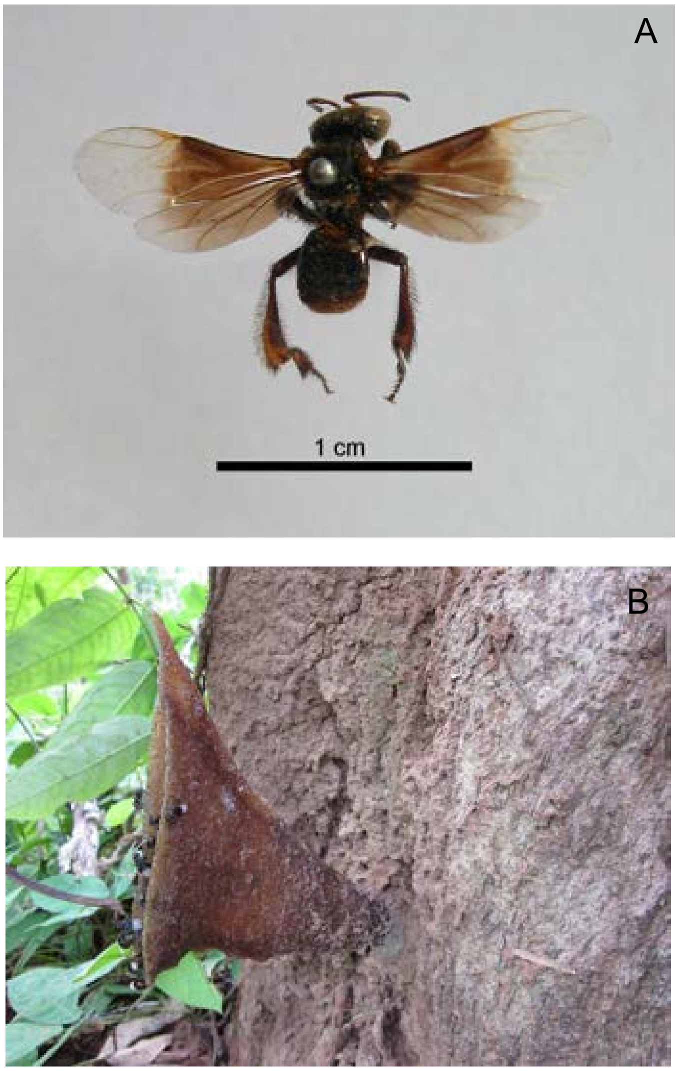

Figure 3.9 *Tetrigona apicalis* and its nest entrance tube.

A. *Tetrigona apicalis*

B. Nest entrance tube

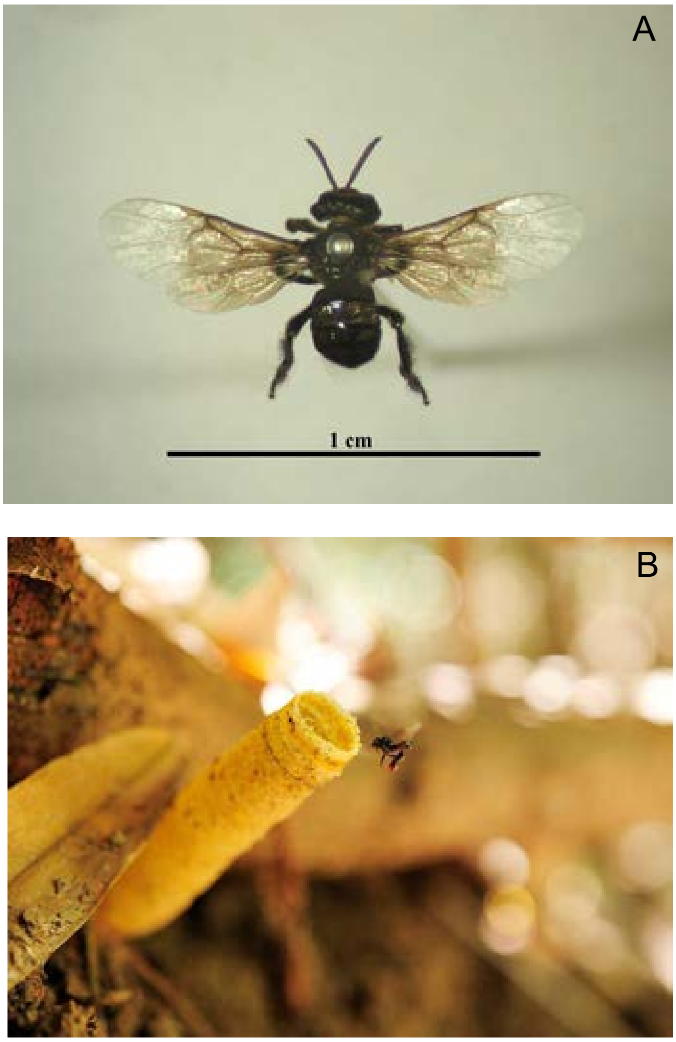

Figure 3.10 *Tetragonilla collina* and its nest entrance tube.

A. *Tetragonilla collina*

B. Nest entrance tube

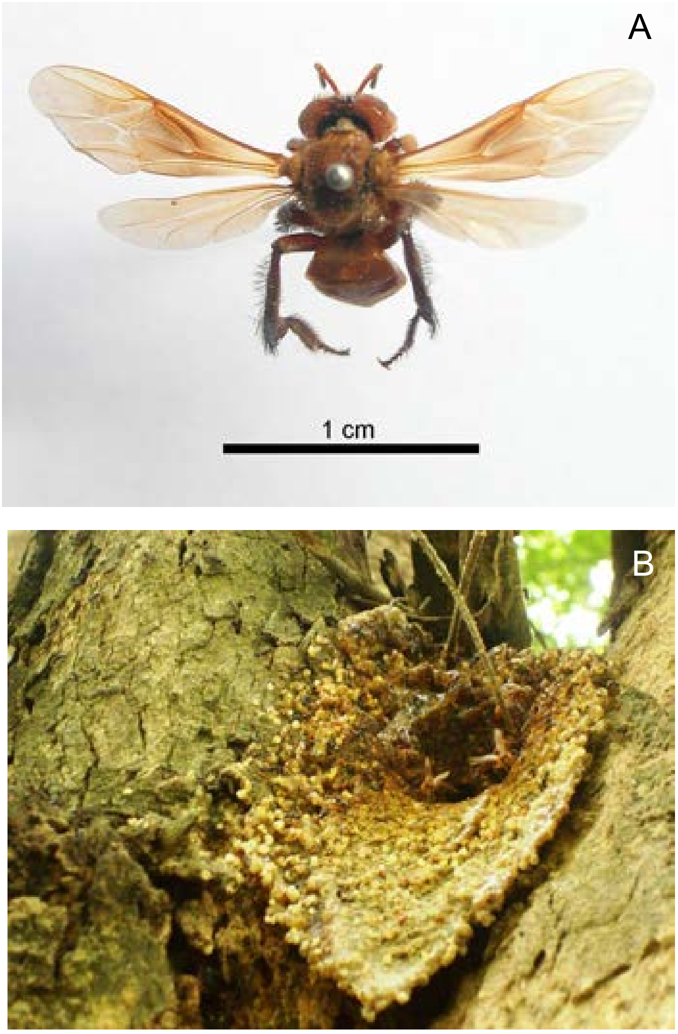

Figure 3.11 *Homotrigona fimbriata* and its nest entrance tube.

A. *Homotrigona fimbriata*

B. Nest entrance tube

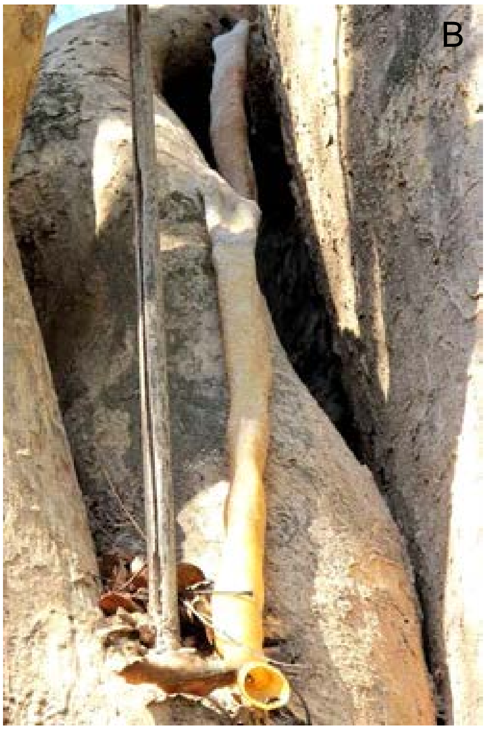

Figure 3.12 *Tetrigona melanoleuca* and its nest entrance tube.

A. *Tetrigona melanoleuca*

B. Nest entrance tube

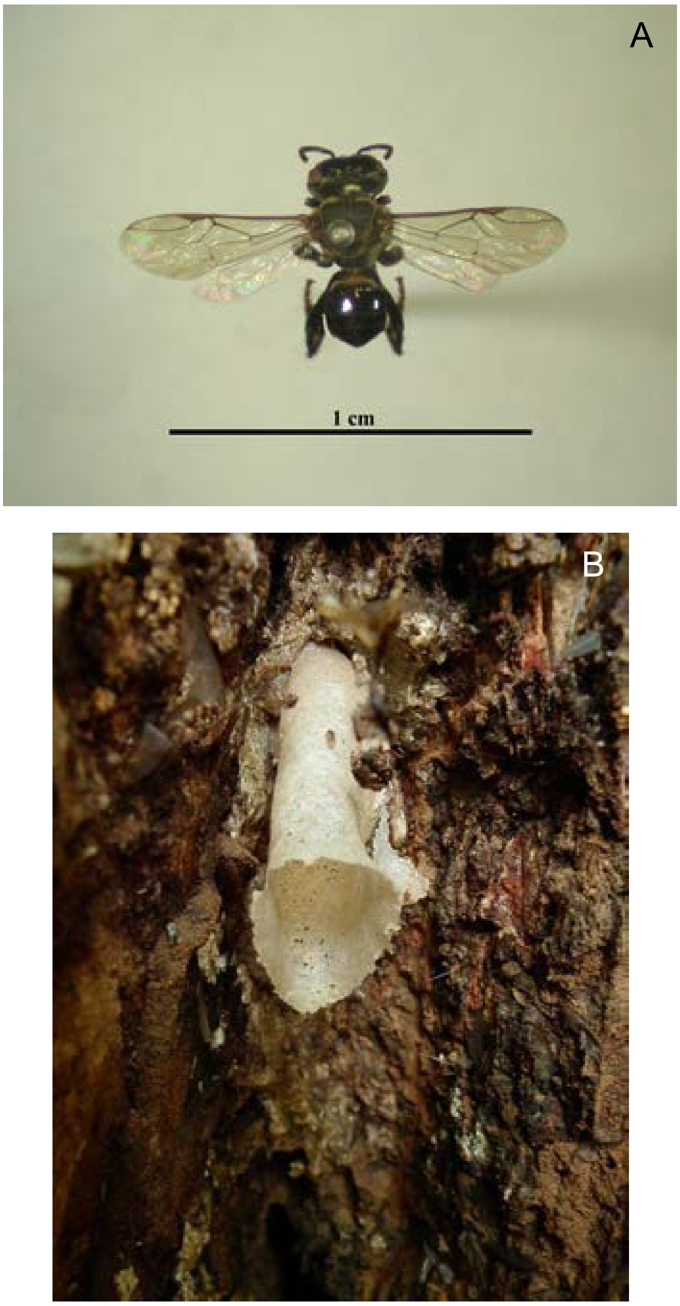

Figure 3.13 *Lepidotrigona terminata* and its nestrance tube.

A. *Lepidotrigona terminata*

B. Nest entrance tube

Figure 3.14 *Tetragonula pagdeni*

2.3 Discussion

A total of 145 nests belonging to 6 species of stingless bees. Klakasikorn (2005) reported that two stingless bee species, *Tetragonilla collina* and *Tetragonula laeviceps* were found in Nan province. In present study, we found only *Tetragonilla collina* but *Tetragonula laeviceps* was not found. Because the previous study surveyed total area of Nan province, while in this study focus in Chulalongkorn university forest station.

The data analysed in this study show the species diversity of stingless bees in this area to be low. This may resulted from food resorces partitioning among different stingless bees species (Nagamitsu *et al*., 1999; Kajobe and Echazarreta, 2005; Jongjitvimol and Wattanachaiyingcharoen, 2007a) and also the abundance of food plants in the natural forest (Salim *et al*., 2012). The dominant species can be detected in *Tetragonilla collina* species. Jongjitvimol *et al*., (2005) suggested that *Tetragonilla collina* was common species in the north of Thailand, and they play an important role in the pollination of crops and wild plants.

The present study found that most stingless bees built their nest in termite mound, particularly *Tetragonilla collina* and nest usually has aggregation of nests. Rinderer, *et al*., (2002) and Jongjitvimol *et al*., (2005) suggested that nest dispersion of *Tetragonilla collina* is a visibly clumped dispersion. The dispersion of nest causes aggregation of nests. Cameron *et al*., (2004) studied microsatellite analysis of *Tetragonilla collina* revealed that colonies inside the aggregations were not related. Jongjitvimol and Wattanachaiyingcharoen, 2007b reported that the nesting sites of *Tetragonilla collina* are in the termite mound. The temperature in the cavities of the termite mound may be suitable for the stinglees bees.

Most of *Tetrigona apicalis* nested in the live tree hollow. Eltz *et al*. (2003) reported that cavities in trunk are important and suitable for stingless bees nesting sites. Cavities in tree have optimal temperature in support of activities within stingless bees nests and may help guarding from the natural enemies.

At the research station, the unique characteristic of the nest entrance of stingless bees can be used to identify the species. Different species have different nest entrances. Moreover, we found that the body sizes of the six species are different. Michener (1974) and Sakagami (1982) reported that all stingless bees build elaborate nests with structures that are often characteristic for the species. Michener (2000) suggested that the stingless bee species existing worldwide differ considerably in nest size, body size and color. Preferences in the collection of resins from plants to built their nests may be specific to their nest entrances (Inson, 2006).

CHAPTER IV

POLLEN FOOD SOURCES OF *Tetragonilla collina* and *Tetrigona apicalis* IN LAI NAN SUBDISTRICT WIANG SA DISTRICT, NAN PROVINCE

4.1 Methodology

Study sites and nests of stingless bees

The studiedy nests of stingless bees was conducted at Chulalongkorn University Forest and Research Station at Lai Nan subdistrict, Wiang Sa district, Nan province during September 2010 - August 2011. A total of 145 nests from six species of stingless bees, *Tetragonilla collina, Tetrigona apicalis, Tetrigona melanoleuca, Homotrigona fimbriata, Lepidotrigona terminata* and *Tetragonula pagdeni* were found in this study site. Nests of *Tetragonilla collina* and *Tetrigona apicalis* are found more than other species, therefore they are choosen for pollen analysis. The samples of pollen were taken from the three nests of *Tetragonilla collina* (C2, C3, and C4) and the three nests of *Tetrigona apicalis* (A9, A10, and A11) (Figure 4.1). The distance among these six nests of the stingless bee are about 300 m. apart.

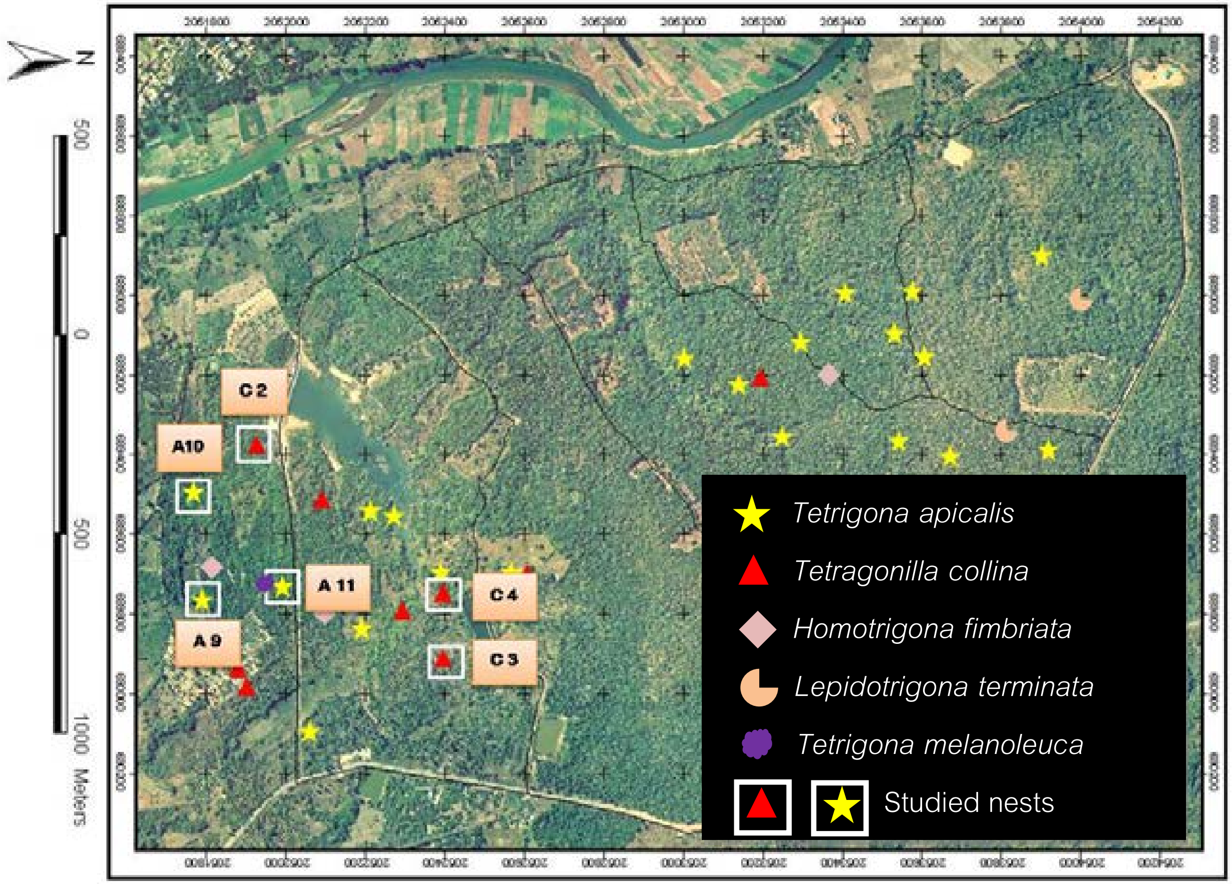

Figure 4.1 The stingless bees studied nests map in Chulalongkorn University Forest and Research Station at Lai Nan sub district, Wiang Sa district, Nan province.

Pollen samples

Three nests of *Tetrigona apicalis* and three nests of *Tetragonilla collina* were used to study foraging behavior from September 2010- August 2011. Nest entrance of these nests are covered with the plastic bag (Figure 4.2), the 30 returning foragers with pollen load were captured at the front of nest entrance by aerial net during foraging time (08.00 -12.00). Different nests were handled in turn on the next day. The pollen samples were stored in the freezer and were prepared for light (LM) and scanning microscopy (SEM) by the standard methods described by Erdtman's technique (1960), and pollen sample were identified by comparing with the pollen of flowering species. Air temperature and relative humidity data were recorded by using the data logger (CEM DT- 171).

Figure 4.2 Nest study of *Tetrigona apicalis* and their nest entrance.

Figure 4.3 Nest study of *Tetragonilla collina* and their nest entrances.

Flowering species

Flowers around the nests in the study area were collected every mounth from September 2010 – August 2011. The flowers were identified using the field guide to forest trees of northern Thailand (Gardner *et al*., 2000; Dumrongrojwatthana, 2004) and anthers were collected from flowers for acetolysis method.

Pollen analysis

Pollen samples from stingless bees and from flowers were prepared for acetolysis method (Erdtman, 1960) as following detailed (Figure 4.4).

1) Boil the pollen samples in 10% KOH (3 min).
2) Removed the pollen samples from 10% KOH by sieving crucible for fraction screen in centrifuge tube, 15 ml.
3) Washed the samples with distilled water 3 times. Each time, pollen were mixed by stirring rod or used vortex.
4) Removed distilled water with glacial acetic acid.
5) Removed most of organic matters by mean of acetolysis mixture (a mixture of acetic anhydride and concentrated sulfuric acid; 9:1; make the mixture afresh each day) and the suspension is boiled for 1 minute.
6) Removed the acetolysis mixture and washed in glacial acetic acid.
7) Washed with distilled water 3 times.
8) Dehydration the pollen in 70%, 95 % and absolute ethanol.
9) Transferred the pollen sample from centrifuge tube to vial for preparation for LM and SEM observations.

In each step, the suspension were mixed by stirring rod or used vortex , then centrifuges for 1-3 minutes at 3,600 rpm.

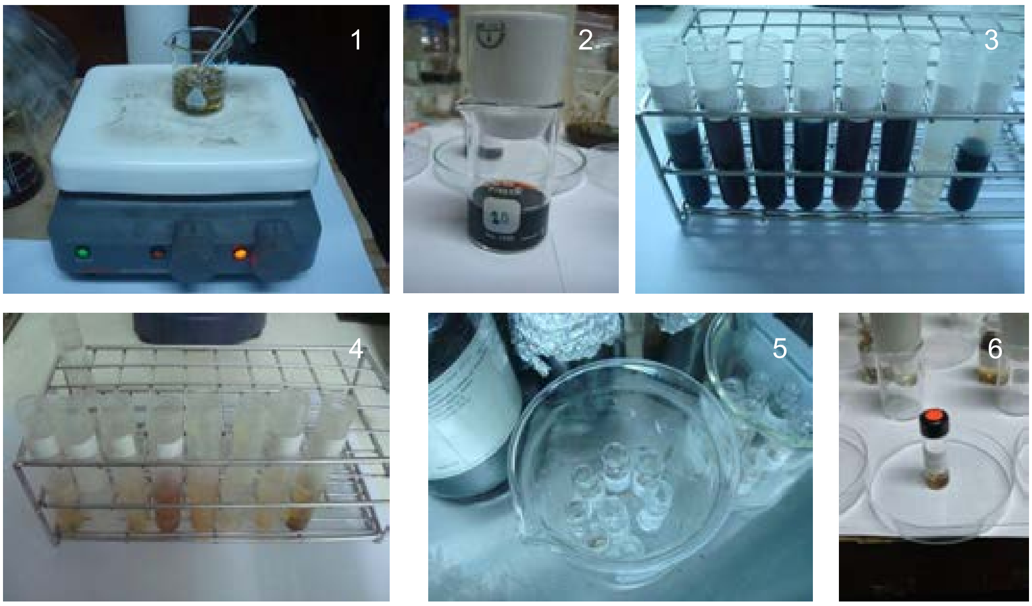

Figure 4.4 Acetolysis method: 1. Boil pollen samples in 10% KOH (3 min)

2 and 3. Removed 10% KOH by sieving crucible for fraction screen in centrifuge tube.

4. Changed the solutions follow aceolysis method.

5 and 6. Transferred pollen sample from centrifuge tube to vial for preparation for LM and SEM observations.

Preparation of pollen for LM examination

To remove absolute ethanol and then add benzene and add 2-3 drop of silicon oil (200 fluid and 350 CS) depend on number of sample and left for 2 day until benzene had completely evaporated inside the fume hood. The permanent three slided was add 1-2 drop of pollen sample in silicon oil and seal with paraffin wax. Quantitative evaluation was made by counting 300 pollen grains per slides (Wilms and Wiechers, 1997).

Determination of frequency classes of pollen types in the samples present on the slide, pollen represented by more than 45 % of the total number of pollen grains are called the predominant pollen (PP); by 16-45 % the secondary pollen (SP); by 3-15 % important minor pollen (IP); and by less than 3 % minor pollen (MP) (Louveaux *et al*., 1978) (Figure 4.5).

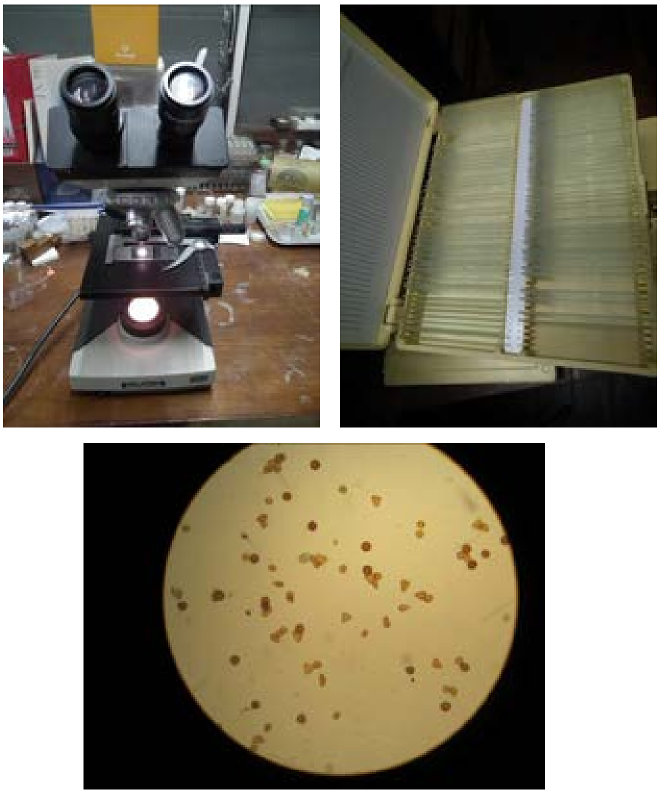

Figure 4.5 Preparation of pollen for LM examination.

Preparation of pollen for SEM examination

Pollen samples within absolute ethanol were freeze dried by the critical point drying (CPD) method, samples were then placed on the stubs with double sided tape and were coated with gold, photographed by a scanning electron microscopy JSM 5410 LV at 15 kV (Figure 4.6).

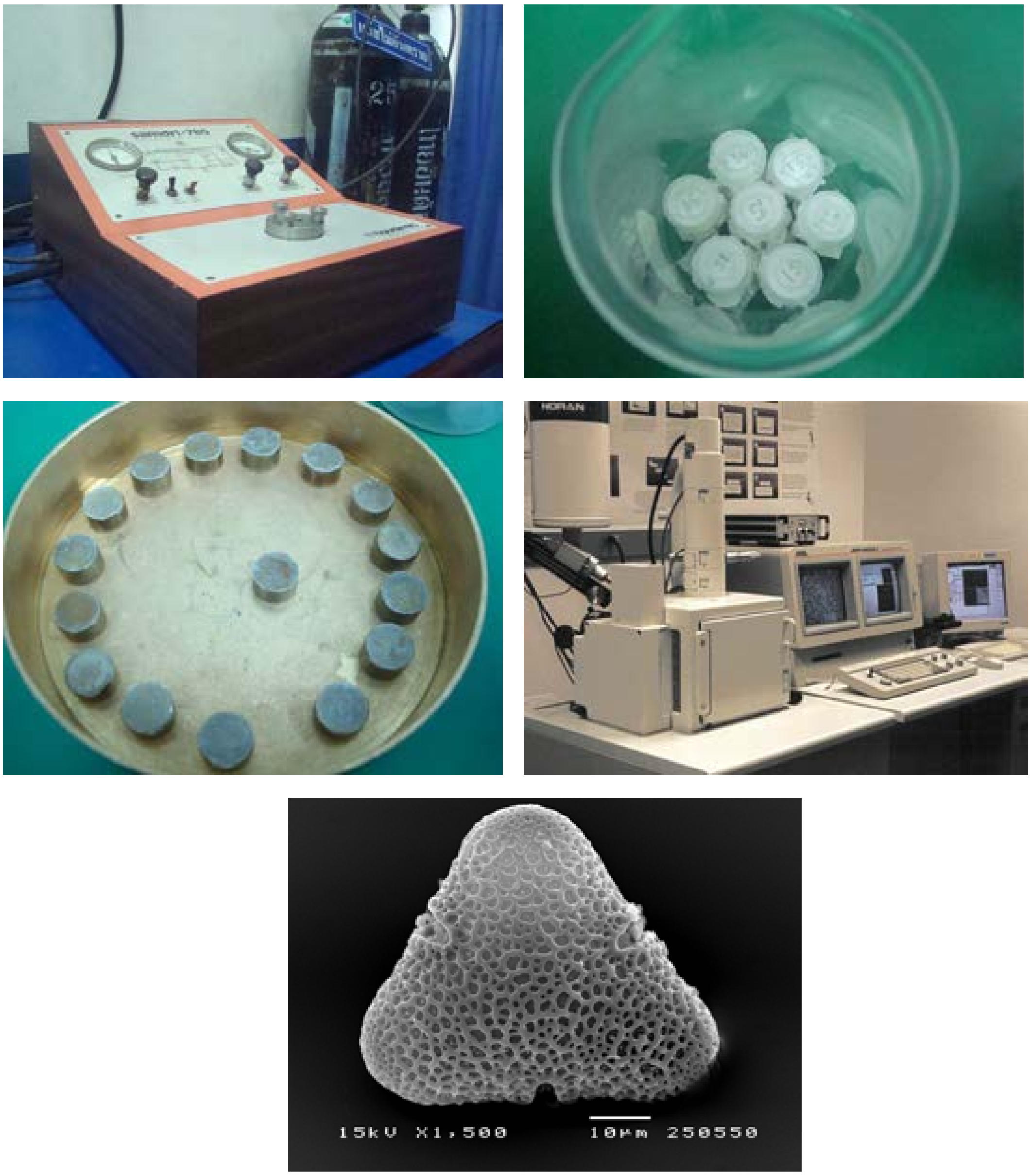

Figure 4.6 Preparation of pollen for SEM examination.

4.2 Results

From this study, 52 plant species of 27 families were found which can be divided into 4 groups : 21 species of herbs, 20 species of trees, 6 species of climbers and 5 species of shrubs. Family Caesalpiniodeae was the most number with nine plant species, followed by Asteraceae (six plant species); Malvaceae, Mimosaceae, Poaceae and Rubiaceae (three plant species each); Acanthaceae, Apocynaceae, Convolvulaceae and Zingiberaceae (two plant species each). Seventeen families were shown a single plant species (Table 4.1).

Table 4.1 The flowering period of 52 species from Chulalongkorn University Forest and Research Station in September 2010-August 2011.

Plant families	Plant species	Plant life form	2010				2011							
			Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Acanthaceae	*Barleria lupulina* Lindl.	s	/						/					
	Thunbergia laurifolia Linn.	c				/	/	/						
Anacardiaceae	*Mangifera indica* Linn.	t						/						
Amaranthaceae	*Celosia argentea* Linn.	s	/											
Apocynaceae	*Amalocalyx microlobus* Pierre ex Spire	c	/	/										
	Wrightia arborea (Dennst.) Mabb.	t								/				
Asteraceae	*Acmella oleracea*(L.) R.K.Jansen	h				/	/							
	Ageratum conyzoides	h	/	/	/	/	/	/				/	/	/
	Bidens alba var. radiata	h	/	/	/	/	/	/	/	/	/	/	/	/
	Chromolaena odoratum (L.) King & H.E.Robins.	h	/	/	/	/	/	/				/	/	/

Plant life form are : t= trees, c= climbers, s= shrubs (more than 1 m in height), h= herbs and herb less than 1 m in height.

Table 4.1 The flowering period of 52 species from Chulalongkorn University Forest and Research Station in September 2010-August 2011 (continued).

Plant families	Plant species	Plant life form	2010				2011							
			Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Asteraceae	*Melampodium divaricatum* (Rich. ex Pers.) DC.	h			/									
	Tridax procumbens Linn.	h	/	/	/	/	/	/	/	/	/	/	/	/
Boraginaceae	*Cordia sebestena* Linn.	t	/								/	/		
Buddlejaceae	*Buddleja asiatica* Lour.	s						/						
Convolvulaceae	*Merremia* vitifolia Haller f.	c			/	/	/							
	Merremia umbellata subsp. *orientalis* (Hall. f.).	c				/	/	/						
Dilleniaceae	*Dillenia ovata* Wall.	t							/	/				
Euphorbiaceae	*Jatropha gossypifolia* Linn.	s								/	/	/		
Hypericaceae	*Cratoxylum formosum* (Jack.) Dyer subsp.	t							/	/				

Plant life form are : t= trees, c= climbers, s= shrubs (more than 1 m in height), h= herbs and herb less than 1 m in height.

Table 4.1 The flowering period of 52 species from Chulalongkorn University Forest and Research Station in September 2010-August 2011 (continued).

Plant families	Plant species	Plant life from	2010				2011							
			Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Lauraceae	*Litsea glutinosa* C.B.Rob.	t									/			
Caesalpinioideae	*Afzelia xylocarpa* Craib.	t							/					
	Arachis sp.	h									/	/		
	Bauhinia acuminata Linn.	t										/		
	Bauhinia saccocalyx Pierre.	t	/						/	/				
	Cassia fistula Linn.	t								/				
	Cassia siamea Lamk.	t	/	/							/	/		
	Leucaena glauca (Lam.) de Wit	t	/	/	/		/				/		/	/
	Samanea saman Merr.	t								/				
	Senna spectabilis Irwin & Barneby.	t										/	/	/

Plant life form are : t= trees, c= climbers, s= shrubs (more than 1 m in height), h= herbs and herb less than 1 m in height.

Table 4.1 The flowering period of 52 species from Chulalongkorn University Forest and Research Station in September 2010-August 2011 (continued).

Plant families	Plant species	Plant Life from	2010				2011							
			Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Lythraceae	*Lagerstroemia floribunda* Jack.	t								/	/			
	Lagerstroemia macrocarpa Wall.	t	/											
Malvaceae	*Sida acuta* Burm. F.	h		/	/									
	Sida cordifolia Linn.	h		/	/									
	Urena lobata Linn.	h		/	/	/				/				
Mimosaceae	*Mimosa pigra* Linn.	s	/	/	/	/	/	/	/	/	/	/	/	/
	Mimosa pudica Linn.	h	/	/	/	/	/	/	/	/	/	/	/	/
	Xylia xylocarpa Roxb. Taub.	t							/					
Orobanchaceae	*Aeginetia indica* Linn.	h	/	/										
Onagraceae	Ludwigia hyssopifolia (G. Don) Exell.	h			/									

Plant life form are : t= trees, c= climbers, s= shrubs (more than 1 m in height), h= herbs and herb less than 1 m in height.

Table 4.1 The flowering period of 51 species from Chulalongkorn University Forest and Research Station in September 2010-August 2011 (continued).

Plant families	Plant species	Plant life from	2010				2011							
			Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Passifloraceae	*Passiflora foetida* Linn.	h							/	/	/	/		
Poaceae	*Arundo donax* L. var. versicolor	h						/						
	Imperata cylindrical Beauv.	h	/	/	/									
	Melinis repens (Willd.) Zizka.	h	/	/										
Rubiaceae	*Haldina cordifolia* (Roxb.) Ridsdale	t		/								/		
	Morinda corcia Ham.	t						/						
	Paederia pilifera Hook. F.	c						/						
Saururaceae	*Houttuynia cordata* Thunb.	h												/
Stilaginaceae	*Antidesma velutinosum* Blume.	t									/			

Plant life form are : t= trees, c= climbers, s= shrubs (more than 1 m in height), h= herbs and herb less than 1 m in height.

Table 4.1 The flowering period of 51 species from Chulalongkorn University Forest and Research Station in September 2010-August 2011 (continued).

Plant families	Plant species	Plant life from	2010				2011							
			Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Tiliceae	*Muntingia calabura* Linn.	t						/	/	/	/	/	/	/
Verbenaceae	*Congea tomentosa* Roxb.	c					/							
Zingiberaceae	*Alpinia galanga* (L.) Willd.	h										/		
	Sostus speciosus (Koen.) Sm.	h		/	/									

Plant life form are : t= trees, c= climbers, s= shrubs (more than 1 m in height), h= herbs and herb less than 1 m in height.

4.2.1 Pollen food sources and quantity of pollen type of stingless bees

The study presented the pollen food sources were collected by two stingless bees species. A total of 59 pollen types were identified in the samples, represented 21 families as follow: Asteraceae (5 pollen types), Caesalpinioideae (4 pollen types), Poaceae (3 pollen types), Convolvulaceae, Euphorbiaceae, Lythraceae, Mimosaceae (two pollen types each), Apiaceae, Anacardiaceae, Amaranthaceae, Apocynaceae, Bombacaceae, Boraginaceae, Hypericaceae, Passifloraceae, Malvaceae, Rosaceae, Sapindaceae, Solanaceae, Tiliceae (1 pollen type each). Twenty - five pollen types are identified to the species level, thirty-four pollen types are unidentified, of those, 9 pollen types can be identified to be family level.

Pollen food sources and quantity of pollen type of *Tetragonilla collina* (C2)

Thirty- three pollen types were found in the pollen samples. Sixteen families belong to Asteraceae (three pollen types); Convolvulaceae and Mimosaceae (two pollen types each) and thirteen families were represented by a single pollen type. Pollen types that could not be identified were classified as “unknown”, and these were obtained in fourteen unknown pollen types.

The highest number of six pollen types were found in September 2010, December 2010 and April 2011. The frequency classes of the different pollen types in the samples, 8 types were recorded in the predominant pollen class (> 45 %): Unknown 1 of Apiaceae, *Leucaena glauca*, *Imperata cyclindrical* and unknown 10, 12, 14, 21 and unknown 22. Secondary pollen class (16-45 %) are 3 tpyes: *Lagerstroemia macrocarpa*, *Passiflora foetida* and *Muntingia calabura*. Important minor pollen class (3-15 %) are 14 pollen types. Minor pollen class (< 3 %) are 8 pollen types (Table 4.2).

The predominant pollen were found in September 2010 to January 2011 and May 2011 to August 2011. Pollen type with occurrence percentages between 16 % and 45 % (secondary pollen) predominated September 2010 and during February 2011 to April 2011. The pollen types with occurrence percentage between 3 % and 15 % (important minor pollen occurred during September 2010 to May 2011, January 2011 and August 2011. The minor pollen appeared during December 2010 to April 2011 and August 2011(Figure 4.7).

Table 4.2 Annual cycle of pollen types in pollen samples harvested by *Tetragonilla collina* (C2) at Chulalongkorn University Forest and Research Station at Lai Nan subdistrict, Wiang Sa district, Nan province.

Plant families	Plant species	2010				2011							
		Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Anacardiaceae	*Mangifera indica*						++						
Apiaceae	Unknown 1					++++							
Apocynaceae	*Wrightia arborea*								++				
Asteraceae	*Acmella oleracea*						++						
	Bidens alba	++		++									
	Melampodium divaricatum			++			+						
Boraginaceae	*Cordia sebestena*									++			
Caesalpinioideae	*Leucaena glauca*	++	++++										+
Convolvulaceae	Unknown 3					+							
	Merremia umbellata					+							
Euphorbiaceae	Unknown 4						++						
Lythraceae	*Lagerstroemia macrocarpa*	+++											
Malvaceae	*Urena lobata*		++						+				

Frequency classes are given for the relative importance of pollen type on the total pollen food soures harvested in one year : ++++ = > 45 %, +++ = 16-45 %, ++ = 3-15 %, and + = < 3 %.

Table 4.2 Annual cycle of pollen types in pollen samples harvested by *Tetragonilla collina* (C2) at Chulalongkorn University Forest and Research Station at Lai Nan subdistrict, Wiang Sa district, Nan province (continued).

Plant families	Plant species	2010				2011							
		Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Mimosaceae	*Mimosa pigra*		++		++								
	M. pudica	++	++		+								++
Passifloraceae	*Passiflora foetida*							+++	+++	++			
Poaceae	*Imperata cylindrical*	++	++		++				++	++++	+		++++
Sapindaceae	Unknown 9							+					
Solanaceae	*Capsicum frutescens*					++							
Tiliceae	*Muntingia calabura*						+++						
	Unknown 10	++++											
	Unknown 11			++									
	Unknown 12			++++									
	Unknown 13				++								
	Unknown 14				++++								
	Unknown 15				++								

Frequency classes are given for the relative importance of pollen type on the total pollen food soures harvested in one year : ++++ = > 45 %, +++ = 16-45 %, ++ = 3-15 %, and + = < 3 %.

Table 4.2 Annual cycle of pollen types in pollen samples harvested by *Tetragonilla collina* (C2) at Chulalongkorn University Forest and Research Station at Lai Nan subdistrict, Wiang Sa district, Nan province (continued).

Plant families	Plant species	2010				2011							
		Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
	Unknown 16					++							
	Unknown 17							++					
	Unknown 18							++					
	Unknown 19								++				
	Unknown 20								++				
	Unknown 21										++++		
	Unknown 22											++++	

Frequency classes are given for the relative importance of pollen type on the total pollen food soures harvested in one year : ++++ = > 45 %, +++ = 16-45 %, ++ = 3-15 %, and + = < 3 %.

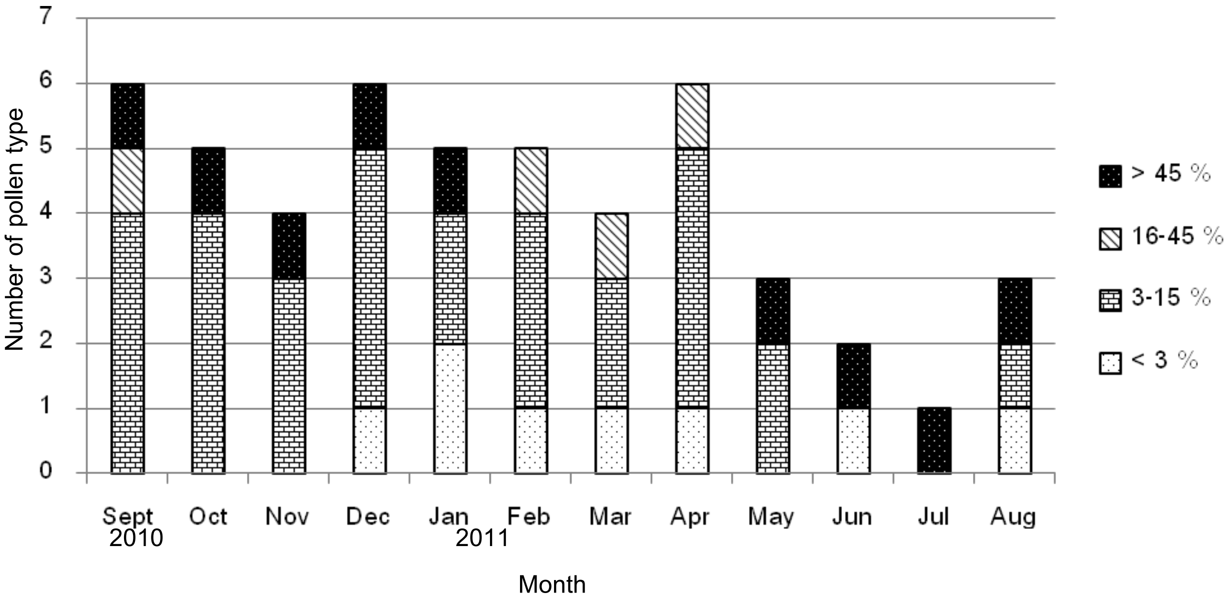

Figure 4.7 Frequency classes of pollen types of *Tetragonilla collina* (C2)

Pollen food sources of *Tetragonilla collina* (C3)

Twenty- two pollen types were found in the pollen samples. Twelve families belong to the Asteraceae (two pollen types) and eleven families were represented by a single pollen type. Nine pollen types could be identifield and thirteen pollen types could not be identifield.

Six pollen types, the highest number were found in December 2010 and February 2011. The frequency classes of the different pollen types in the samples, 6 types were recorded in the predominant pollen class (> 45 %): *Celosia argentea*, *I. cylindrical* and unknown 10, 12, 26 and unknown 27. *C. argentea* occurred in December 2010. *I. cylindrical* predominated October 2010 and during June 2011 to August 2011. Secondary pollen class (16-45 %) are 3 tpyes: *Cordia sebestena, P. foetida* and *I. cylindrical*. The minor pollen class (3-15 %) are 15 pollen types: *Chromolaena odoratum*, *Tridax procumbens, Merremia umbellata*., Unknown 4, *Cassia fistula*, *Passiflora foetida, I. cylindrical*, *Mimosa pigra*, Myrtaceae (Unknown 5), Rosaceae (Unknown 8), Sapindaceae (Unknown 9), Unknown 16, 23, 24, 25 and Unknown 31 (Table 4.3)

Pollen type with occurrence percentages between 16 % and 45 % (secondary pollen) predominated in December 2010, March 2011 and May 2011. The pollen types with occurrence percentage between 3 % and 15 % occurred in October 2010 to December 2010 and during February 2011 to May 2011 and August 2011. The minor pollen were found in November 2010 (Figure 4.8).

Table 4.3 Annual cycle of pollen types in pollen samples harvested by *Tetragonilla collina* (C3) at Chulalongkorn University Forest and Research Station at Lai Nan subdistrict, Wiang Sa district, Nan province.

Plant families	Plant species	2010				2011							
		Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Amaranthaceae	*Celosia argentea*				++++								
Asteraceae	*Chromolaena odoratum*		++										
	Tridax procumbens						++						
Boraginaceae	*Cordia sebestena*				+++								
Caesalpinioideae	*Cassia fistula*								++				
Convolvulaceae	*Merremia* sp 2.				++								
Euphorbiaceae	Unknown 4						++						
Mimosaceae	*Mimosa pigra*			++	++								
Myrtaceae	Unknown 5							++					
Passifloraceae	*Passiflora foetida*							+++		++			

Frequency classes are given for the relative importance of pollen type on the total pollen food soures harvested in one year : ++++ = > 45 %, +++ = 16-45 %, ++ = 3-15 %, and + = < 3 %.

Table 4.3 Annual cycle of pollen types in pollen samples harvested by *Tetragonilla collina* (C3) at Chulalongkorn University Forest and Research Station at Lai Nan subdistrict, Wiang Sa district, Nan province (continued).

Plant families	Plant species	2010				2011							
		Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Poaceae	*Imperata cylindrical*	++	++++	+				++	++	+++	++++	++++	++++
Rosaceae	Unknown 8						++						
Sapindaceae	Unknown 9						++						
	Unknown 10	++++											
	Unknown 12			++++									
	Unknown 16						++						
	Unknown 23				++								
	Unknown 24				++								
	Unknown 25						++						
	Unknown 26								++++				
	Unknown 27											++++	
	Unknown 31												++

Frequency classes are given for the relative importance of pollen type on the total pollen food soures harvested in one year : ++++ = > 45 %, +++ = 16-45 %, ++ = 3-15 %, and + = < 3 %.

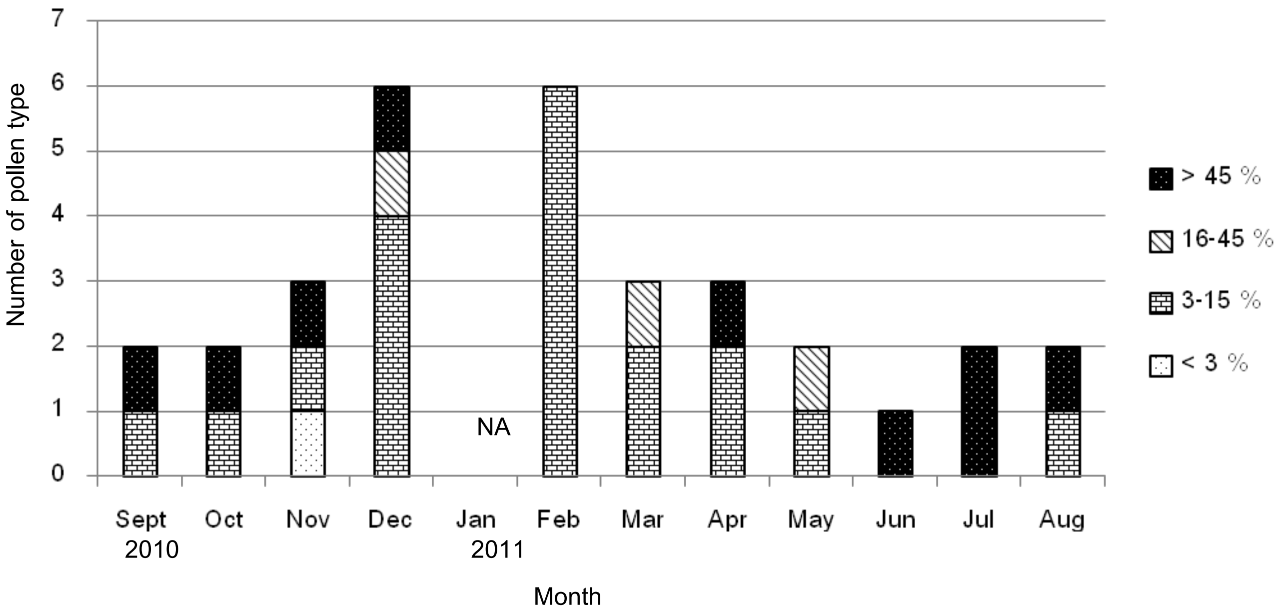

Figure 4.8 Frequency classes of pollen types of *Tetragonilla collina* (C3).

NA= No foraging behavior of stingless bees

Pollen food sources of *Tetragonilla collina* (C4)

Twenty- three pollen types were found in pollen samples. Nine families belong to the Poaceae (three pollen types); Mimosaceae (two pollen types), and seven families were represented by a single pollen type. Of twenty- three pollen types, eleven pollen types could not be identified.

The highest number of six pollen types were found in February 2011. The frequency classes of the different pollen types in the samples, 3 types were recorded in predominant pollen (> 45 %): *Bauhinia acuminate,* Unknown 10, and Unknown 12. *B. acuminate* occurred in March 2011. Unknown 10 predominated in September 2010 and Unknown 12 occered in November 2010. Secondary pollen class (16-45 %) are 4 types: *Merremia umbellata*, *I. cylindrical*, Unknown 4 and Unknown 27. *M. umbellata* occurred in December 2010. The pollen type of Unknown 4 occurred during January 2011 to February 2011. *I. cylindrical* was found in October 2010 and August 2011. The minor pollen class (3-15 %) had 15 pollen types: Apiaceae (Unknown 1), *Celosia argentea*, *T. procumbens*, *M. pigra*, *M. pudica*, *I. cylindrical,* Euphorbiaceae (Unknown 4), Poaceae (Unknown 6 and unknown 7), Rosaceae (Unknown 8), Sapindaceae (Unknown 9), Unknown 15, 18, 26, 28, 29, and Unknown 30. The minor pollen predominated during October 2010 to May 2011 and June 2011. The minor pollen had 2 types, *Passiflora foetida* was found in May 2011 and *I. cylindrical* was found in August 2011 (Table 4.4 and Figure 4.9).

Table 4.4 Annual cycle of pollen types in pollen samples harvested by *Tetragonilla collina* (C4) at Chulalongkorn University Forest and Research Station at Lai Nan subdistrict, Wiang Sa district, Nan province.

Plant families	Plant species	2010				2011							
		Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Apiaceae	Unknown 1					++	++						
Amaranthaceae	*Celosia argentea*					++			++				
Asteraceae	*Tridax procumbens*							++					
Convolvulaceae	*Merremia umbellata*				+++								
Euphorbiaceae	Unknown 4				++	+++	+++						
Caesalpinioideae	*Bauhinia acuminata*							+++					
Passifloraceae	*Passiflora foetida*									+			
Mimosaceae	*Mimosa pigra*		++	++									
	M. pudica		++										
Poaceae	*Imperata cylindrical*	+	+++		+	+	+		+	++	+++		+
	Unknown 6			++									
	Unknown 7											++	

Frequency classes are given for the relative importance of pollen type on the total pollen food soures harvested in one year : ++++ = > 45 %, +++ = 16-45 %, ++ = 3-15 %, and + = < 3 %.

Table 4.4 Annual cycle of pollen types in pollen samples harvest by *Tetragonilla collina* (C4) at Chulalongkorn University Forest and Research Station at Lai Nan subdistrict, Wiang Sa district, Nan province (continued).

Plant families	Plant species	2010				2011							
		Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Rosaceae	Unknown 8						++						
Sapindaceae	Unknown 9							++					
	Unknown 10	++++											
	Unknown 12			++++									
	Unknown 16					++	++						
	Unknown 18							++					
	Unknown 26							++	++				
	Unknown 27												+++
	Unknown 28						++						
	Unknown 29								++				
	Unknown 30											++	

Frequency classes are given for the relative importance of pollen type on the total pollen food soures harvested in one year : ++++ = > 45 %, +++ = 16-45 %, ++ = 3-15 %, and + = < 3 %.

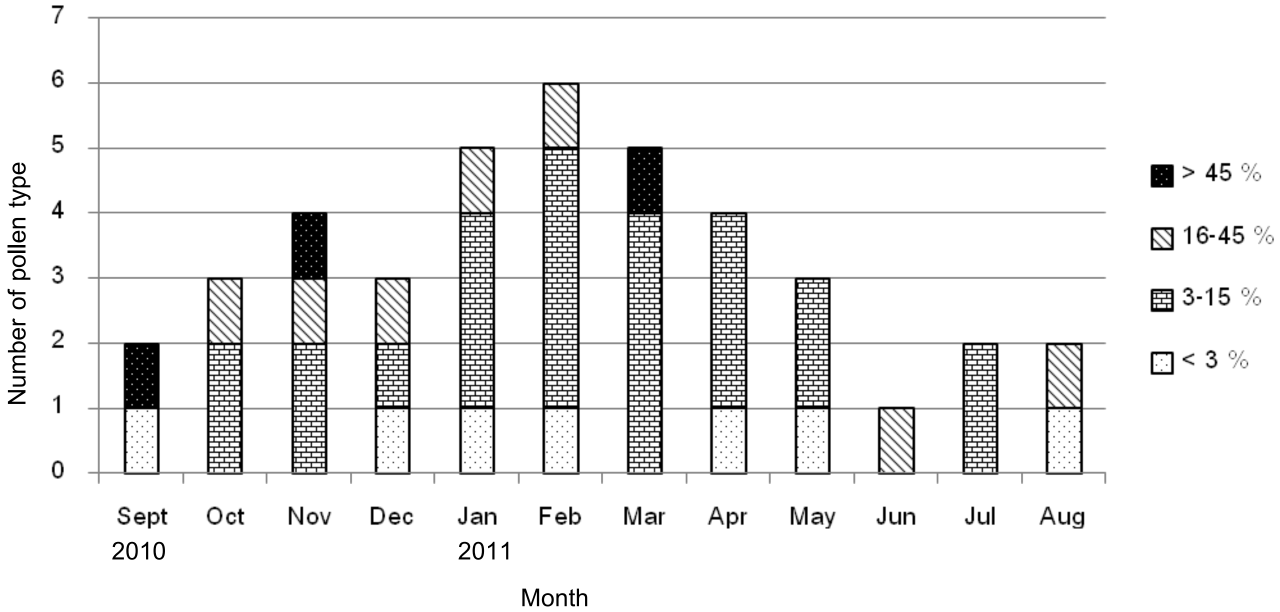

Figure 4.9 Frequency classes of pollen types of *Tetragonilla collina* (C4).

NA= No foraging behavior of stingless bees

Pollen food sources of *Tetrigona apicalis* (A9)

The pollen types collected by *Tetrigona apicalis* were found in Table 4.5, twelve pollen types, belonging to seven families and six unidentified pollen types. The mimosaceae and Poaceae families were the highest number with two types while Caesalpinioideae, Euphorbiaceae, Hypericacee, Lythraceae, and Sapindaceae were represented by a single pollen type.

The highest number of four pollen types were found in November 2010. The frequency classes of the different pollen types in the samples, 8 pollen types were recorded in predominant pollen class (> 45 %): Euphorbiaceae (Unknown 4)., *Cratoxylum formosum*, *Leucaena glauca*, *I. cylindrical, L. macrocarpa,* Unknown 20, Unknown 21 and Unknown 32. Euphorbiaceae (Unknown 4) occurred in December 2010 to February 2011. *C. formosum* occurred in March 2011. *L. glauca* represented in October 2010 and August 2011. Unknown 32 occerrd in February 2011. *L. macrocarpa* and Unknown 20 occurred in April 2011. Unknown 21 occurred in June 2011 and *I. cylindrical* represented in August 2011. *L. glauca* is the secondary pollen occurred in November 2010. The minor pollen class (3-15 %) had 3 pollen types: *Mimosa pigra*, *M. pudica* with occurred in November 2010 and Sapindaceae (Unknown 9) occurred in March 2011. Pollen type with occurrence percentages below 3 % (minor pollen) are *L. glauca* and Unknown 6 of Poaceae occurred in November 2010, December 2010, March 2011 and May 2011. The pollen types with occurrence percentage between 3 % and 15 % occurred during October 2010 to December 2010 and during from February 2011 to May 2011and August 2011 The minor pollens were found in November 2010 (Figure 4.10).

Table 4.5 Annual cycle of pollen types in pollen samples harvested by *Tetrigona apicalis* (A9) at Chulalongkorn University Forest and Research Station at Lai Nan subdistrict, Wiang Sa district, Nan province.

Plant families	Plant species	2010				2011							
		Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Caesalpinioideae	*Leucaena glauca*		++++	+++								+	++++
Euphorbiaceae	Unknown 4				++++	++++	++++						
Hypericaceae	*Cratoxylum formosum*							++++					
Lythraceae	*Lagerstroemia maccrocapa*								++++				
Mimosaceae	*Mimosa pigra*			++									
	M. pudica			++									
Poaceae	*Imperata cylindrical*												++++
	Unknown 6			+									
Sapimdaceae	Unknown 9							++					
	Unknown 20								++++				
	Unknown 21										++++		
	Unknown 32						++++						

Frequency classes are given for the relative importance of pollen type on the total pollen food soures harvested in one year : ++++ = > 45 %, +++ = 16-45 %, ++ = 3-15 %, and + = < 3 %.

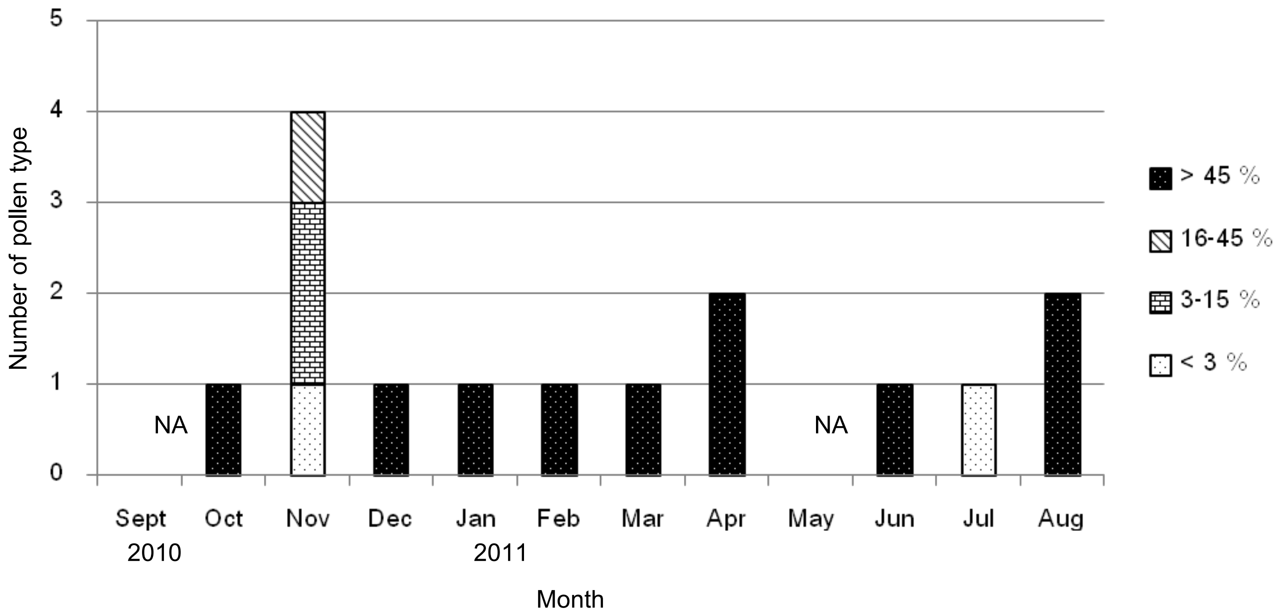

Figure 4.10 Frequency classes of pollen types of *Tetrigona apicalis* (A9).

NA= No foraging behavior of stingless bees

Pollen food sources of *Tetrigona apicalis* (A10)

The pollen types collected by *Tetrigona apicalis* were found in Table 4.6, 18 pollen types, belonging to 4 families and 10 unidentified pollen types. The Euphorbiaceae, Caesalpinioideae, Mimosaceae and Poaceae families were represented by two pollen type.

The highest number of six pollen types were found in December 2010. The frequency classes of the different pollen types in the samples, 8 pollen types were recorded in predominant pollen (> 45 %): *Jatropha gossypifolia*, Unknown 4, *L. glauca*, *I. cylindrical*, Unknown 6 of Poaceae, Unknown 9 of Sapindaceae, Unknown 12, Unknown 18, Unknown 20, Unknown 21, Unknown 26, Unknown 32, Unknown 33 and Unknown 34. *J. gossypifolia* occurred in June 2011. Unknown 4 occurred in January 2011, *L. glauca* occurred in October 2010, *I. cylindrical* and Unknown 6 of Poaceae occurred in May 2011. Unknown 12 occurred in November 2010, Unknown 9, and Unknown 18 occurred in March 2011. Unknown 20 and Unknown 26 represented in April 2011, Unknown 21, Unknown 33 and Unknown 34 were found in June 2011, December 2010 and February 2011, respectively. *L. glauca* and unknown 12 are the secondary pollen occurred in November 2010. The minor pollen class (3-15 %) had 6 pollen types: Unknown 4, *C. siamea*, *M. pigra*, *M. pudica*, *I. cylindrical* and Unknown 32. *M. pigra*, *M. pudica* and Unknown 32 were found in December 2010. Unknown 4, *C. siamea* and *I. cylindrical* represented in February 2011, May 2011 and July 2011, respectively. *I. cylindrical* is pollen type with occurrence percentages below 3 % (minor pollen) with occurred in December 2010 and August 2011 (Table 4.6 and Figure 4.11).

Table 4.6 Annual cycle of pollen types in pollen samples harvested by *Tetrigona apicalis* (A10) at Chulalongkorn University Forest and Research Station at Lai Nan subdistrict, Wiang Sa district, Nan province.

Plant families	Plant species	2010				2011							
		Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Euphorbiaceae	*Jatropha gossypifolia*										++++		
	Unknown 4					++++	++						
Caesalpinioideae	*Cassia siamea*									++			
	Leucaena glauca		++++									++++	+++
Mimosaceae	*Mimosa pigra*				++								
	M. pudica				++								
Poaceae	*Imperata cylindrical*				+					++++		++	+
	Unknown 6									++++			
Sapindaceae	Unknown 9							++++					

Frequency classes are given for the relative importance of pollen type on the total pollen food soures harvested in one year : ++++ = > 45 %, +++ = 16-45 %, ++ = 3-15 %, and + = < 3 %.

Table 4.6 Annual cycle of pollen types in pollen samples harvested by *Tetrigona apicalis* (A10) at Chulalongkorn University Forest and Research Station at Lai Nan subdistrict, Wiang Sa district, Nan province continued..

Plant families	Plant species	2010				2011							
		Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
	Unknown 12			++++									
	Unknown 14				+++								
	Unknown 18							++++					
	Unknown 20								++++				
	Unknown 21										++++		
	Unknown 26								++++				
	Unknown 32				++								
	Unknown 33				++++								
	Unknown 34						++++						

Frequency classes are given for the relative importance of pollen type on the total pollen food soures harvested in one year : ++++ = > 45 %, +++ = 16-45 %, ++ = 3-15 %, and + = < 3 %.

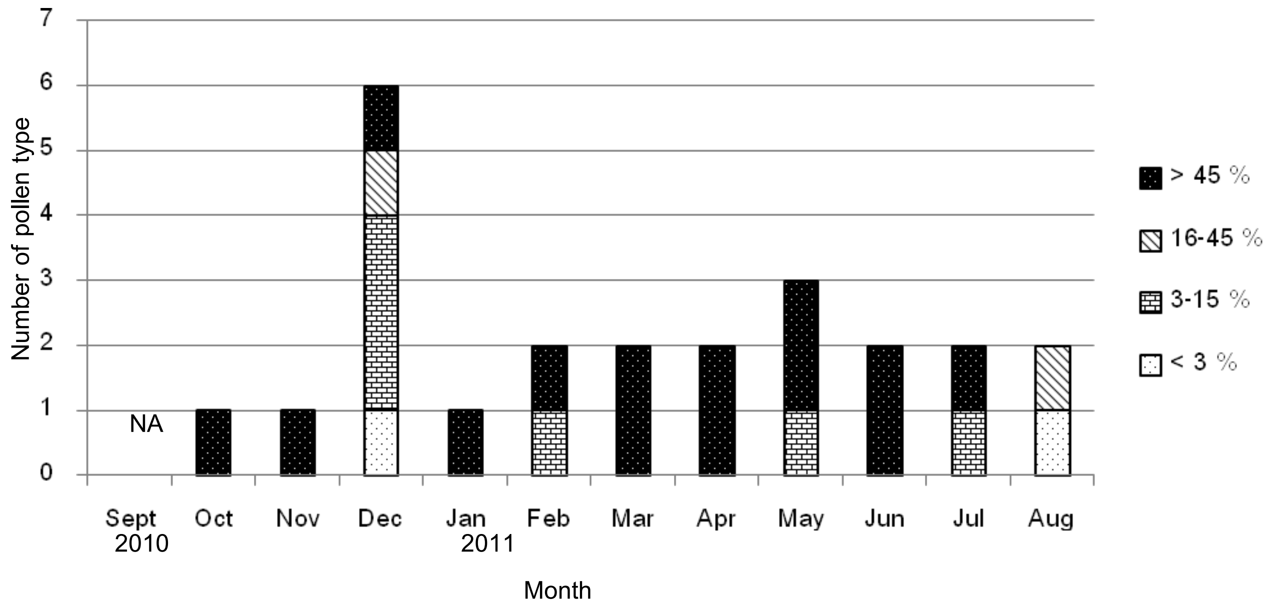

Figure 4.11 Frequency classes of pollen types of *Tetrigona apicalis* (A10).

NA= No foraging behavior of stingless bees

Pollen food sources of *Tetrigona apicalis* (A11)

The pollen types collected by *Tetrigona apicalis* were found in Table 4.7, 13 pollen types, belonging to 6 families and 7 unidentified pollen types. The Poaceae are the most number with two types while Bombacaceae, Caesalpinioideae, Euphorbiaceae, Hypericacee, Lythraceae, and Sapindaceae were represented by a single pollen type.

Ten pollen types were recorded in predominant pollen (> 45 %): Unknown 2 of Bombacaceae, Unknown 4 of Euphorbiaceae, *C. formosum, L. glauca, L. macrocorpa,* Unknown 9 of Sapindaceae, Unknown 12, Unknown 20, Unknown 21, and Unknown 26. Unknown 2 of Bombacaceae, Unknown 4 of Euphorbiaceae, *L. glauca*, Unknown 12, and Unknown 21 represented in October 2010, November 2010, December 2010, January 2011 and June 2011, respectively. *C. formosum*, Unknown 9 of Sapindaceae and Unknown 20 occurred in March 2011. *L. macrocorpa* and unknown 26 occurred in March 2011. Unknown 4 of Euphorbiaceae and unknown 17 are the secondary pollen occurred in February 2011 and April 2011 respectively. Unknown 4 of Euphorbiaceae is the minor pollen class (3-15 %) occurred in January 2011. Poaceae (*I. cylindrical* and Unknown 6) are minor pollen with occurred in November 2010, December 2010 and June 2011 (Table 4.7 and Figure 4.12).

Table 4.7 Annual cycle of pollen types in pollen samples harvest by *Tetrigona apicalis* (A11) at Chulalongkorn University Forest and Research Station at Lai Nan subdistrict, Wiang Sa district, Nan province.

Plant families	Plant species	2010				2011							
		Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Bombacaceae	Unknown 2					++++							
Euphorbiaceae	Unknown 4				++++	++	+++						
Hypericaceae	*Cratoxylum formosum*							++++					
Lythraceae	*Lagerstroemia macrocorpa*								++++				
Caesalpinioideae	*Leucaena glauca*		++++										++++
Poaceae	*Imperata cylindrical*										+		
	Unknown 6			+	+								
Sapindaceae	Unknown 9							++++					
	Unknown 12			++++									
	Unknown 18					+++							
	Unknown 20							++++	+++				
	Unknown 21										++++		
	Unknown 26								++++				

Frequency classes are given for the relative importance of pollen type on the total pollen food soures harvested in one year : ++++ = > 45 %, +++ = 16-45 %, ++ = 3-15 %, and + = < 3 %.

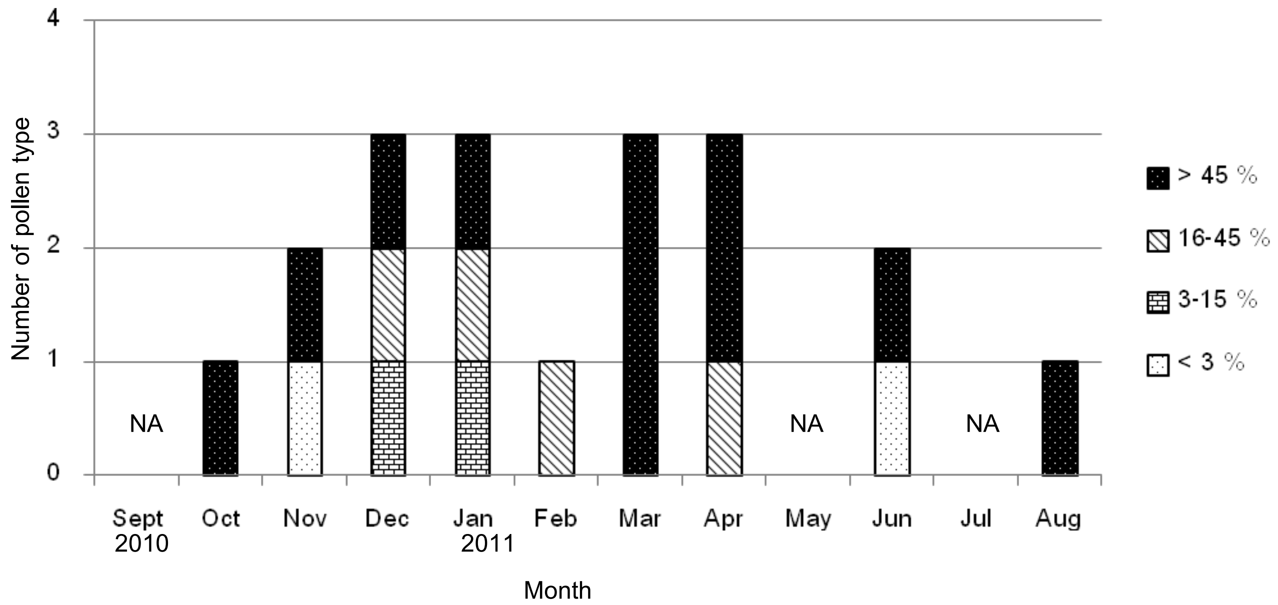

Figure 4.12 Frequency classes of pollen types of *Tetrigona apicalis* (A11).

NA= No foraging behavior of stingless bees

Pollen food sources of all three *Tetragonilla collina* nests (C2, C3, and C4)

In all pollen types studied of *Tetragonilla collina*, a total of 51 plant species of 19 families, of those plant species, 30 pollen types could not be identified. Thirty-three pollen type collected by C2, twenty-two pollen types collected by C3 and twenty- three pollen types collected by C3.

Among 51 pollen types, 9 pollen types were recorded in three nests: Caesalpinioideae, *M. pigra*; Convolvulaceae, *M. umbellat*a.; Euphorbiaceae, Unknown 4.; Passifloraceae, *P. foetida*; Poaceae, *I. cyclindrical*; Sapindaceae, Unknown 9; Unknown 10, Unknown 12, and Unknown 16. Apiaceae, Unknown 1 was found in C2 and C4. Three pollen types were recorded in C2 and C4: Apiaceae, Unknown 1; Mimosaceae*, M. pudica* and Unknown 18. Five pollen types were found in C3 and C4: Amaranthaceae, *C. argentea*; Asteraceae, *T. daxprocumbens*; Unknown 8 of Rosaceae, Unknown 26 and Unknown 27. Boraginaceae, *C. sebestena* occurred in C2 and C3. Twenty pollen types were found in C2: Anacardiaceae, *M. indica*; Apocynaceae, *W. arborea*; Asteraceae, *A. oleracea*; *B. alba*; *M. divaricatum*, Caesalpinioideae, *L. glauca*; Convolvulaceae, Unknown 3; Lythraceae, *L. floribunda*; Malvaceae, *Urena lobata*; Sapindaceae, Unknown 9; Solanaceae, *C. frutescens* ; Tiliceae, *M. calabura*; Unknown 11; Unknown 14; Unknown 16; Unknown 17, Unknown 20. Seven pollen types were found in C3: Asteraceae, *C. odoratum*; Caesalpinioideae, *C. fistula*; Myrtaceae, Unknown 5; Unknown 23; Unknown 24 and Unknown 25. Six pollen types were only found in C4: Caesalpinioideae, *B. acuminate*; Poaceae, Unknown 6, Unknown7; Unknown28, Unknown 29; Unknown 30 and Unknown 31 (Table 4.8).

Pollen food sources of all three *Tetrigona apicalis* nests (A9, A10 and A 11)

In all pollen types studied of *Tetrigona apicalis* , a total of 22 plant species of 8 families, of those plant species, 14 pollen types could not be identified. Twelve pollen type collected by A9, eighteen pollen types collected by A10 and thirteen pollen types collected by A11.

Among 22 pollen types, 6 pollen types were recorded in three nests: Caesalpinioideae, *L. glauca*; Euphorbiaceae, Unknown 4; Unknown 6 of Poaceae; Unknown 9 of Sapindaceae, unknown 20 and Unknown 21. Three pollen types were recorded in A9 and A01: Mimosaceae, *M. pigra*, *M. pudica* and Unknown 32. Four pollen types were recorded in A10 and A11: Poaceae, *I. cylindrical*; Unknown 12; Unknown 18 and Unknown 26. Lythraceae, *L. macrocarpa* was only one type found in A9 and A11.

The pollen type of Unknown 8 was found in A9. Six pollen types were found in A10: Caesalpinioideae, *C. siamiea*; Euphorbiaceae, *J. gossypifolia*; Unknown 14; Unknown 33 and Unknown 34. A11 had only one pollen type: Bombacaceae, Unknown 2 (Table 4.8).

Pollen food sources of two species of stingless bees *Tetragonilla collina* and *Tetrigona apicalis*

Table 4.8 shows, pollen food sources of two species of stingless bees, we found 59 plant species of 21 families and unidentified 34 pollen types. Total of unknown 34 pollen type could be identified to the family level with 9 pollen types.

Tetragonilla collina had 37 pollen types of 14 families: Apiceae, Unknown 1; Anacardiaceae, *M. indica*; Amaranthaceae, *C. argentea*; Apocynaceae, *W. arborea*; Asteraceae*, A. oleracea*, *B. alba*, *C. odoratum*, *M. divaricatum*, *T. procumbens*; Boranginaceae, *C. sebestena*; Caesalpinioideae, *B. acuminate*, *C. fistula*, *C. siamea*; Convolvulaceae, *M. umbellata*., Unknown 3; Lythraceae, *L. floribunda*; Malvaceae, *U. lobata*, Passifloraceae, *P. foetida*; Poaceae, Unknown 7; Rosaceae, Unknown 8; Solanaceae, *C. frutescens*; Tiliceae, *M. calabura*; Unknown 11; Unknown 13; Unknown 15; Unknown 16; Unknown 17; Unknown 19; Unknown 22; Unknown 23; Unknown 24; Unknown 25; Unknown 27; Unknown 28; Unknown 29 and Unknown 30, Unknown 31;.

Tetrigona apicalis had 8 pollen types of 4 families: Bombacaceae, Unknown 2; Caesalpinioideae, *C. siamea*; Euphorbiaceae, *J. gossypifolia*; Hypericaceae. *C. formosum*; Lythraceae, *L. macrocarpa*; Unknown 32; Unknown 33 and Unknown 34.

Fourteen pollen types of five families were occurred in *Tetragonilla collina* and *Tetrigona apicalis*: Caesalpinioideae, *L. glauca*; Euphorbiaceae, Unknown 4., Mimosaceae, *M. pigra*, *M. pudica*; Poaceae, *I. cylindrical*, Unknown 6; Sapindaceae, Unknown 9; Unknown 10; Unknown 12; Unknown 14; Unknown 18; Unknown 20; Unknown 21 and Unknown 26.

Pollen food sources of *Tetragonilla collina* comprising 10 herbs, 8 trees, 2 shurbs, and 1 climb plant life form. *Tetrigona apicalis* consist of 4 trees, 2 herbs, and 2 shurbs plant life form (Figure 4.13).

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Table 4.8 Pollen food sources were collected from six nests of two species of the *Tetragonilla collina* (C2, C3, and C4) and *Tetrigona apicalis* (A10, A11, and A12) at Chulalongkorn University Forest and Research Station at Lai Nan subdistrict, Wiang Sa district, Nan province.

Plant families	Plant species	Plant life form	C2	C3	C4	A9	A10	A11
Apiaceae	Unknown 1	-	/		/			
Anacardiaceae	*Mangifera indica*	t	/					
Amaranthaceae	*Celosia argentea*	s		/	/			
Apocynaceae	*Wrightia arborea*	t	/					
Asteraceae	*Acmella oleracea*	h	/					
	Bidens alba	h	/					
	Chromolaena odoratum	h		/				
	Melampodium divaricatum	h	/					
	Tridax procumbens	h		/	/			
Bombacaceae	Unknown 2	-						/
Boraginaceae	*Cordia sebestena*	t	/	/				

Table 4.8 Pollen food sources were collected from six nests of two species of the *Tetragonilla collina* (C2, C3, and C4) and *Tetrigona apicalis* (A10, A11, And A12) at Chulalongkorn University Forest and Research Station at Lai Nan subdistrict, Wiang Sa district, Nan province (continued).

Plant families	Plant species	Plant life form	C2	C3	C4	A9	A10	A11
Caesalpinioideae	*Bauhinia acuminata*	t			/			
	Cassia fistula	t		/				
	Cassia siamea	t					/	
	Leucaena glauca	t	/			/	/	/
Convolvulaceae	*Merremia umbellata*	c	/	/	/			
	Unknown 3	-	/					
Euphorbiaceae	*Jatropha gossypifolia*	s					/	
	Unknown 4	-	/	/	/	/	/	/
Hypericaceae	*Cratoxylum formosum*	t				/		/
Lythraceae	*Lagerstroemia floribunda*	t	/					
	L. macrocarpa	t				/		/

Table 4.8 Pollen food sources were collected from six nests of two species of the *Tetragonilla collina* (C2, C3, and C4) and *Tetrigona apicalis* (A10, A11, and A12) at Chulalongkorn University Forest and Research Station at Lai Nan subdistrict, Wiang Sa district, Nan province (continued).

Plant families	Plant species	Plant life form	C2	C3	C4	A9	A10	A11
Malvaceae	*Urena lobata*	h	/					
Mimosaceae	*Mimosa pigra*	s	/	/	/	/	/	
	M. pudica	h	/		/	/	/	
Myrtaceae	Unknown 5	-		/				
Passifloraceae	*Passiflora foetida*	h	/	/	/			
Poaceae	*Imperata cylindrical*	h	/	/	/		/	/
	Unknown 6	-			/	/	/	/
	Unknown 7	-			/			
Rosaceae	Unknown 8	-		/	/			
Sapindaceae	Unknown 9	-	/	/	/	/	/	/
Solanaceae	*Capsicum frutescens*	h	/					
Tiliceae	*Muntingia calabura*	t	/					
	Unknown 10	-	/	/	/	/		
	Unknown 11	-	/					
	Unknown 12	-	/	/	/		/	/

Table 4.8 Pollen food sources were collected from six nests of two species of the *Tetragonilla collina* (C2, C3, and C4) and *Tetrigona apicalis* (A10, A11, And A12) at Chulalongkorn University Forest and Research Station at Lai Nan subdistrict, Wiang Sa district, Nan province (continued).

Plant families	Plant species	Plant life form	C2	C3	C4	A9	A10	A11
	Unknown 13	-	/					
	Unknown 14	-	/				/	
	Unknown 15	-	/					
	Unknown 16	-	/	/	/			
	Unknown 17	-	/					
	Unknown 18	-	/		/		/	/
	Unknown 19	-	/					
	Unknown 20	-	/			/	/	/
	Unknown 21	-	/			/	/	/
	Unknown 22	-	/					
	Unknown 23	-		/				
	Unknown 24	-		/				
	Unknown 25	-		/				

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Table 4.8 Pollen food sources were collected from six nests of two species of the *Tetragonilla collina* (C2, C3, and C4) and *Tetrigona apicalis* (A10, A11, and A12) at Chulalongkorn University Forest and Research Station at Lai Nan subdistrict, Wiang Sa district, Nan province (continued).

Plant families	Plant species	Plant life form	C2	C3	C4	A9	A10	A11
	Unknown 26	-		/	/		/	/
	Unknown 27	-		/	/			
	Unknown 28	-			/			
	Unknown 29	-			/			
	Unknown 30	-			/			
	Unknown 31	-		/				
	Unknown 32	-				/	/	
	Unknown 33	-					/	
	Unknown 34	-					/	
Total: 21 families	59 species		33	22	23	12	18	13

84

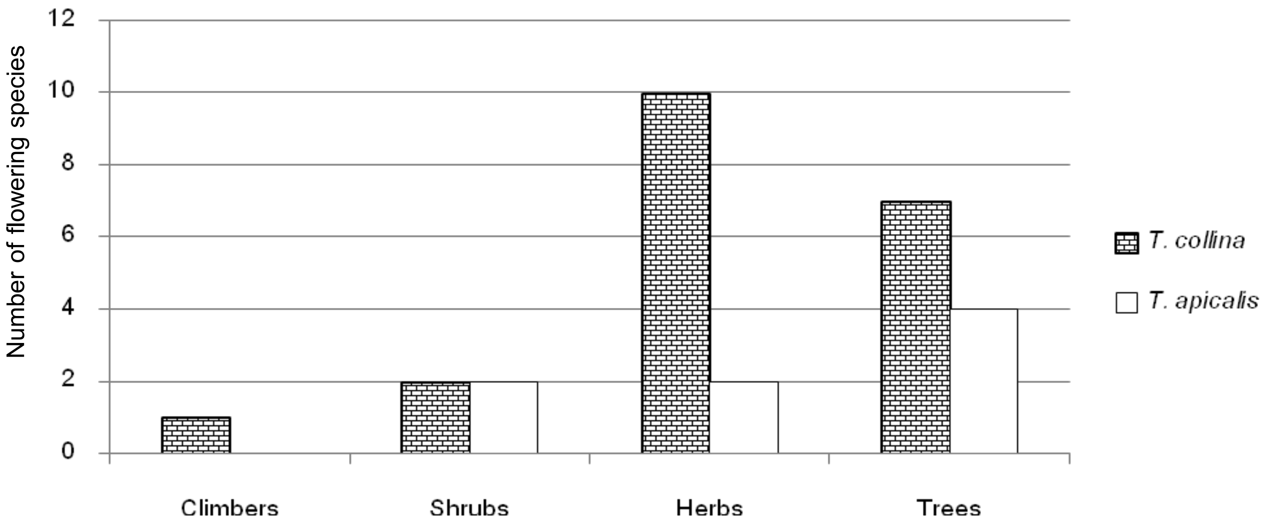

Figure 4.13 Number of flowering species collected by *Tetragonilla collina* and *Tetrigona apicalis*; climbers, shrubs, herbs and trees for pollen food sources.

The correlation between pollen food sources of stingless bees *Tetragonilla collina* and *Tetrigona apicalis* with flowering plants in each month.

Pollen harvesting by stingless bees, *Tetragonilla collina* and *Tetrigona apicalis* during September 2010 – August 2011, the number of pollen types and number of flowering plants were not correlated. The highest number of flowering plants (seventeen species) are recored during September 2010 to October 2010 while the lowest number of flowering plant occurred in July 2011 (nine species).

During the highest number of flowering plants, the total number of nests of *Tetragonilla collina*, the number of pollen food sources of these stingless bee was found less than ten pollen types. In C2 had 6 and 5 pollen types, C3 had 2 pollen types in each month and C4 had 2 and 3 pollen types represented in September and October. For C2, the highest pollen types are represented in September 2010, December 2010 and April 2011, while the lowest pollen types occurred in July 2011. For C3, December 2010 and February 2011 were found the highest of pollen types, whereas June 2011 was the lowest of pollen type found. For C4, the highest pollen type occurred in February 2011, while the lowest pollen type occurred in June 2011 (Figure 4.14).

The total number of nests of *Tetrigona apicalis*, the most number of flowering plants was recorded during September 2010 to October 2010, but the number of pollen food sources in each nest of these stingless bee was found only one type. For A9, November 2010 was the month with the highest number of pollen types, whereas October 2010, December 2010, January 2011, June 2011 and July 2011 were the lowest of pollen types found. For A10, the highest pollen type represented in December 2010, while the lowest of pollen types occurred in October 2010, November 2010 and January 2011. For A11, January 2011, March 2011 and April 2011 were the highest pollen types found, while the lowest of pollen types occurred in October 2010, February 2011 and August 2011 (Figure 4.15).

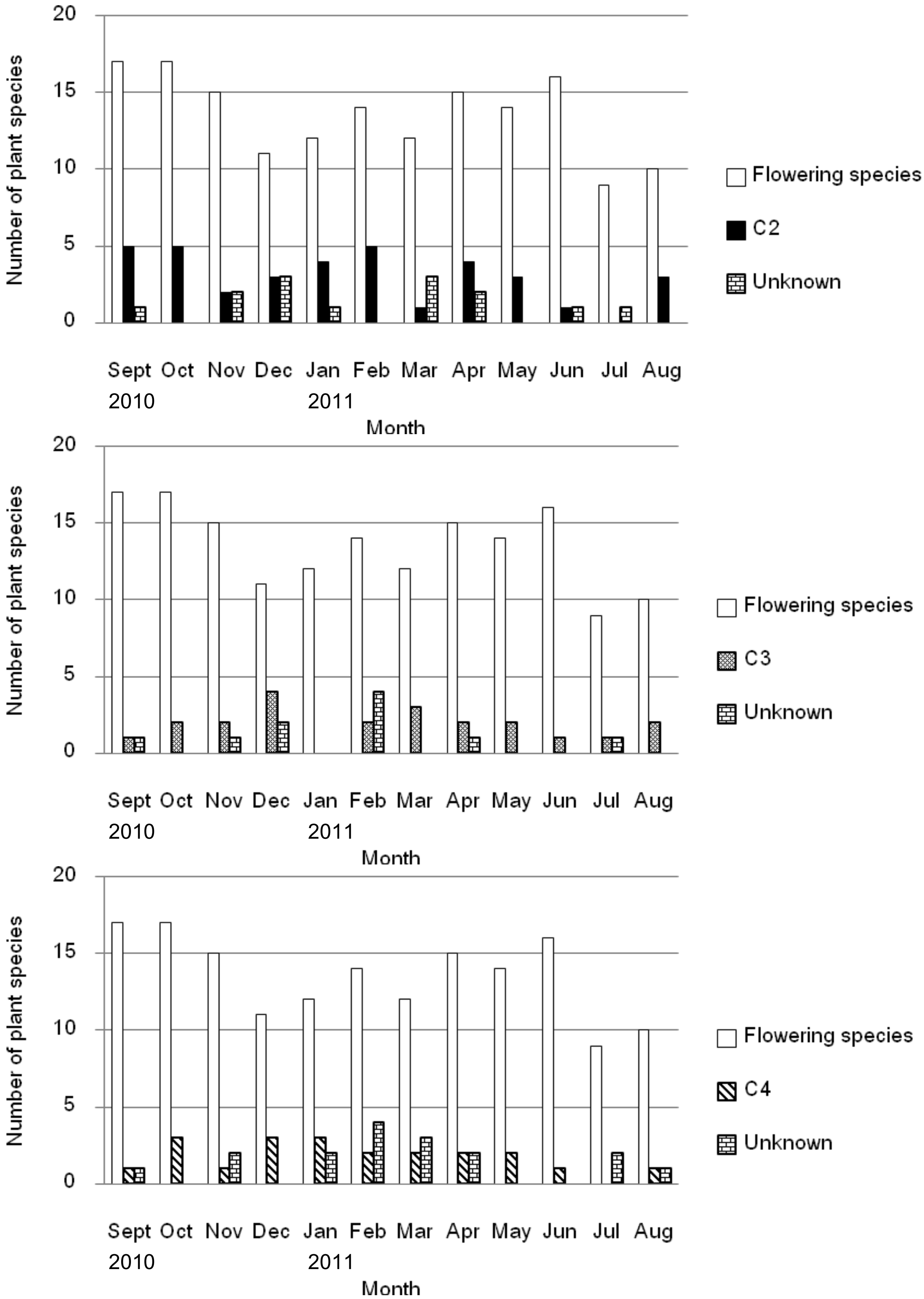

Figure 4.14 Number of flowered species compared to plant species found in pollen collected by *Tetragonilla collina*.

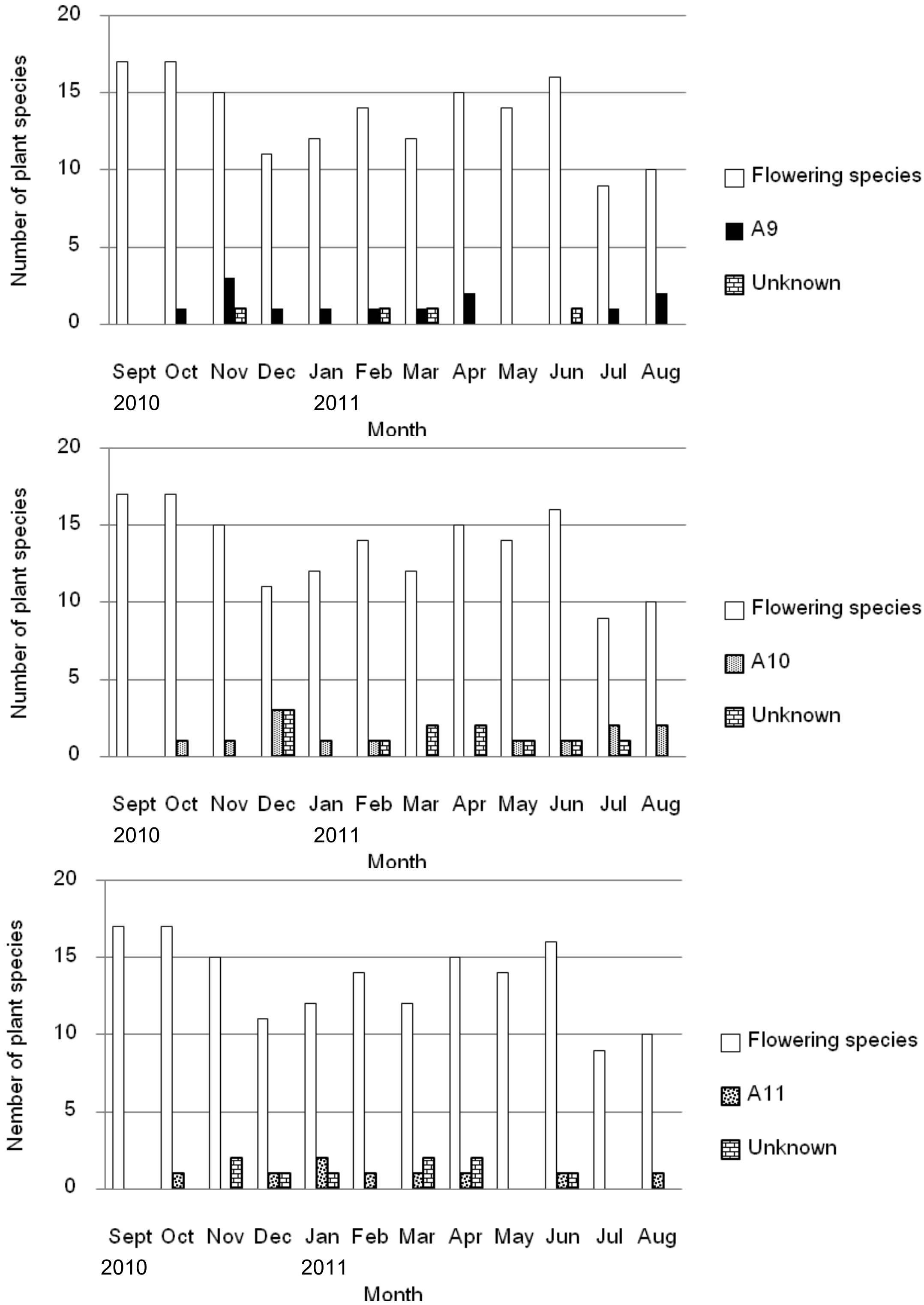

Figure 4.15 Number of flowered species compared to plant species found in pollen collected by *Tetrigona apicalis*.

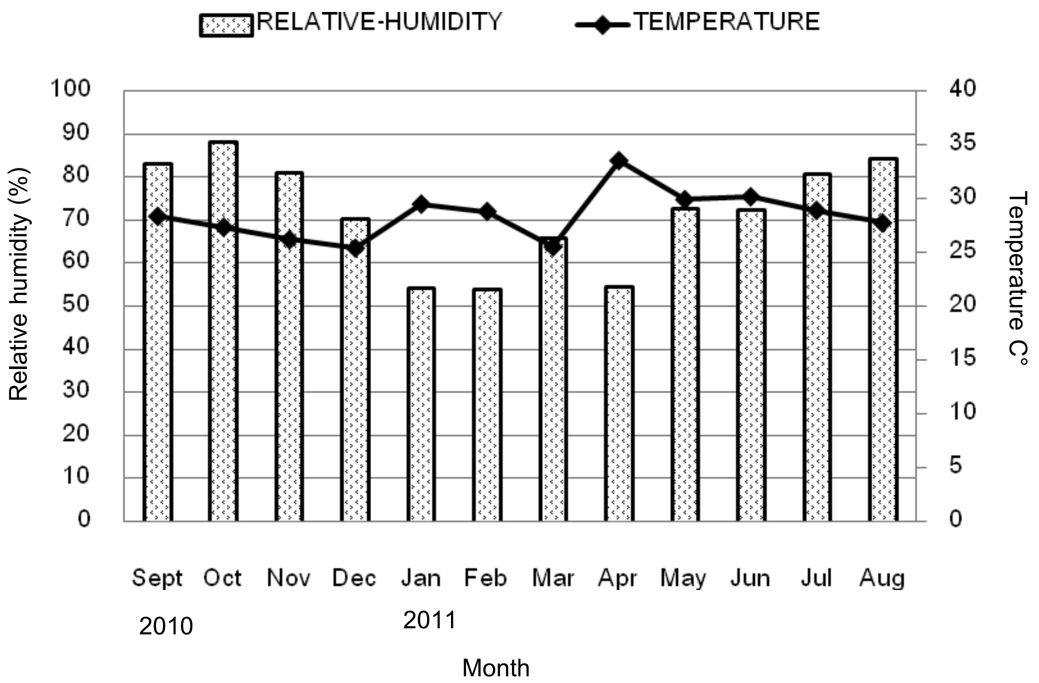

Figure 4.16 The relative humidity (%) and average temperature (°C), September 2010-August 2011, Chulalongkorn University Forest and Research Station at Lai Nan subdistrict, Wiang Sa district, Nan province.

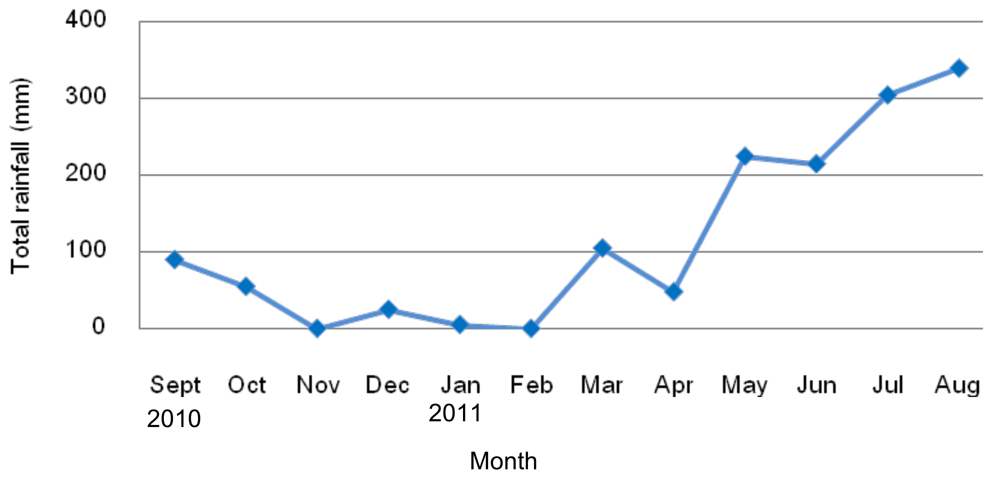

Figure 4.17 The toal rainfall (mm), September 2010- August 2011, Chulalongkorn University Forest and Research Station at Lai Nan subdistrict, Wiang Sa district, Nan province.

Description of pollen types

1. Apiaceae

Unknown 1

Pollen class:	3- zonocolporate
Pollen unit:	monad
Polarity:	isopolar
P/E ratio:	2.67
Shape class:	prolate
Size class:	medium grain
Outline:	-
Aperture:	colporate
Sculpturing:	striate

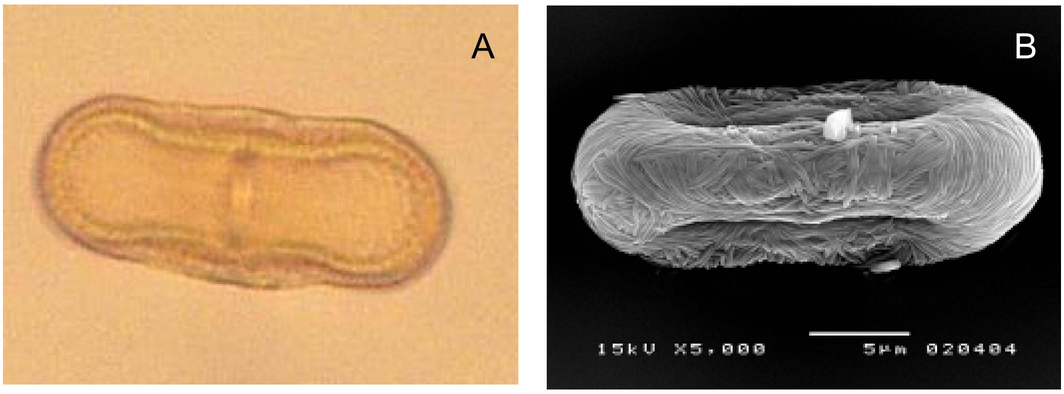

Figure 4.18 LM and SEM micrographs of Apiaceae, Unknown 1

A.– B. Grain and aperture

2. Amaranthaceae

Celosia argentea Linn.

Pollen class:	polypantoporate
Pollen unit:	monad
Polarity:	apolar
P/E ratio:	1.00
Shape class:	spheroidal
Size class:	medium grain
Outline:	circular
Aperture:	inaperturate
Sculpturing:	micro echinate

Figure 4.19 Flower and SEM micrographs of *C. argentea*

A. Flower of *C. argentea*

B. Grain

C. Sculpturing

3. Anacardiaceae

Mangifera indica Linn.

Pollen class:	3-zonocolporate
Pollen unit:	monad
Polarity:	isopolar
P/E ratio:	1.23
Shape class:	subspheroidal
Size class:	small grain
Outline:	circular
Aperture:	colporate
Sculpturing:	perforate

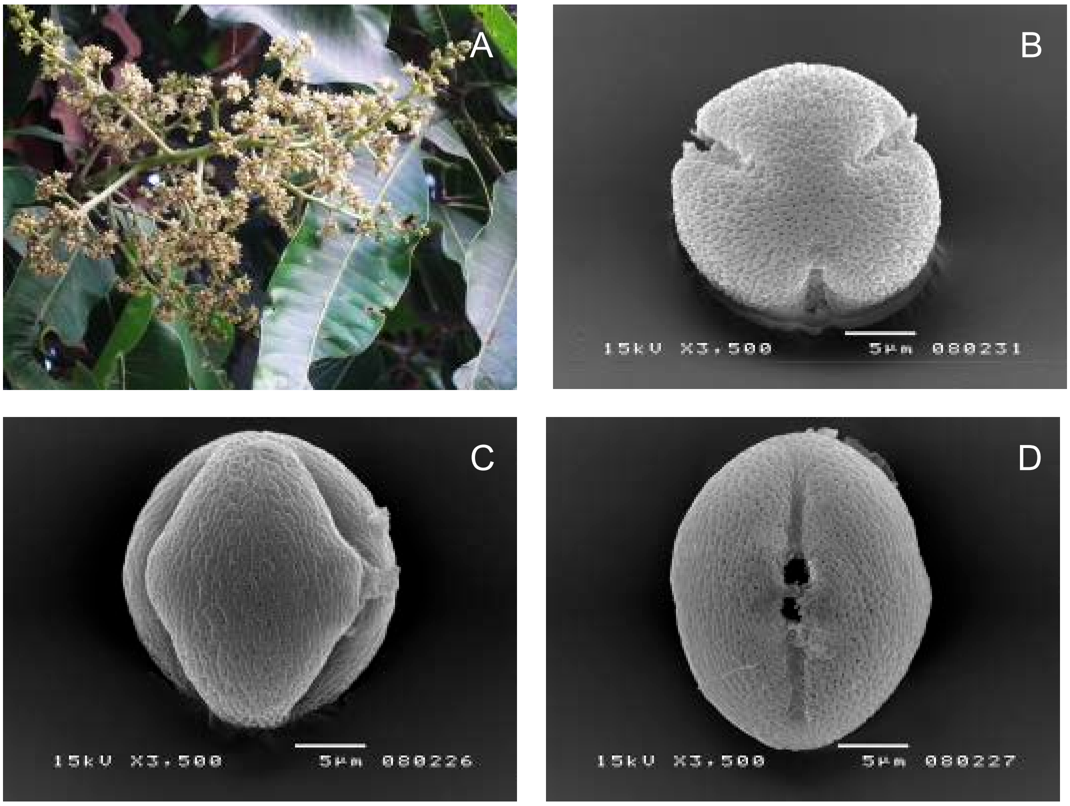

Figure 4.20 Flower and SEM micrographs of *M. indica*

A. Flower of *M. indica* B. Polar view

C. Equatorial view D. Aperture and Sculpturing

4. Apocynaceae

Wrightia arborea (Dennst.) Mabb.

Pollen class:	4 - porate
Pollen unit:	monad
Polarity:	isopolar
P/E ratio:	1.25
Shape class:	subspheroidal
Size class:	medium grain
Outline:	circular
Aperture:	porate
Sculpturing:	-

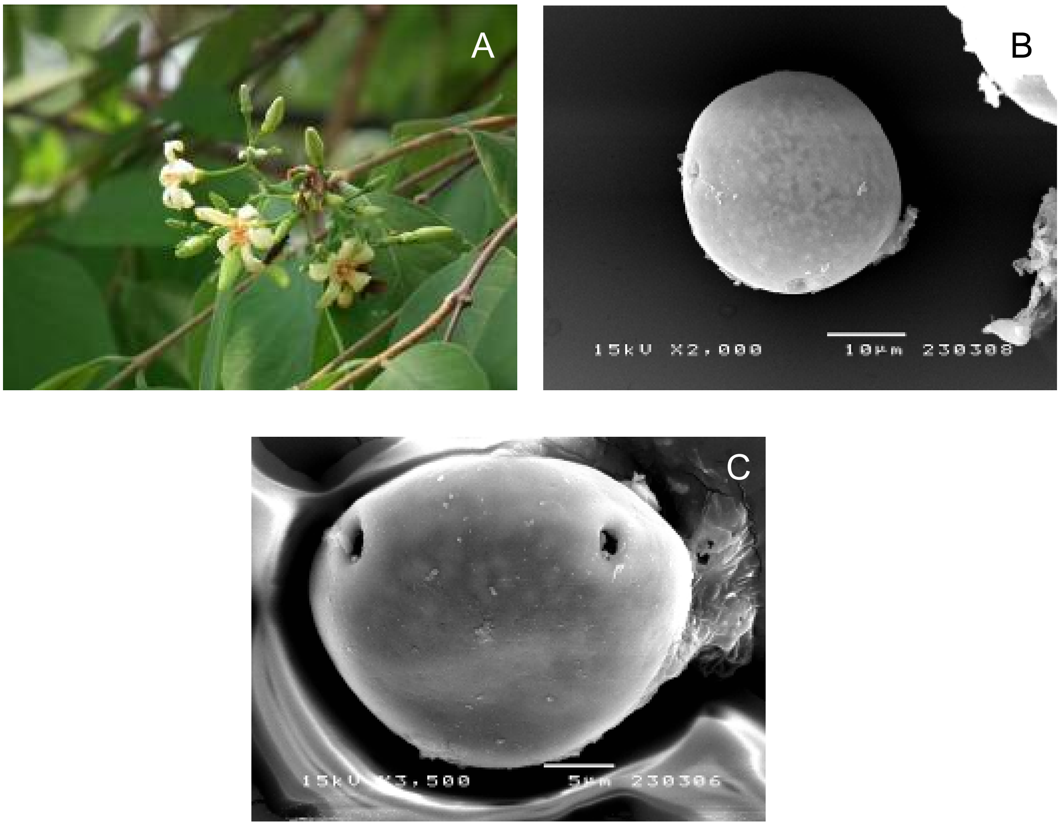

Figure 4.21 Flower and SEM micrographs of *W. arborea*

A. Flower of *W. arborea*.

B. Polar view

C. Equatorial view

5. Asteraceae

Acmella oleracea Linn.

Pollen class:	3- zonocolporate
Pollen unit:	monad
Polarity:	isopolar
P/E ratio:	1.00
Shape class:	subspheroidal
Size class:	small grain
Outline:	circular
Aperture:	tricolporate
Sculpturing:	echinate

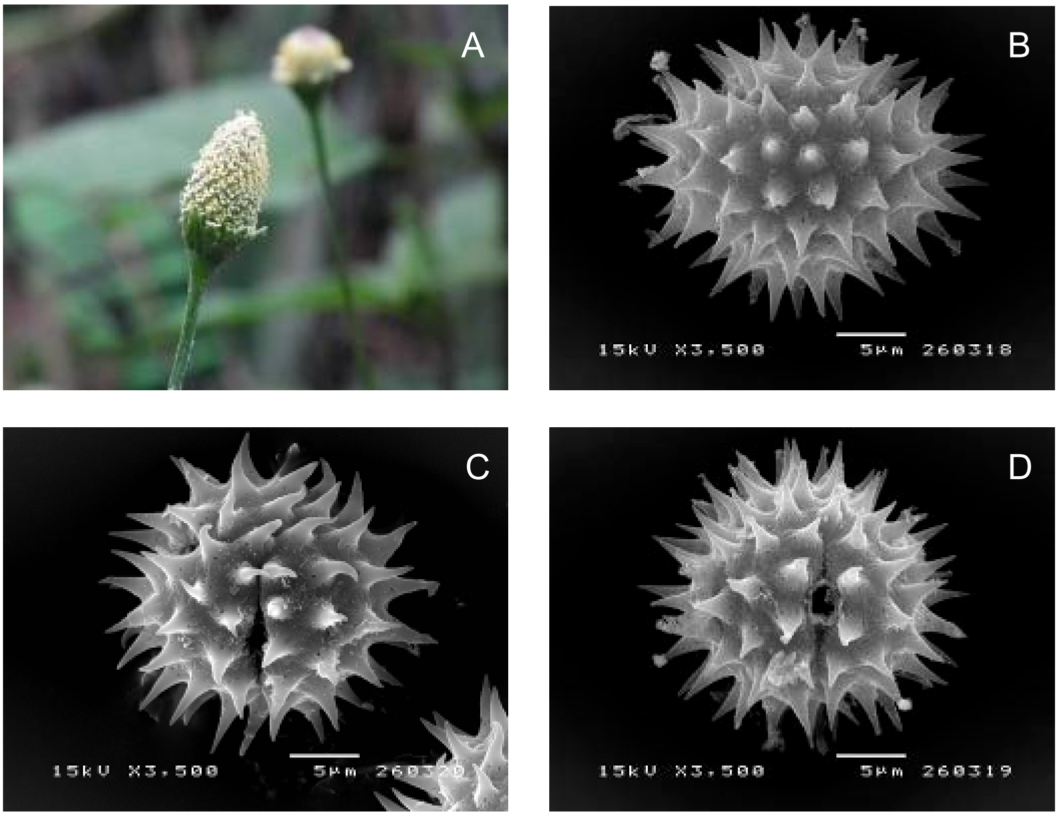

Figure 4.22 Flower and SEM micrographs of *A. oleracea*

A. Flower of *A. oleracea* B. Polar view

C. Equatorial view D. Aperture and Sculpturing

6. Asteraceae

Bidens alba Linn.

Pollen class:	3-zonocolporate
Pollen unit:	monad
Polarity:	isopolar
P/E ratio:	0.86
Shape class:	subspheroidal
Size class:	small grain
Outline:	circular
Aperture:	tricolporate
Sculpturing:	echinate

Figure 4.23 Flower and SEM micrographs of *B. alba*

A. Flower of *B. alba*. B. Equatorial view

C. Aperture and Sculpturing

7. Asteraceae

Chromolaena odoratum (L.) King & Robinson

Pollen class:	3-zonocolpate
Pollen unit:	monad
Polarity:	isopolar
P/E ratio:	0.77
Shape class:	subspheroidal
Size class:	small grain
Outline:	circular
Aperture:	tricolpate
Sculpturing:	echinate

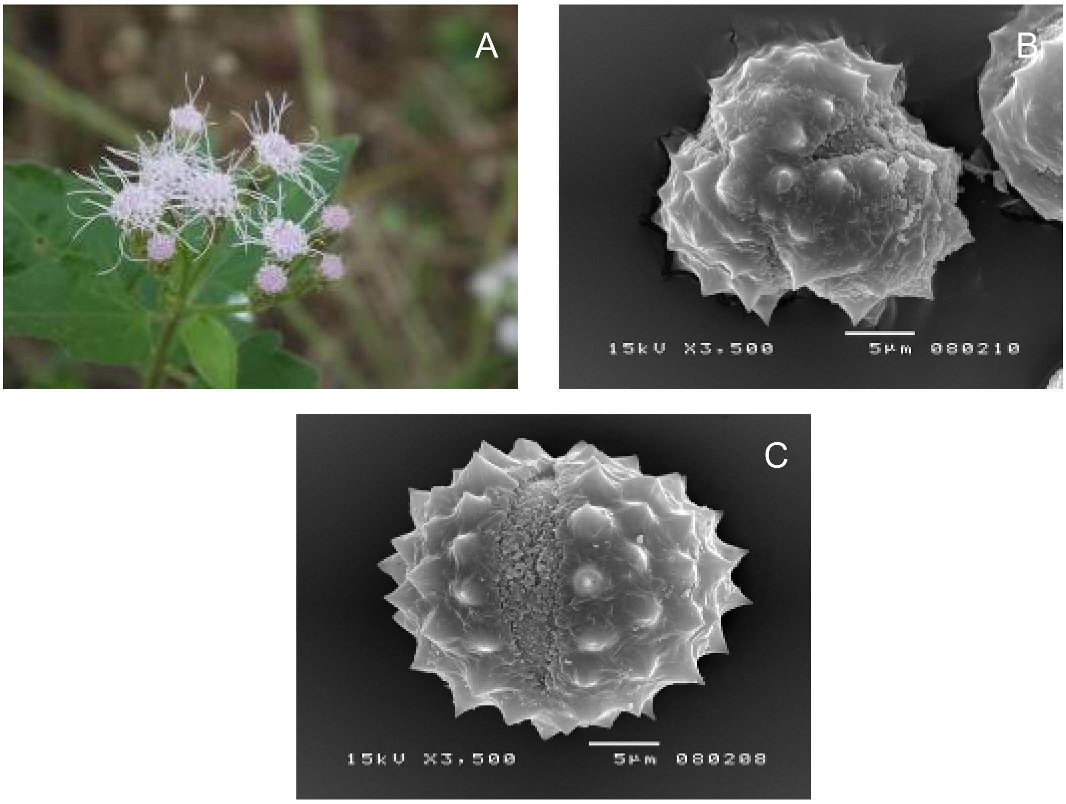

Figure 4.24 Flower and SEM micrographs of *C. odoratum*

A. Flower of *C. odoratum* B. Polar view

C. Aperture and Sculpturing

8. Asteraceae

Melampodium divaricatum (Rich. ex Pers.) DC.

Pollen class:	3-zonocolporate
Pollen unit:	monad
Polarity:	isopolar
P/E ratio:	0.80
Shape class:	subspheroidal
Size class:	medium class
Outline:	circular
Aperture:	tricolporate
Sculpturing:	echinate

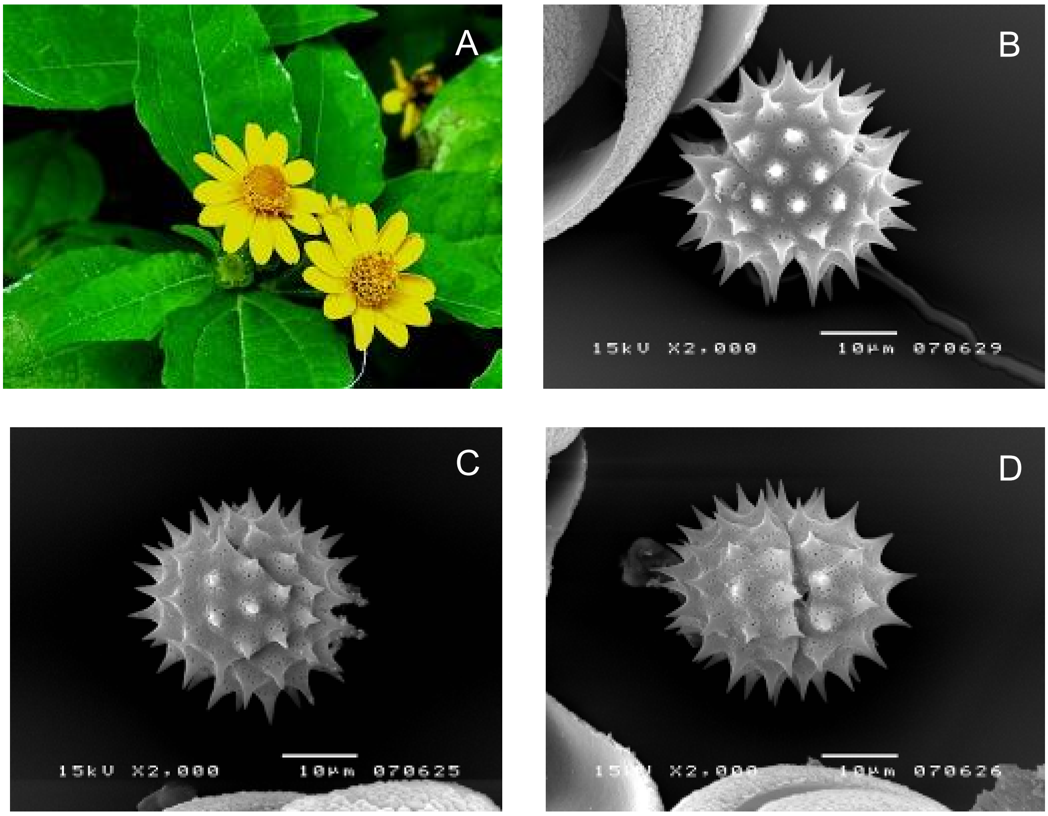

Figure 4.25 Flower and SEM micrographs of *M. divaricatum*

A. Flower of *M. divaricatum* B. Polar view

C. Equatorial view D. Aperture and Sculpturing

9. Asteraceae

Tridax procumbens Linn.

Pollen class:	3-zonocolporate
Pollen unit:	monad
Polarity:	isopolar
P/E ratio:	0.87
Shape class:	stephanocolporate
Size class:	medium grain
Outline:	circular
Aperture:	colporate
Sculpturing:	echinate

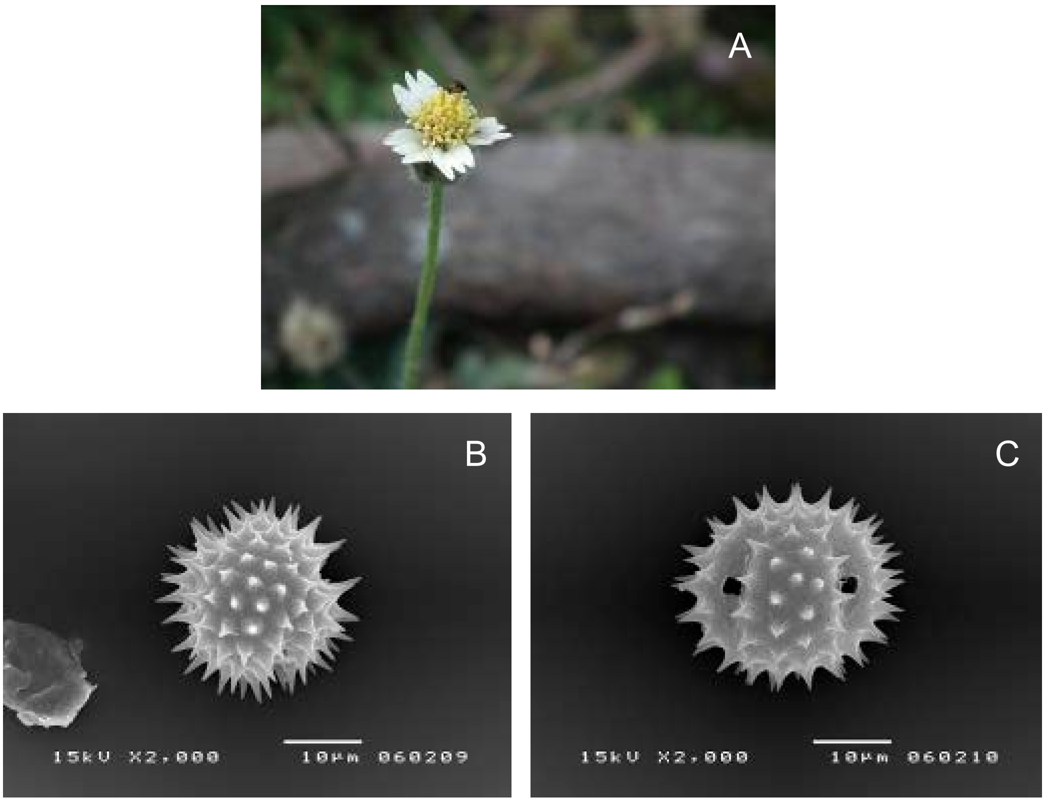

Figure 4.26 Flower and SEM micrographs of *T. procumbens*

A. Flower of *T. procumbens* B. Polar view

C. Equatorial view

10. Bombacaceae

Unknown 2

Pollen class:	tricolporate
Pollen unit:	monad
Polarity:	isopolar
P/E ratio:	0.59
Shape class:	subspheroidal
Size class:	medium grain
Outline:	triangular
Aperture:	tricolporate
Sculpturing:	reticulate

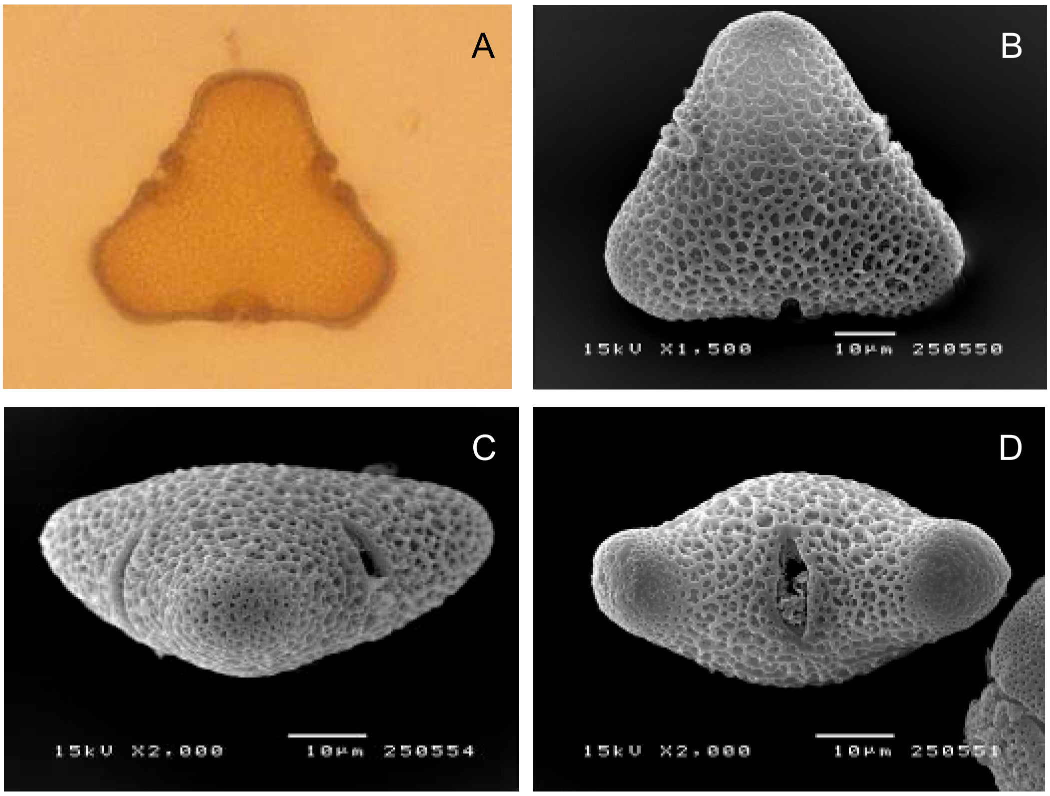

Figure 4.27 LM and SEM micrographs of Unknown 2

A.-B. Polar view

C. Equatorial view

D. Aperture and Sculpturing

11. Boraginaceae

Cordia sebestena Linn.

Pollen class:	3-zonocolpate
Pollen unit:	monad
Polarity:	isopolar
P/E ratio:	0.96
Shape class:	subspheroidal
Size class:	medium grain
Outline:	circular
Aperture:	colpate
Sculpturing:	reticulate

Figure 4.28 Flower and SEM micrographs of *C. sebestena*

A. Flower of *C. sebestena*

B. Polar view

C. Equatorial view

12. Caesalpinioideae

Bauhinia acuminate Linn.

Pollen class:	inaperture
Pollen unit:	monad
Polarity:	apolar
P/E ratio:	1.33
Shape class:	subspheroidal
Size class:	very large grain
Outline:	circular
Aperture:	inaperture
Sculpturing:	reticulate

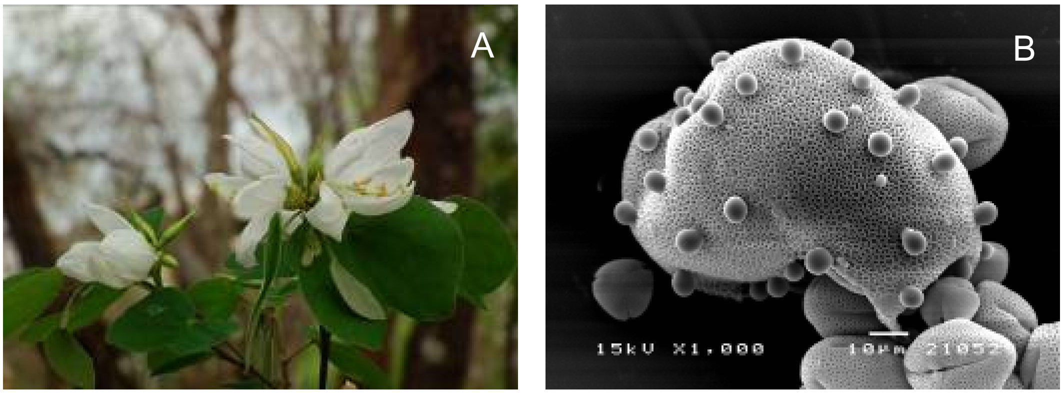

Figure 4.29 Flower and SEM micrographs of *B. acuminate*

A. Flower of *B. acuminate*

B. Sculpturing

13. Caesalpinioideae

Cassia fistula Linn.

Pollen class:	3-zonocolporate
Pollen unit:	monad
Polarity:	isopolar
P/E ratio:	1.04
Shape class:	subspheroidal
Size class:	medium grain
Outline:	circular
Aperture:	colporate
Sculpturing:	perforate

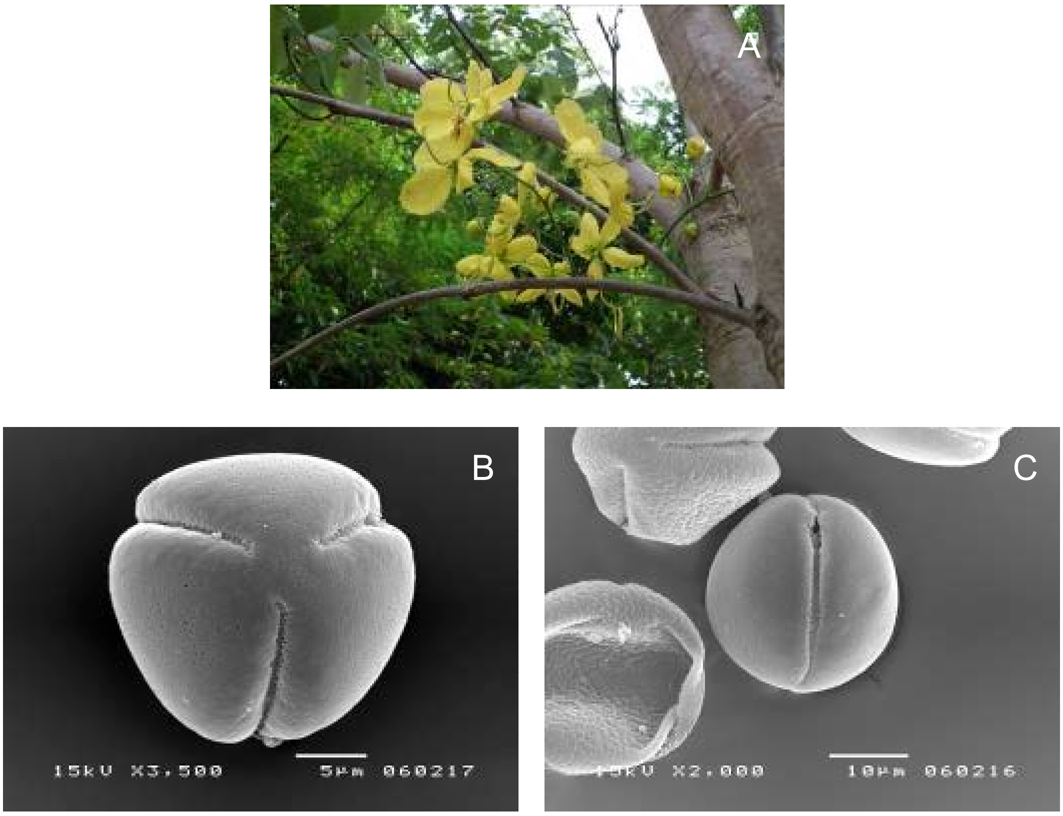

Figure 4.30 Flower and SEM micrographs of *C. fistula*

A. Flower of *C. fistula* B. Polar view

C. Aperture and Sculpturing

14. Caesalpinioideae

Cassia siamea Lamk.

Pollen class:	3-zonocolporate
Pollen unit:	monad
Polarity:	isopolar
P/E ratio:	1.05
Shape class:	subspheroidal
Size class:	medium grain
Outline:	circular
Aperture:	tricolporate
Sculpturing:	perforate

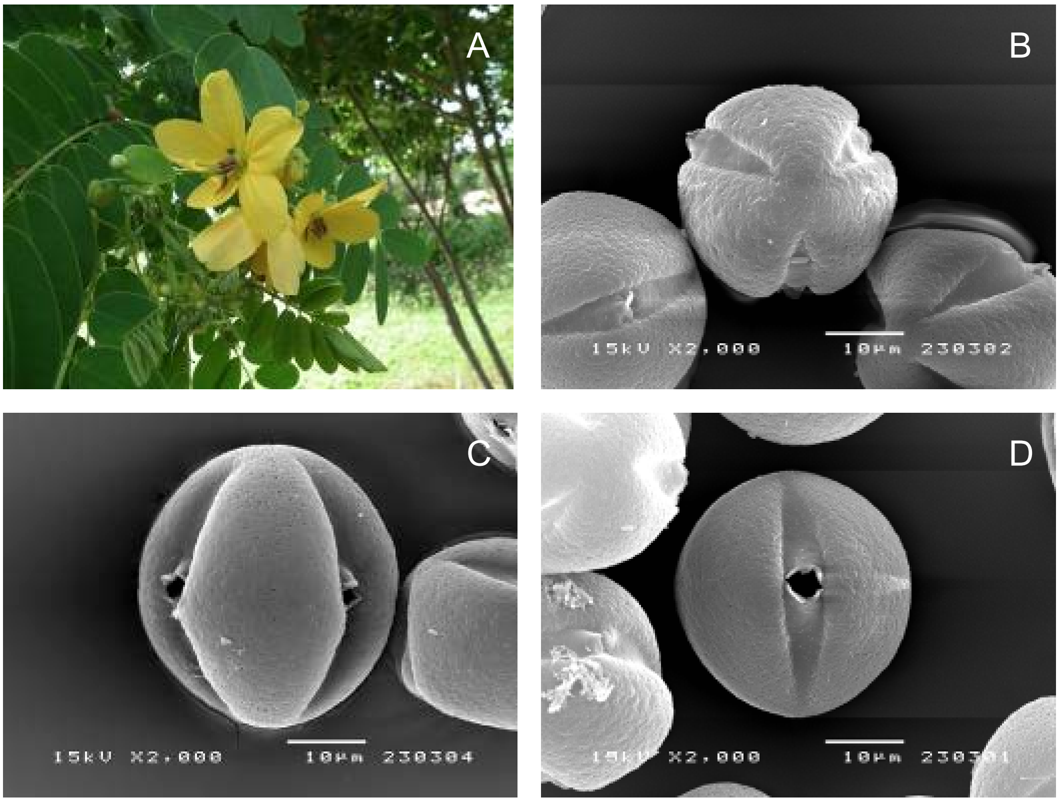

Figure 4.31 Flower and SEM micrographs of *C. siamea*

A. Flower of *C. siamea* B. Polar view

C. Equatorial view D. Aperture and Sculpturing

15. Caesalpinioideae

Leucaena glauca (Lam.) de Wit

Pollen class:	3-zonocolporate
Pollen unit:	monad
Polarity:	isopolar
P/E ratio:	1.11
Shape class:	subspheroidal
Size class:	medium grain
Outline:	circular
Aperture:	tricolporate
Sculpturing:	perforate

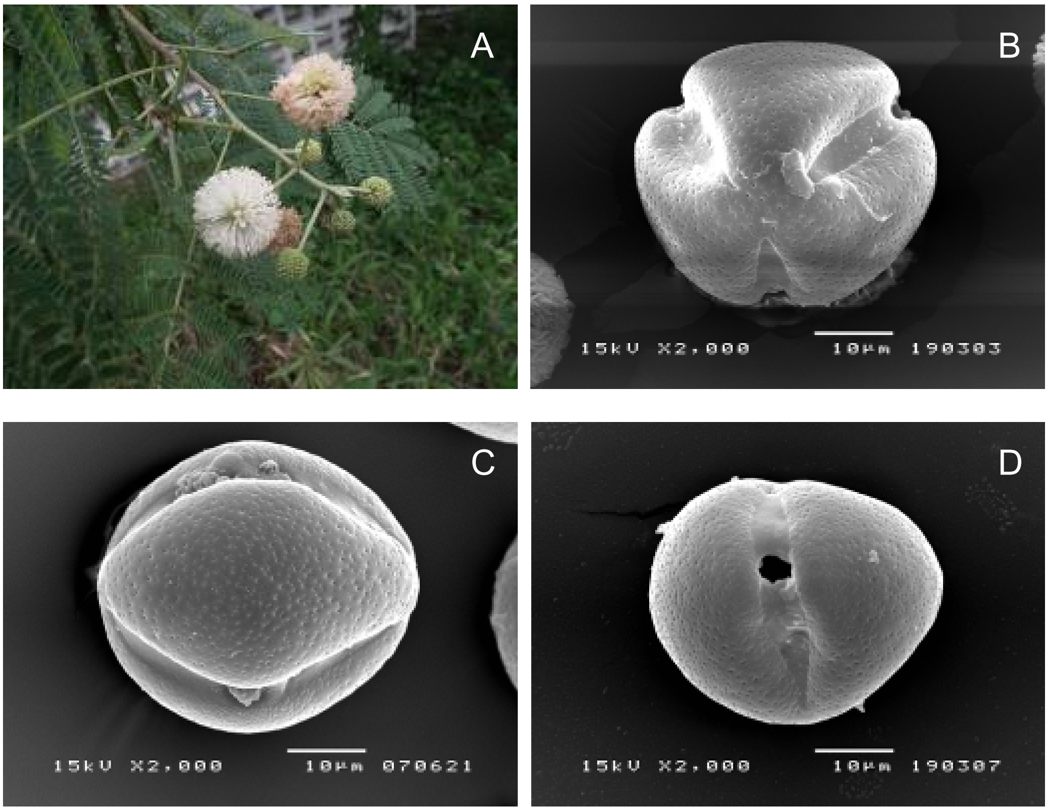

Figure 4.32 Flower and SEM micrographs of *L. glauca*

A. Flower of *L. glauca* B. Polar view

C. Equatorial view D. Aperture and Sculpturing

16. Convolvulaceae

Merremia umbellata subsp. *orientalis* (Hall. f.).

Pollen class:	6- colpate
Pollen unit:	monad
Polarity:	isopolar
P/E ratio:	1.00
Shape class:	oblate spheroidal
Size class:	large grain
Outline:	circular
Aperture:	colpate
Sculpturing:	perforate with superatectal granules

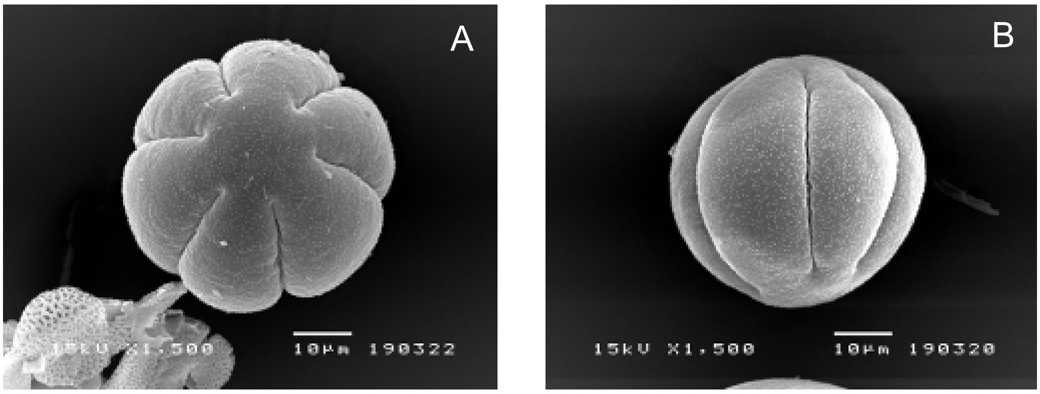

Figure 4.33 SEM micrographs of *M. umbellata*

A. Polar view

B. Equatorial view

17. Convolvulaceae

Unknown 3

Pollen class:	-
Pollen unit:	monad
Polarity:	isopolar
P/E ratio:	1.07
Shape class:	subspheroidal
Size class:	very large grain
Outline:	circular
Aperture:	-
Sculpturing:	echinate

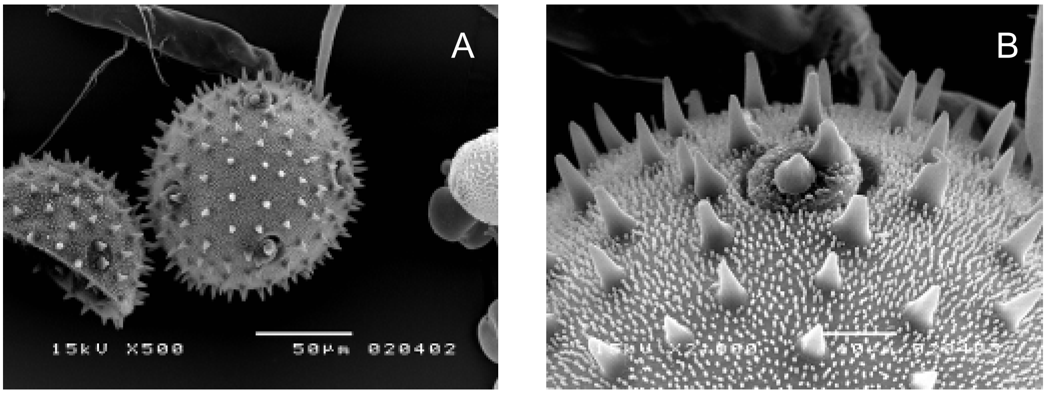

Figure 4.34 SEM micrographs of Unknown 3

A. Grain

B. Sculpturing

18. Euphorbiaceae

Jatropha gossypifolia Linn.

Pollen class:	
Pollen unit:	monad
Polarity:	isopolar
P/E ratio:	1.00
Shape class:	subspheroidal
Size class:	medium grain
Outline:	circular
Aperture:	inaperture
Sculpturing:	croton pattern

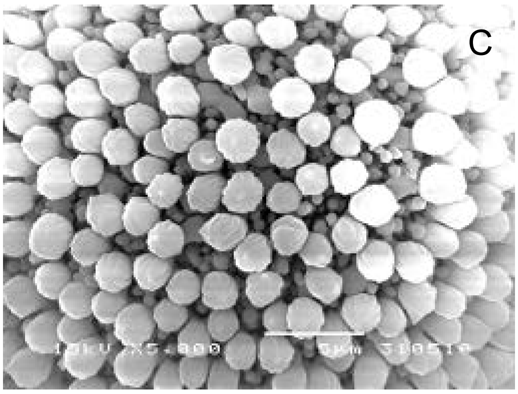

Figure 4.35 SEM micrographs of *J. gossypifolia*

A. Flower of *J. gossypifolia*

B. Grain

C. Sculpturing

19. Euphorbiaceae

Unknown 4

Pollen class:	croton pattern
Pollen unit:	monad
Polarity:	apolar
P/E ratio:	0.89
Shape class:	subspheroidal
Size class:	medium grain
Outline:	circular
Aperture:	inaperturate
Sculpturing:	croton pattern

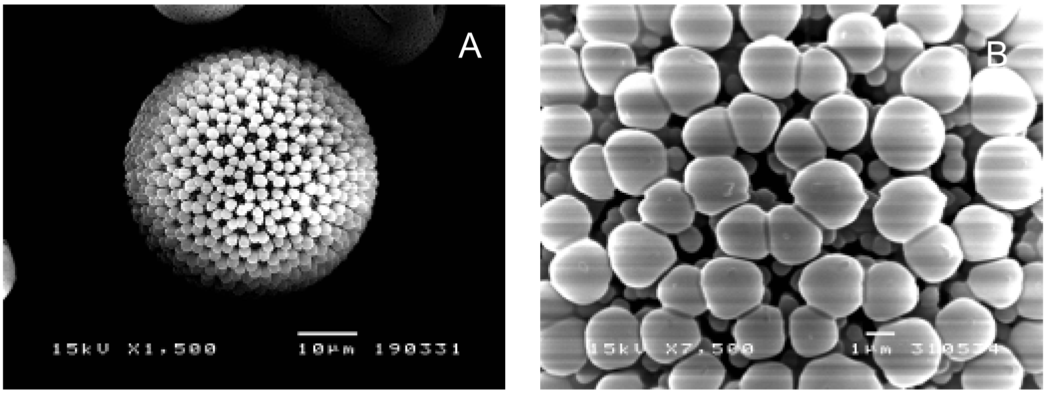

Figure 4.36 SEM micrographs of Unknown 4

A. Grain

B. Sculpturing

20. Hypericaceae

Cratoxylum formosum (Jack.) Dyer subsp.

Pollen class:	3-zonocolporate
Pollen unit:	monad
Polarity:	isopolar
P/E ratio:	1.04
Shape class:	subspheroidal
Size class:	medium grain
Outline:	circular
Aperture:	tricolporate
Sculpturing:	perforate

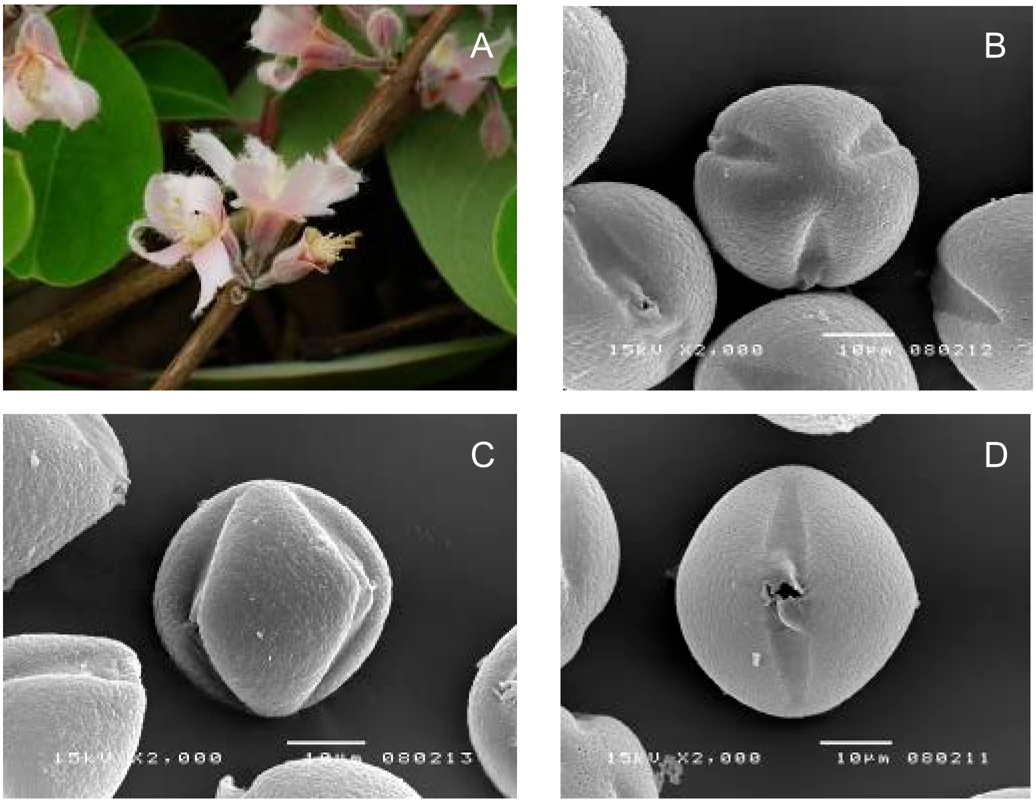

Figure 4.37 Flower and SEM micrographs of *C. formosum*

A. Flower of *C. formosum* B. Polar view

C. Equatorial view D. Aperture and Sculpturing

21. Lythraceae

Lagerstroemia floribunda Jack

Pollen class:	3-zonocolporate
Pollen unit:	monad
Polarity:	isopolar
P/E ratio:	1.03
Shape class:	subprolate
Size class:	medium grian
Outline:	circular
Aperture:	tricolporate
Sculpturing:	regulate

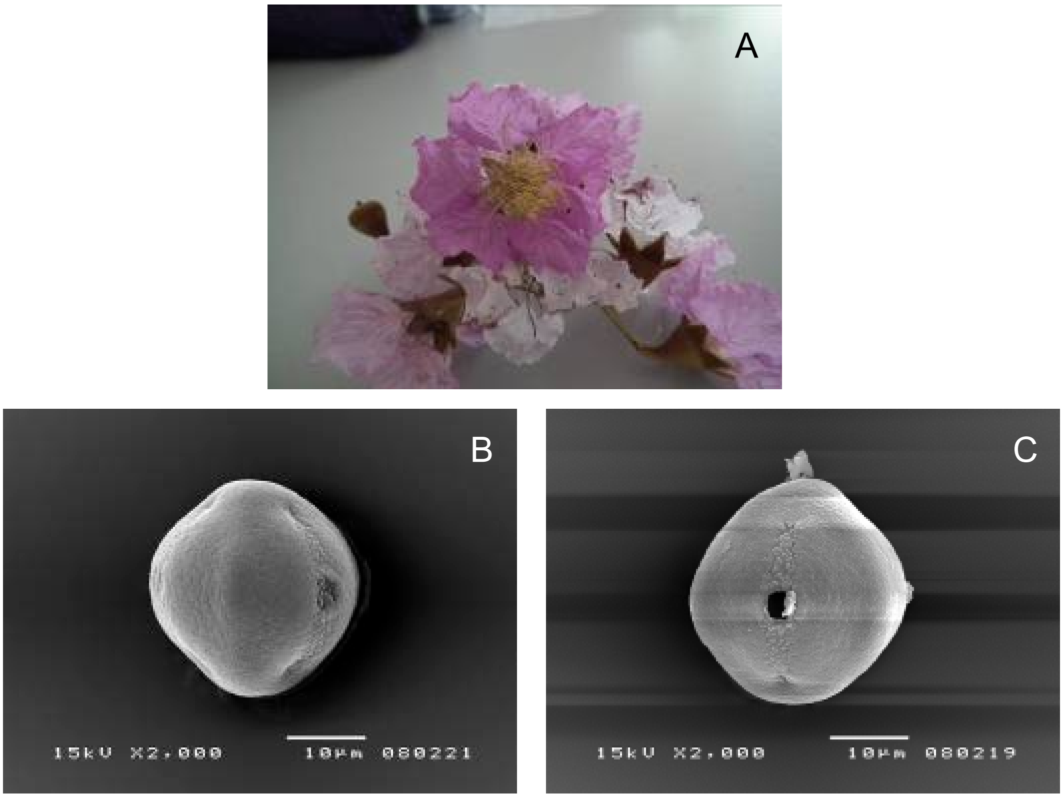

Figure 4.38 Flower and SEM micrographs of *L. floribunda*

A. Flower of *L. floribunda* B. Equatorial view

C. Aperture and Sculpturing

22. Lythraceae

Lagerstroemia macrocarpa Jack

Pollen class:	3-zonoporate
Pollen unit:	monad
Polarity:	isopolar
P/E ratio:	1.03
Shape class:	subspheroidal
Size class:	medium grain
Outline:	triangular
Aperture:	porate
Sculpturing:	-

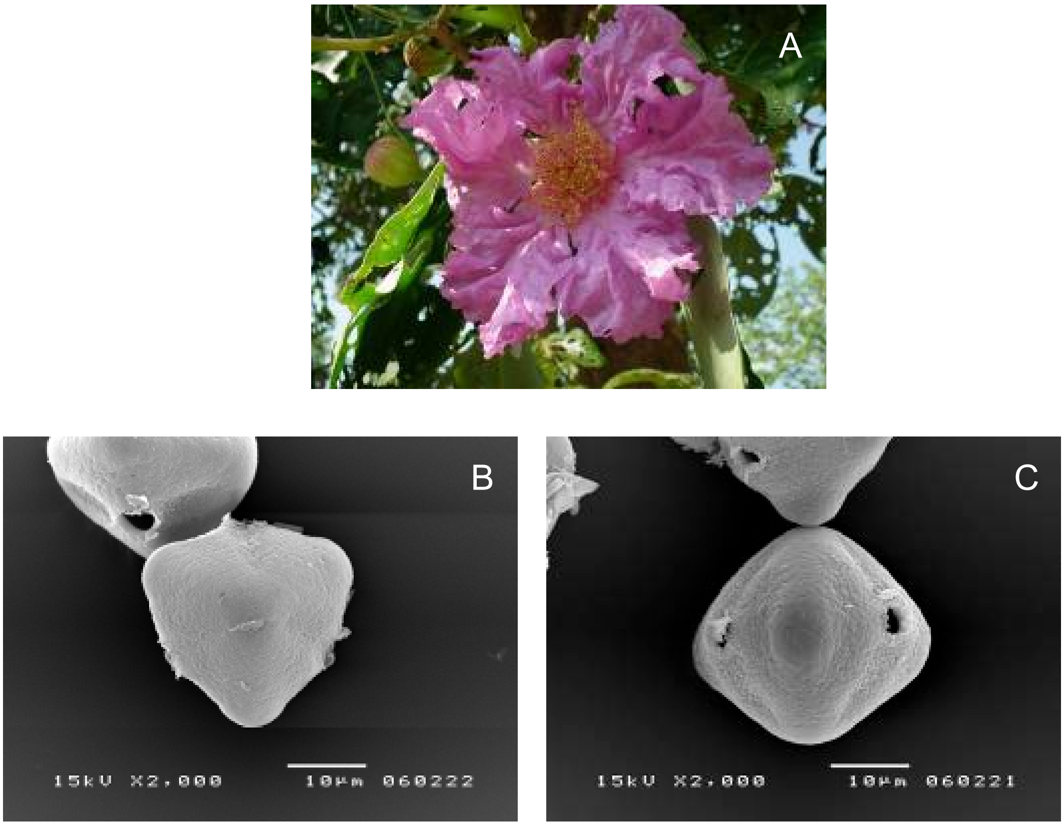

Figure 4.39 Flower and SEM micrographs of *L. macrocarpa*

A. Flower of *L. floribunda* B. Polar view

C. Equatorial view

23. Malvaceae

Urena lobata Linn.

Pollen class:	polypantoporate
Pollen unit:	monad
Polarity:	apolar
P/E ratio:	0.98
Shape class:	subspheroidal
Size class:	very large grain
Outline:	circular
Aperture:	periporaye
Sculpturing:	echinate

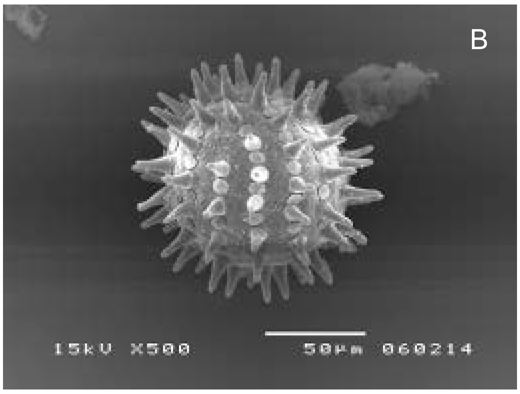

Figure 4.40 Flower and SEM micrographs of *U. lobata*

A. Flower of *U. lobata* B. Grain and sculpturing

24. Mimosaceae

Mimosa pudica Linn.

Pollen class:	inaperturate
Pollen unit:	tetrads
Polarity:	isopolar
P/E ratio:	-
Shape class:	-
Size class:	medium grain
Outline:	circular
Aperture:	inaperturate
Sculpturing:	psilaie

Figure 4.41 Flower and SEM micrographs of *M. pudica*

A. Flower of *M. pudica* B. Polar view

C. Equatorial view

25. Mimosaceae

Mimosa pigra Linn.

Pollen class:	inaperture
Pollen unit:	tetrads
Polarity:	apolar
P/E ratio:	0.98
Shape class:	rhomboidal
Size class:	medium grain
Outline:	circular
Aperture:	inaperture
Sculpturing:	psilate

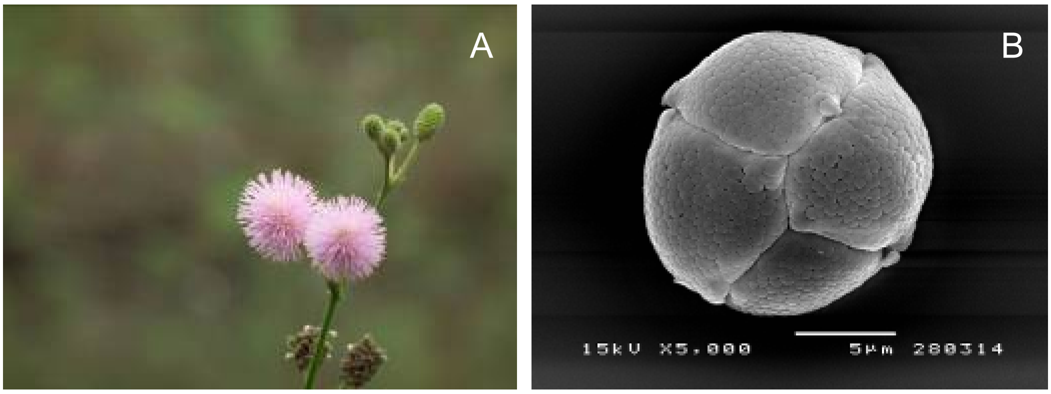

Figure 4.42 Flower and SEM micrographs of *M. pigra*

A. Flower of *M. pudica* B. Grain

26. Myrtaceae

Unknown 5

Pollen class:	-
Pollen unit:	monad
Polarity:	isopolar
P/E ratio:	-
Shape class:	subspheroidal
Size class:	small grain
Outline:	triangular
Aperture:	syncolporate
Sculpturing:	-

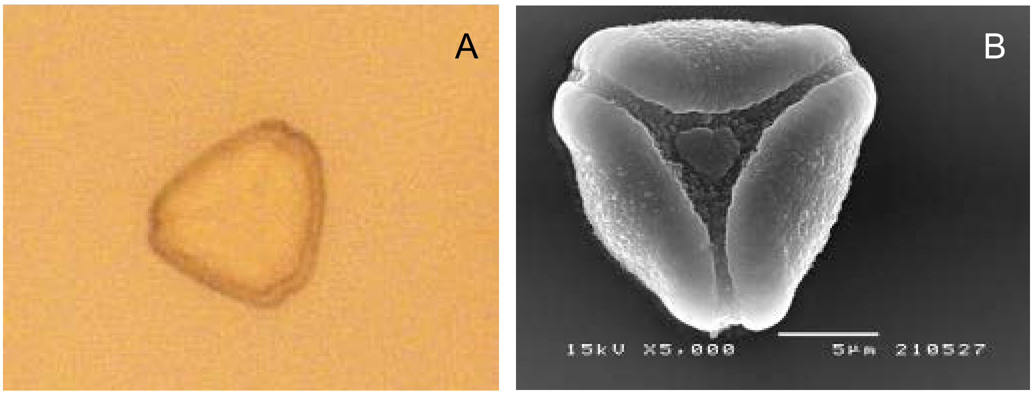

Figure 4.43 LM and SEM micrographs of Myrtaceae, Unknown 6

A. Grain

B. B. Aperture

27. Passifloraceae

Passiflora foetida Linn.

Pollen class:	-
Pollen unit:	monad
Polarity:	isopolar
P/E ratio:	1
Shape class:	subspheroidal
Size class:	medium grain
Outline:	circular
Aperture:	tricolporate
Sculpturing:	reticulate

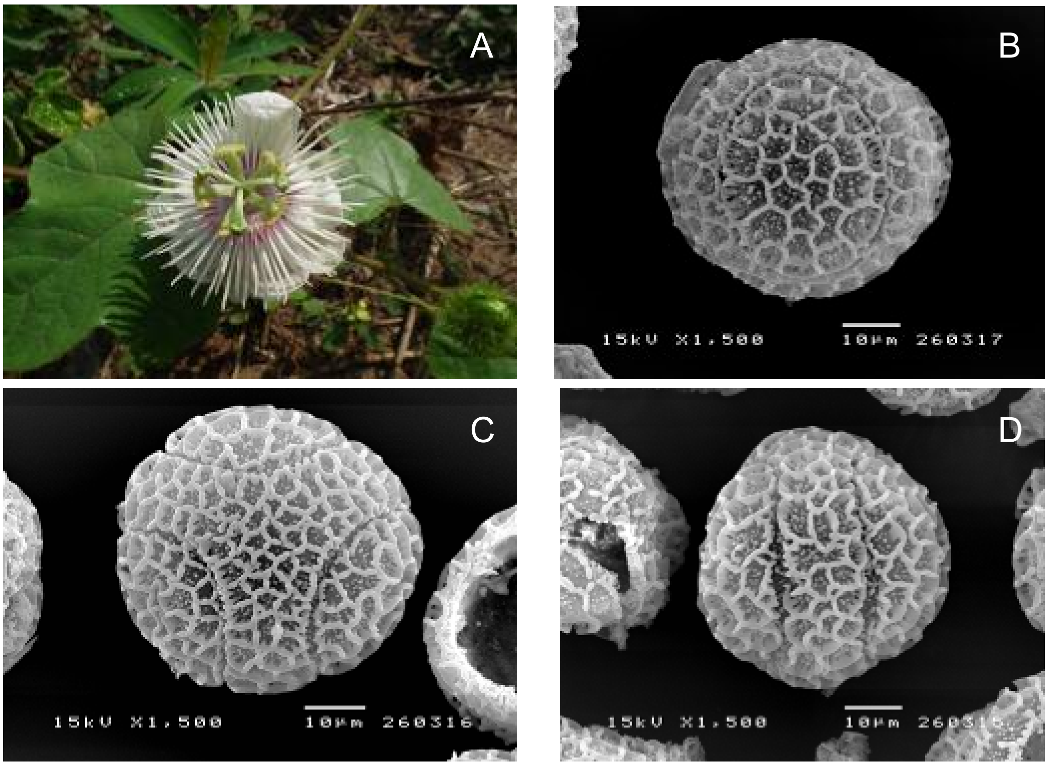

Figure 4.44 Flower and SEM micrographs of *P. foetida*

A. Flower of *P. foetida*

B. Polar view

C. Equatorial view

28. Poaceae

Imperata cylindrical (L.) Beauv.

Pollen class:	monoporate
Pollen unit:	monad
Polarity:	isopolar
P/E ratio:	1.06
Shape class:	prolate-spheroidal
Size class:	medium grain
Outline:	circular
Aperture:	porate
Sculpturing:	granulate

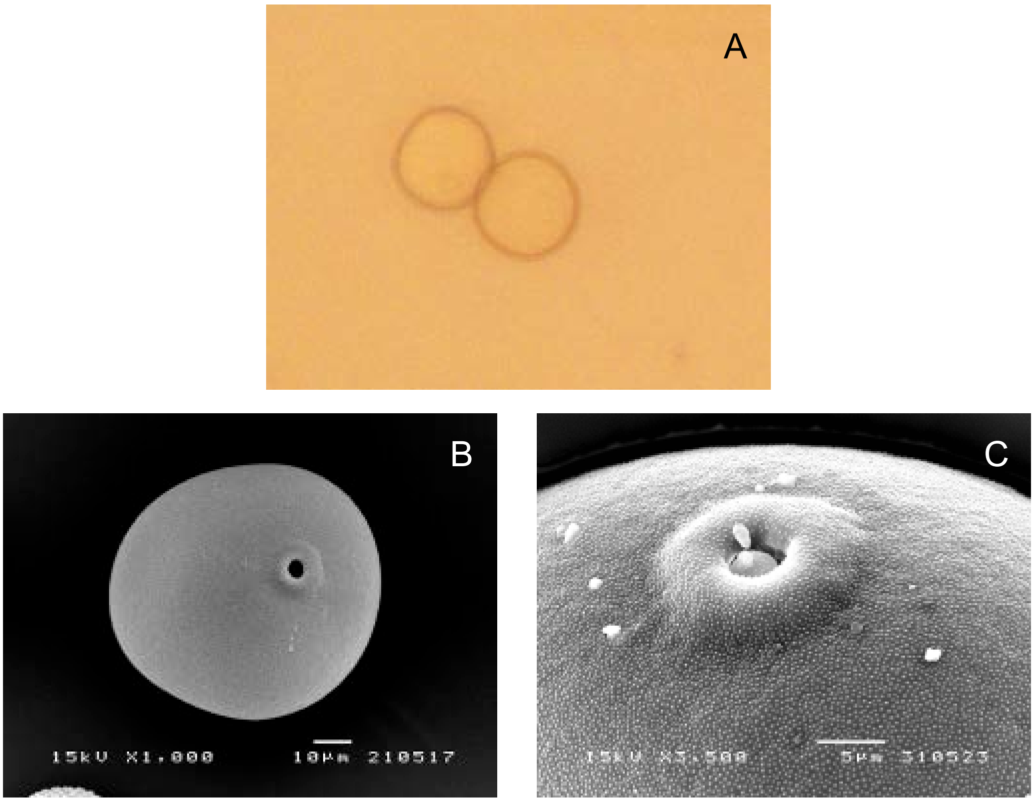

Figure 4.45 LM and SEM micrographs of *I. cylindrical*

A. –B. Grain

C. Aperture and sculptering

29. Poaceae

Unknown 6

Pollen class:	monoporate
Pollen unit:	monad
Polarity:	apolar
P/E ratio:	1.01
Shape class:	prolate-spheroidal
Size class:	medium grain
Outline:	circular
Aperture:	porate
Sculpturing:	granulate

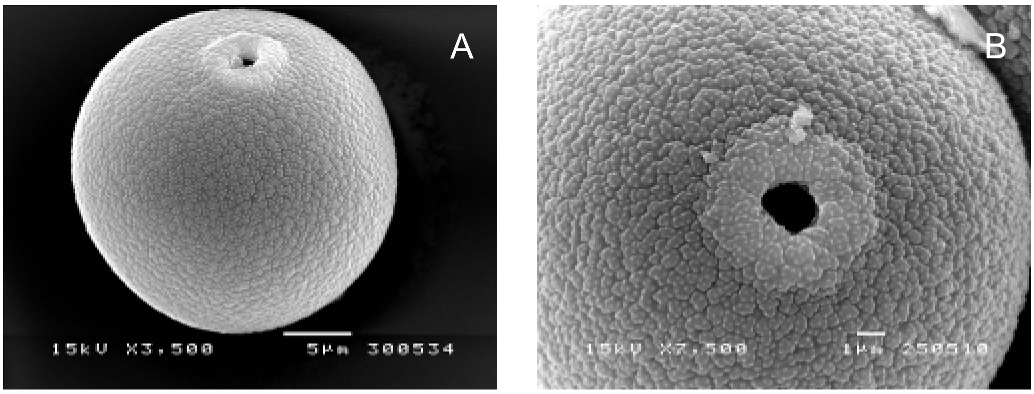

Figure 4.46 SEM micrographs of Unknown 6

A. Grain

B. Aperture and sculptering

30. Poaceae

Unknown 7

Pollen class:	monoporate
Pollen unit:	monad
Polarity:	isopolar
P/E ratio:	1.12
Shape class:	prolate-spheroidal
Size class:	medium grain
Outline:	circular
Aperture:	porate
Sculpturing:	-

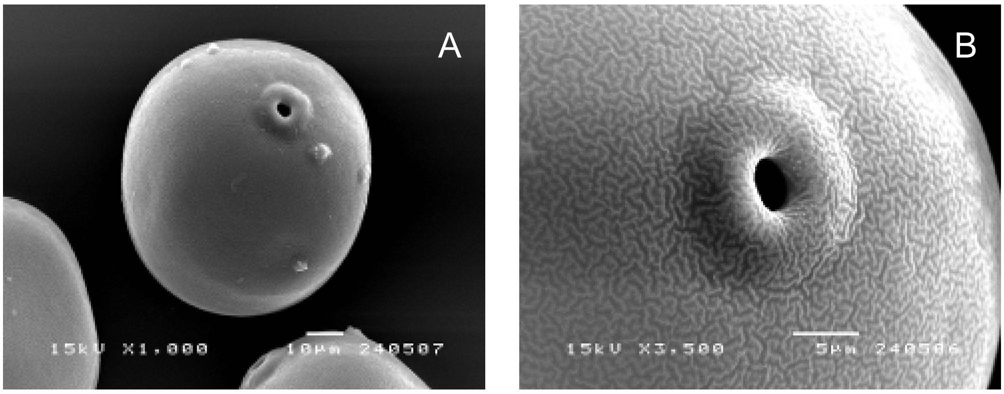

Figure 4.47 SEM micrographs of Unknown 7

A. Grain

B. Aperture and sculpturing

31. Rosaceae

Unknown 8

Pollen class:	3-zonocolporate
Pollen unit:	monad
Polarity:	isopolar
P/E ratio:	1.25
Shape class:	subprolate
Size class:	medium grain
Outline:	circular lobate
Aperture:	tricolporate
Sculpturing:	strinate

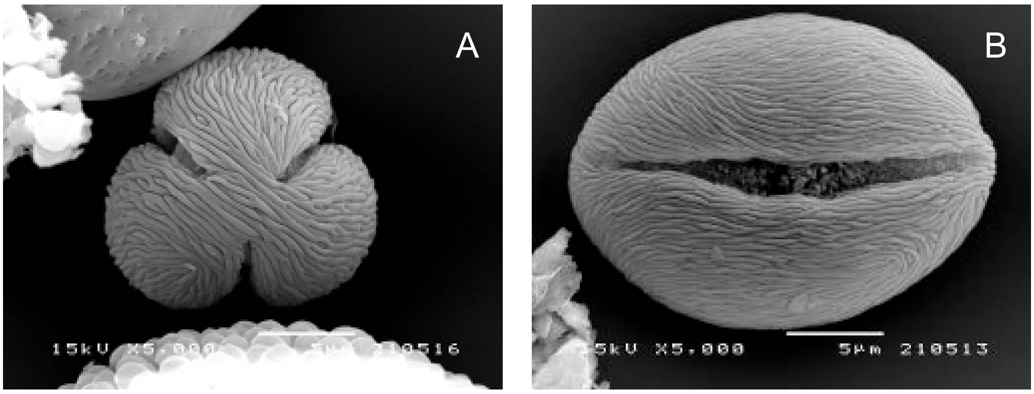

Figure 4.48 SEM micrographs of Unknown 8

A. Polar view

B. Aperture and Sculpturing

32. Sapindaceae

Unknown 9

Pollen class:	3- zonocolporate
Pollen unit:	monad
Polarity:	isopolar
P/E ratio:	0.86
Shape class:	suboblate
Size class:	small grain
Outline:	semi angular
Aperture:	tricolporate
Sculpturing:	strinate

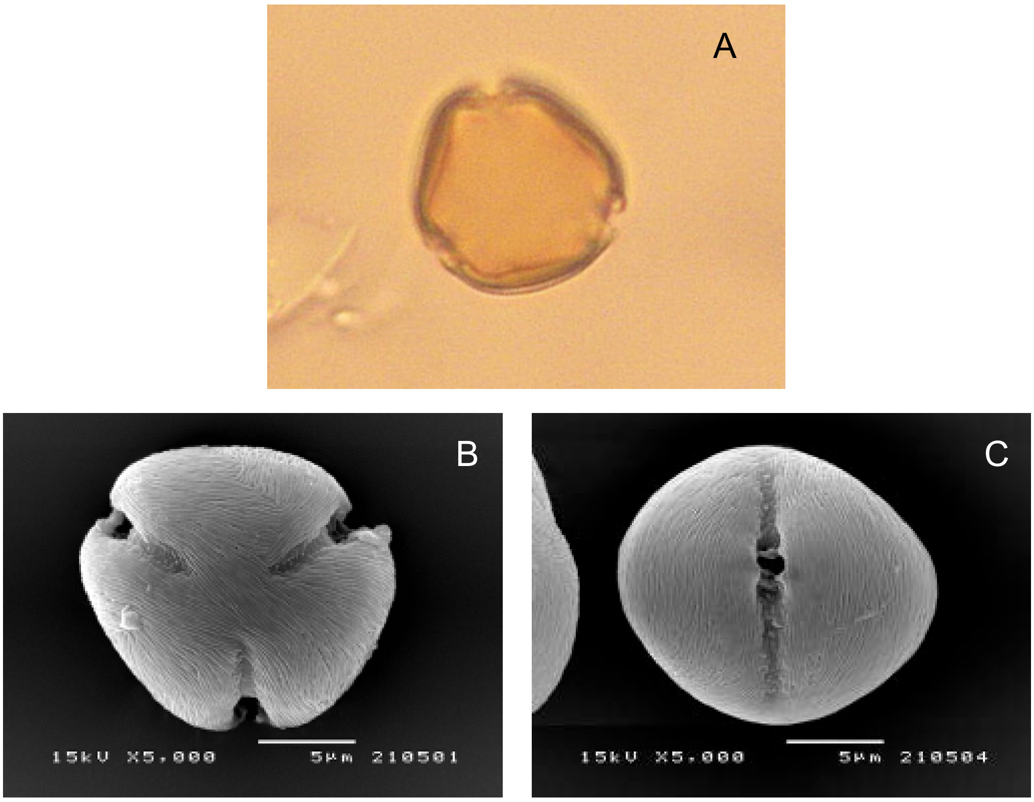

Figure 4.49 LM and SEM micrographs of Unknown 9

A. – B. Polar view

C. Aperture and Sculpturing

33.Solanaceae

Capsicum frutescens Linn.

Pollen class:	3-zonocolporate
Pollen unit:	monad
Polarity:	isopolar
P/E ratio:	0.95
Shape class:	prolate-spheroidal
Size class:	small
Outline:	semiangular
Aperture:	tricolporate
Sculpturing:	granulate

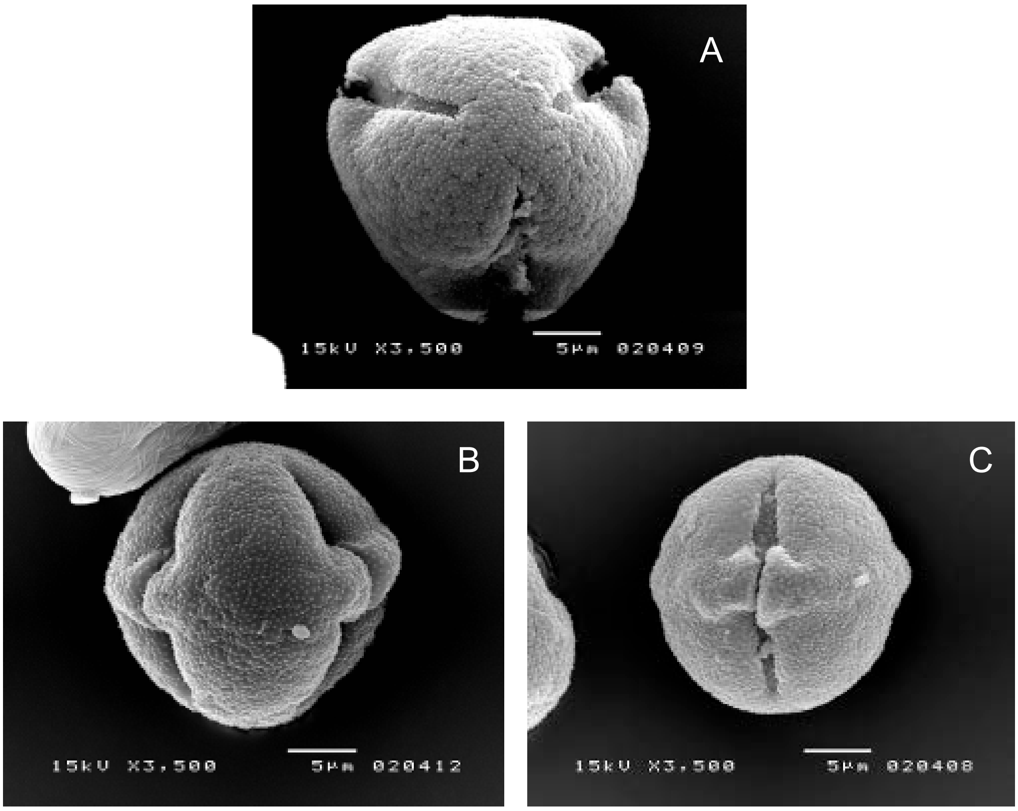

Figure 4.50 SEM micrographs of *C. frutescens*

A. Polar view B. Equatorial view

C. Aperture and Sculpturing

34. Tiliceae

Muntingia calabura Linn.

Pollen class:	3- zonocolporate
Occurring of pollen:	monad
Polarity:	isopolar
P/E ratio:	1.08
Shape class:	subspheroidal
Size class:	small grain
Outline:	circular
Aperture:	tricolporate
Sculpturing:	recticulate

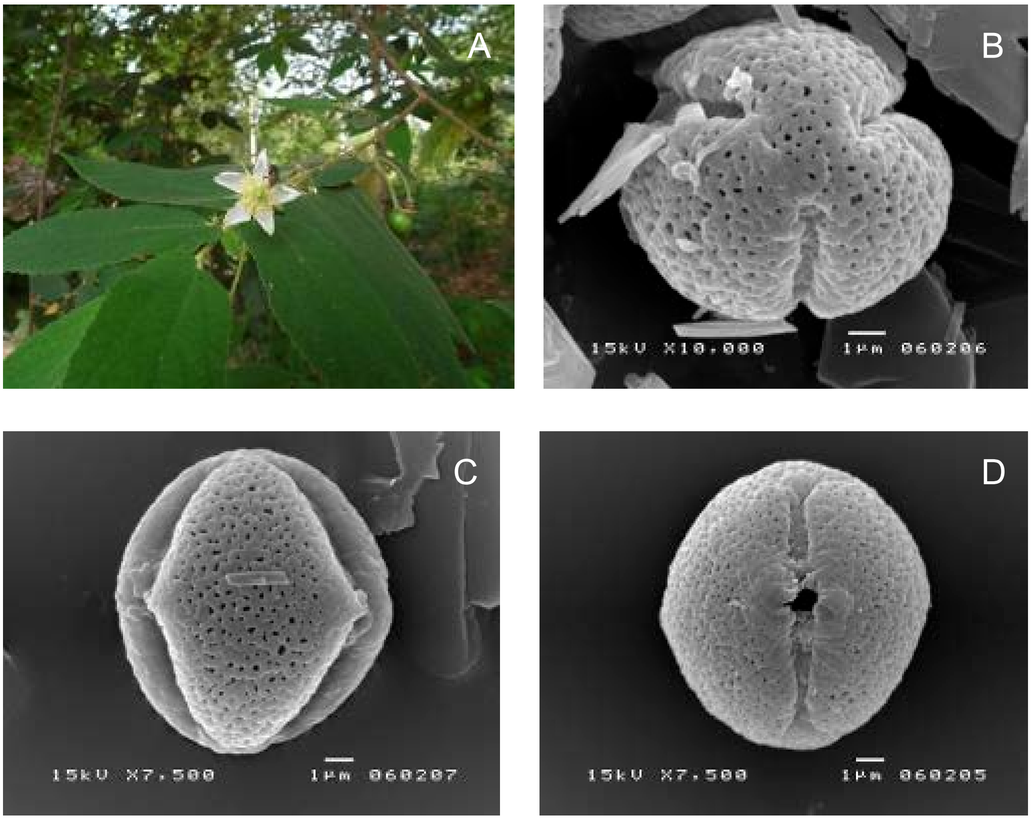

Figure 4.51 Flower and SEM micrographs of *M. calabura*

A. Flower of *M. calabura* B. Polar view

C. Equatorial view D. Aperture and Sculpturing

35. Unknown 10

Pollen class:	3-zonocolporate
Pollen unit:	monad
Polarity:	isopolar
P/E ratio:	0.91
Shape class:	subspheroidal
Size class:	small grain
Outline:	circular
Aperture:	tricolporate
Sculpturing:	rugulate

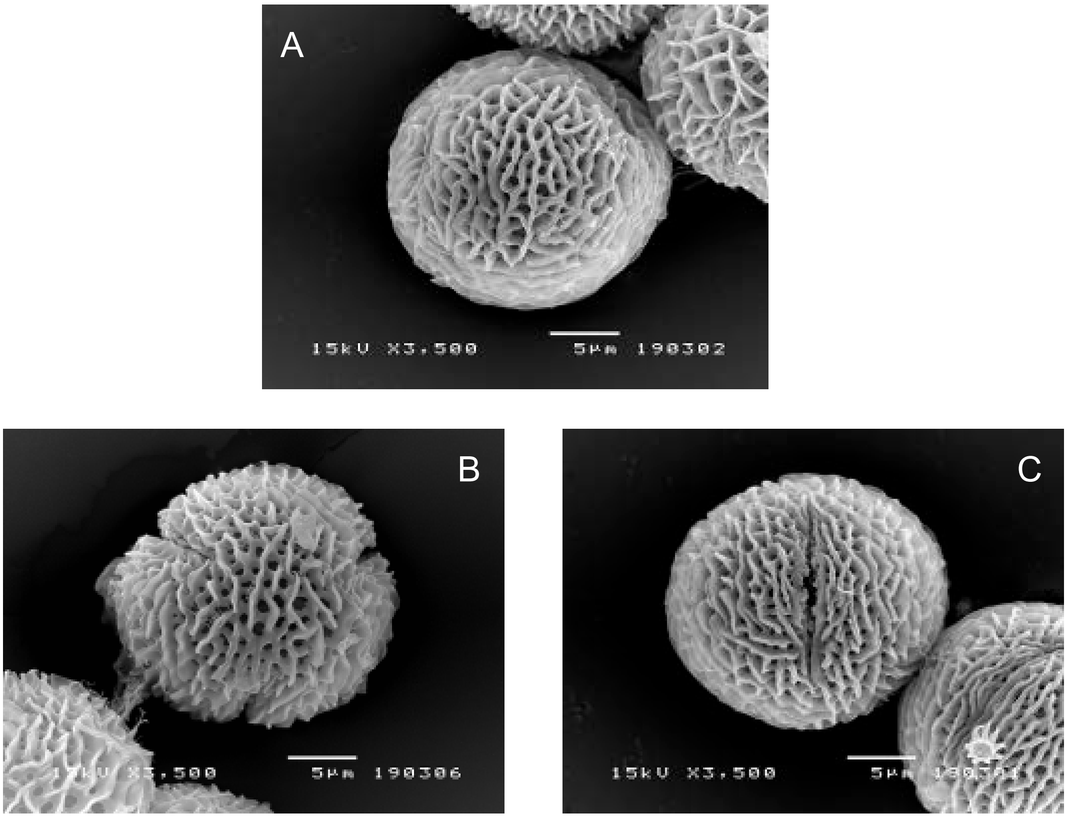

Figure 4.52 SEM micrographs of Unknown 10

A. Polar view B. Equatorial view

C. Aperture and Sculpturing

36. Unknown 11

Pollen class:	3- zonocolporate
Pollen unit:	monad
Polarity:	isopolar
P/E ratio:	0.97
Shape class:	subspheroidal
Size class:	medium grain
Outline:	circular
Aperture:	tricolporate
Sculpturing:	reticulate

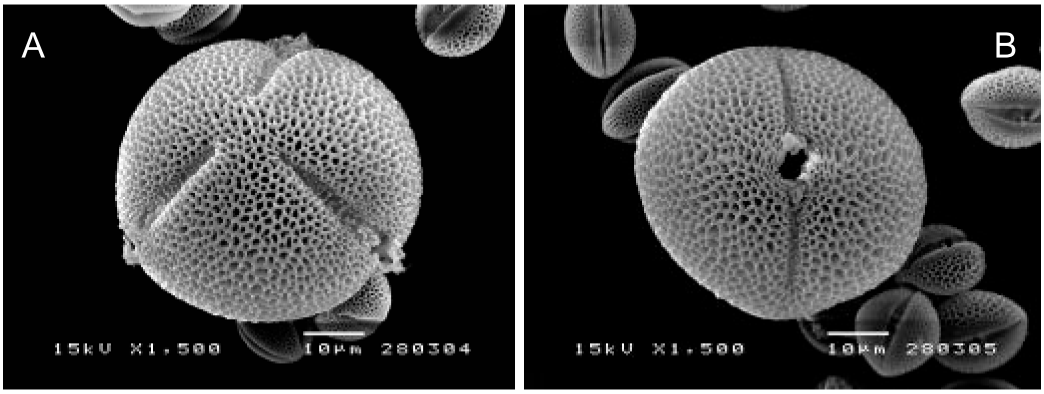

Figure 4.53 SEM micrographs of Unknown 11

A. Polar view

B. Aperture and Sculpturing

37. Unknown 12

Pollen class:	3- zonocolporate
Pollen unit:	monad
Polarity:	isopolar
P/E ratio:	1.31
Shape class:	subprolate
Size class:	small grain
Outline:	circular lobate
Aperture:	tricolporate
Sculpturing:	reticulate

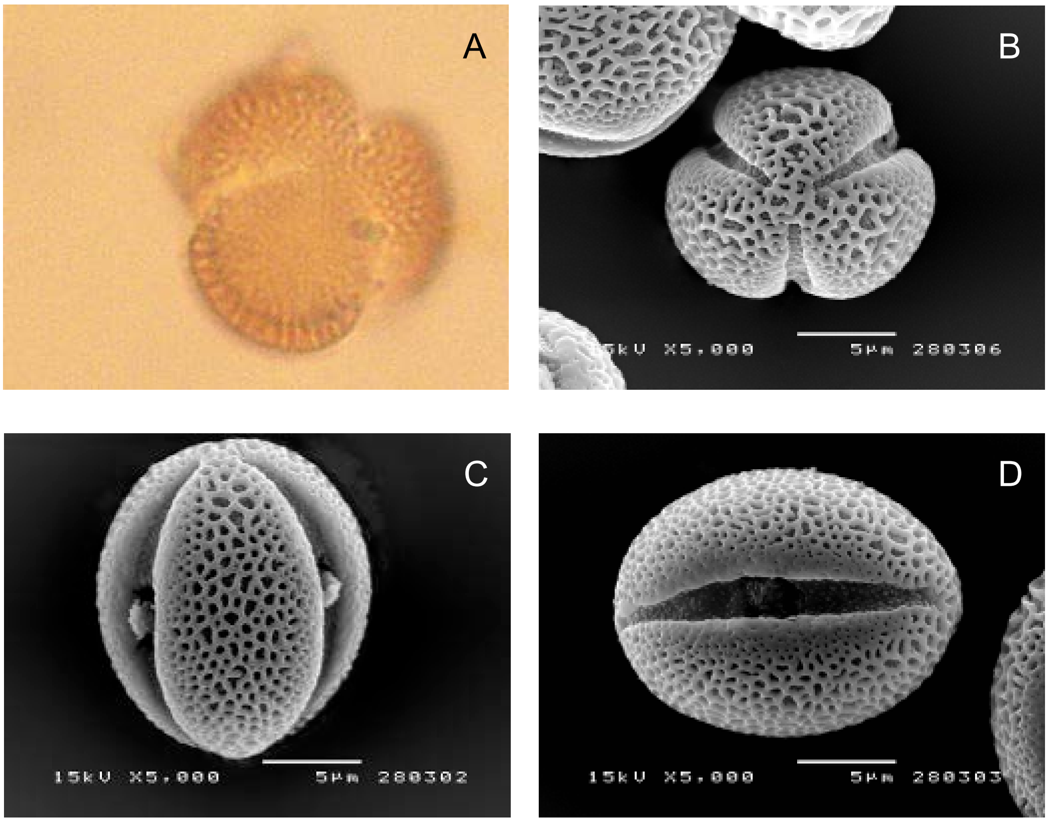

Figure 4.54 LM and SEM micrographs of Unknown 12

A. – B. Polar view C. Equatorial view

D. Aperture and Sculpturing

38. Unknown 13

Pollen class:	3- zonocolporate
Pollen unit:	monad
Polarity:	isopolar
P/E ratio:	1.00
Shape class:	subspheroidal
Size class:	medium grain
Outline:	circular
Aperture:	tricolporate
Sculpturing:	perforate

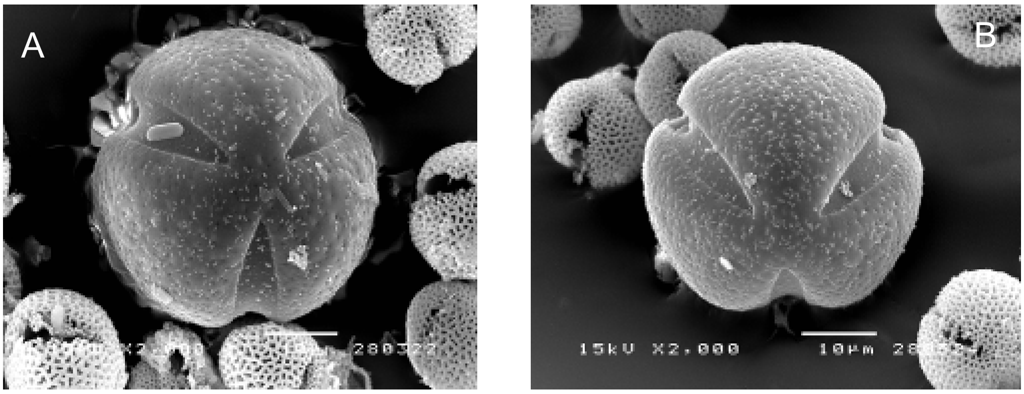

Figure 4.55 SEM micrographs of Unknown 13

A. Polar view B. Aperture and Sculpturing

39. Unknown 14

Pollen class:	3-zonocolpate
Pollen unit:	monad
Polarity:	isopolar
P/E ratio:	1.00
Shape class:	subspheroidal
Size class:	small grain
Outline:	circular
Aperture:	tricolpate
Sculpturing:	reticulate

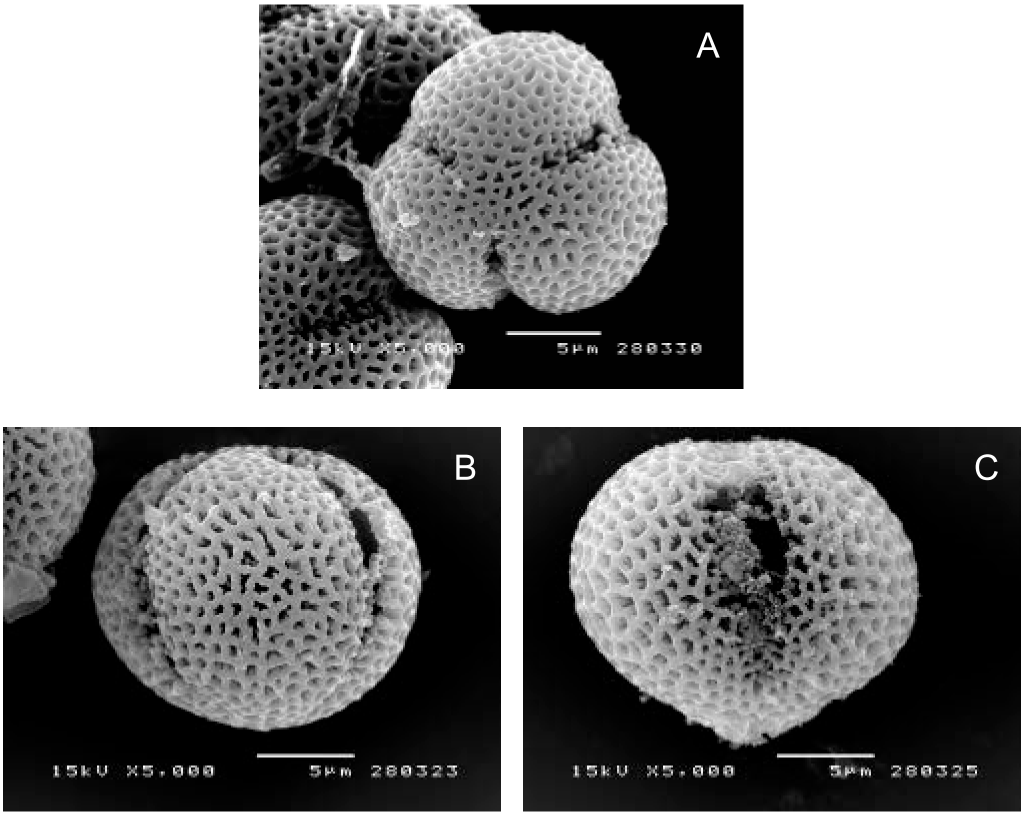

Figure 4.56 SEM micrographs of Unknown 14

A. Polar view B. Equatorial view

C. Aperture and Sculpturing

40. Unknown 15

Pollen class:	3-zonocolporate
Pollen unit:	monad
Polarity:	isopolar
P/E ratio:	1.13
Shape class:	prolate spheroidal
Size class:	small grain
Outline:	circular
Aperture:	tricolporate
Sculpturing:	reticulate

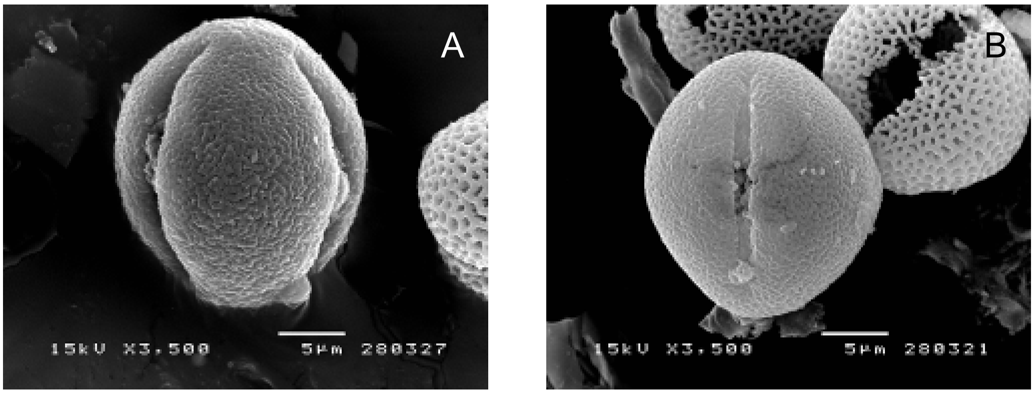

Figure 4.57 SEM micrographs of Unknown 15

. A. Equatorial view B. Aperture and Sculpturing

41. Unknown 16

Pollen class:	3- zonocolporate
Pollen unit:	monad
Polarity:	isopolar
P/E ratio:	0.88
Shape class:	subspheroidal
Size class:	medium grain
Outline:	circular
Aperture:	tricolporate
Sculpturing:	reticulate

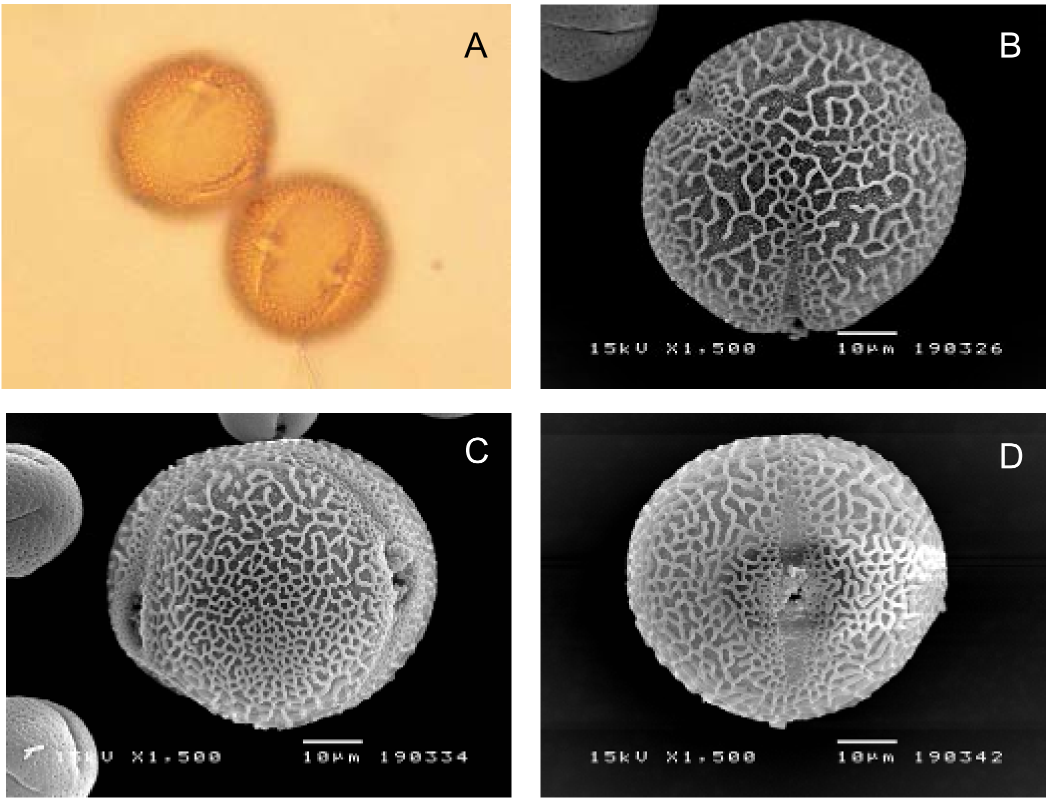

Figure 4.58 LM and SEM micrographs of Unknown 16

A. Equatorial view B. Polar view

C. Equatorial view D. Aperture and Sculpturing

42. Unknown 17

Pollen class:	3-zonocolporate
Pollen unit:	monad
Polarity:	isopolar
P/E ratio:	1.21
Shape class:	subprolate
Size class:	small grain
Outline:	circular
Aperture:	tricolporate
Sculpturing:	reticulate

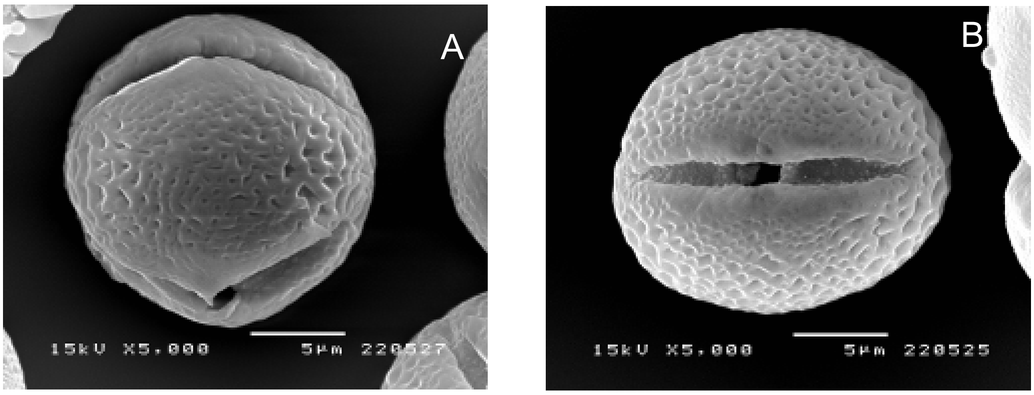

Figure 4.59 SEM micrographs of Unknown 17

A. Equatorial view B. Aperture and Sculpturing

43. Unknown 18

Pollen class:	3- zonocolporate
Pollen unit:	monad
Polarity:	isopolar
P/E ratio:	1.4
Shape class:	subspheroidal
Size class:	medium
Outline:	circular
Aperture:	tricolporate
Sculpturing:	reticurate

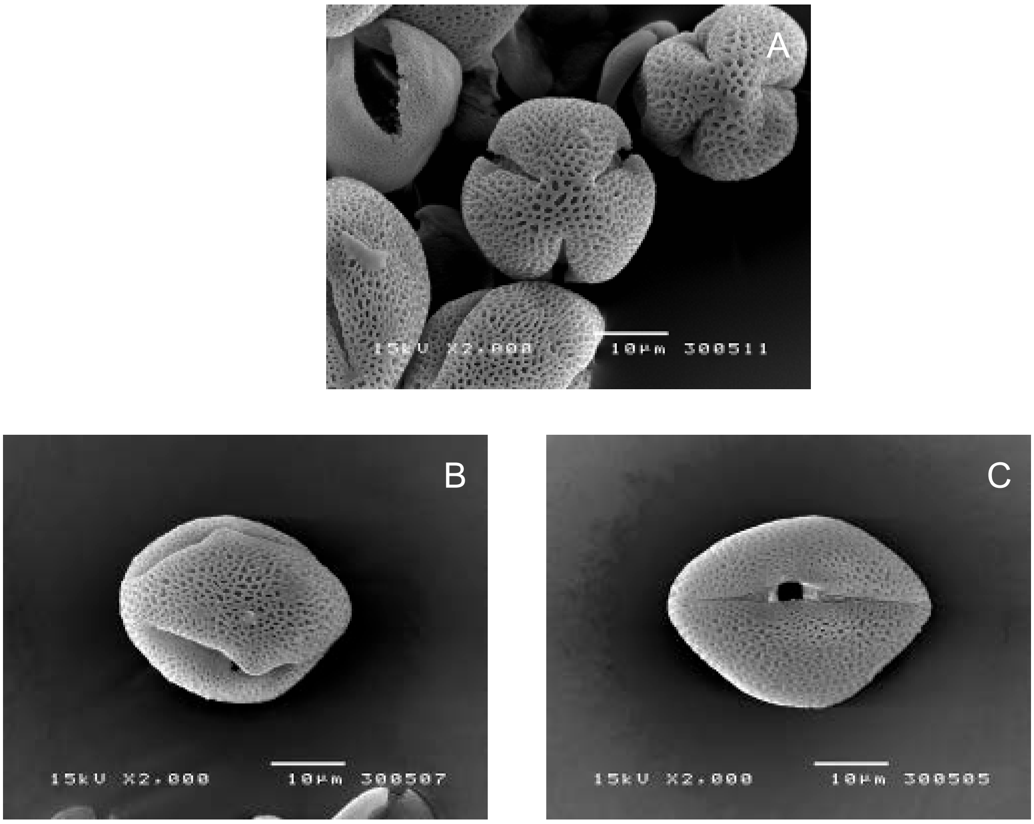

Figure 4.60 SEM micrographs of Unknown 18

A. Polar view B. Equatorial view

C. Aperture and Sculpturing

44. Unknown 19

Pollen class:	3-zonocopolate
Pollen unit:	monad
Polarity:	isopolar
P/E ratio:	1.11
Shape class:	prolate spheroidal
Size class:	small grain
Outline:	circular
Aperture:	tricolporate
Sculpturing:	perforate

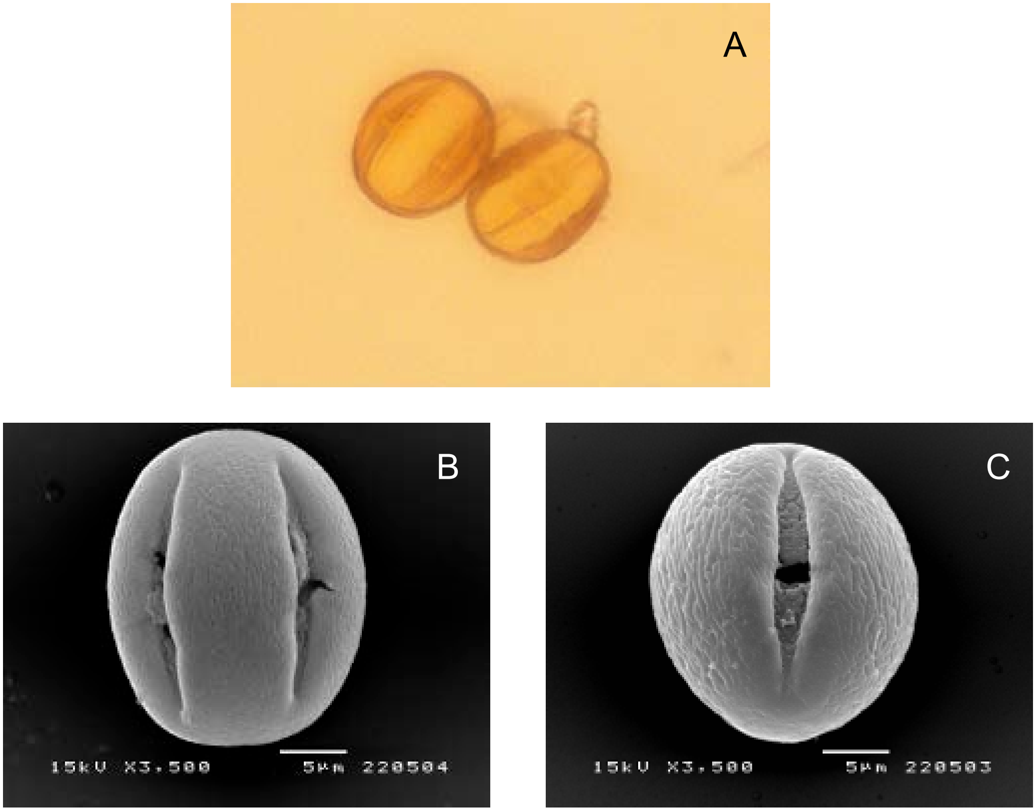

Figure 4.61 LM and SEM micrographs of Unknown 19

. A. – B. Equatorial view

C. Aperture and Sculpturing

45. Unknown 20

Pollen class:	3- zonocolporate
Pollen unit:	monad
Polarity:	isopolar
P/E ratio:	1.08
Shape class:	prolate spheroidal
Size class:	small grain
Outline:	circular
Aperture:	tricolporate
Sculpturing:	reticurate

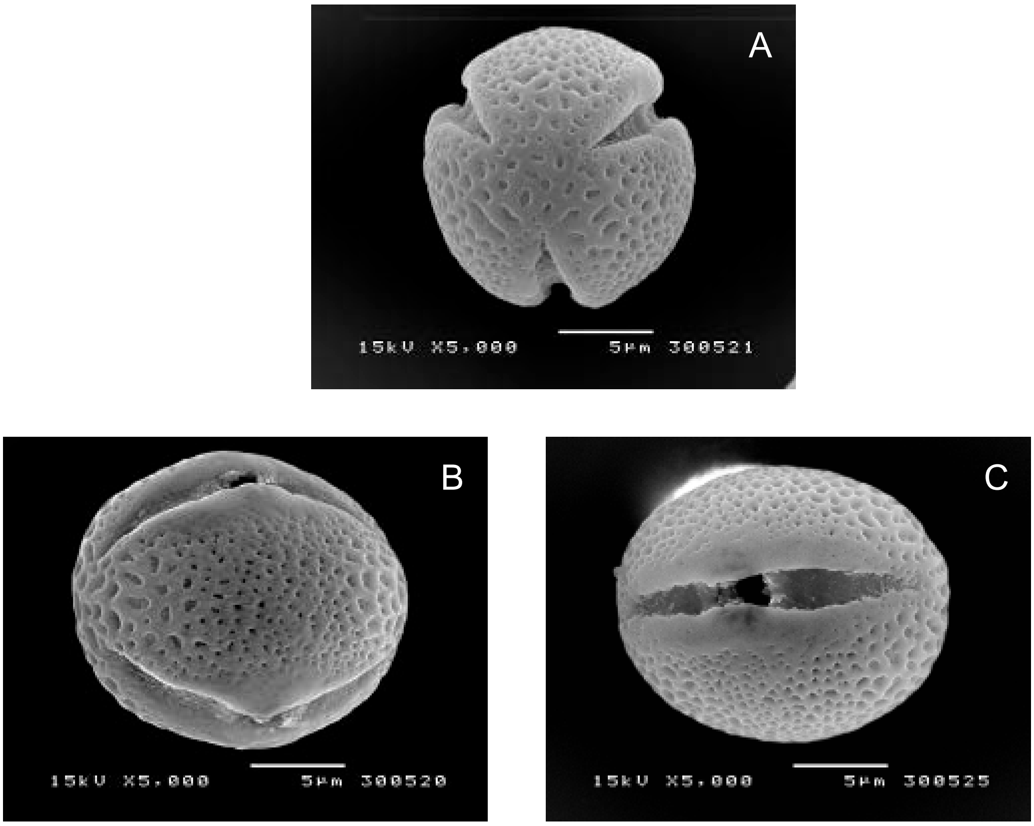

Figure 4.62 SEM micrographs of Unknown 20

A. Polar view B. Equatorial view

C. Aperture and Sculpturing

46. Unknown 21

Pollen class: 3- zonocolporate

Pollen unit: monad

Polarity: isopolar

P/E ratio: 1.21

Shape class: subprolate

Size class: small grain

Outline: circular

Aperture: tricolporate

Sculpturing: reticulate

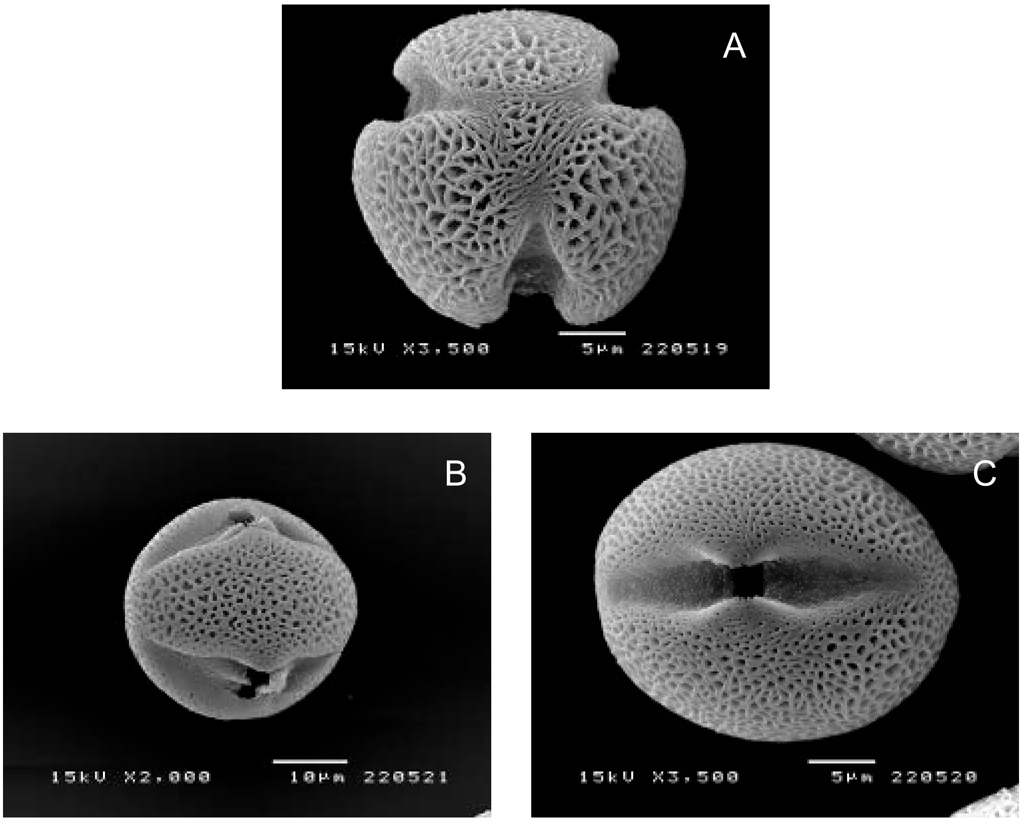

Figure 4.63 SEM micrographs of Unknown 21

A. Polar view B. Equatorial view

C. Aperture and Sculpturing

47. Unknown 22

Pollen class:	3- zonocolporate
Pollen unit:	monad
Polarity:	isopolar
P/E ratio:	1.03
Shape class:	prolate spheroidal
Size class:	medium grain
Outline:	circular
Aperture:	tricolporate
Sculpturing:	-

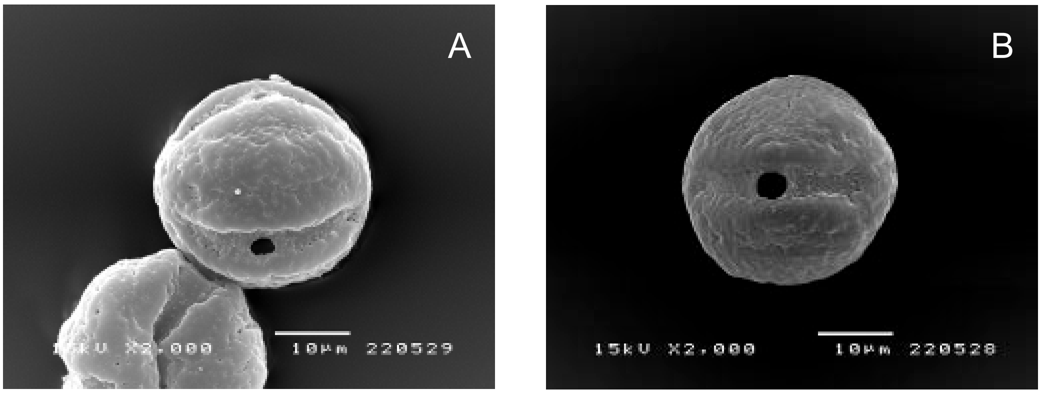

Figure 4.64 SEM micrographs of Unknown 22

A. Equatorial view B. Aperture and Sculpturing

48. Unknown 23

Pollen class:	3- zonotricolpate
Pollen unit:	monad
Polarity:	isopolar
P/E ratio:	0.87
Shape class:	suboblate
Size class:	small grain
Outline:	circular lobate
Aperture:	tricolpate
Sculpturing:	reticurate

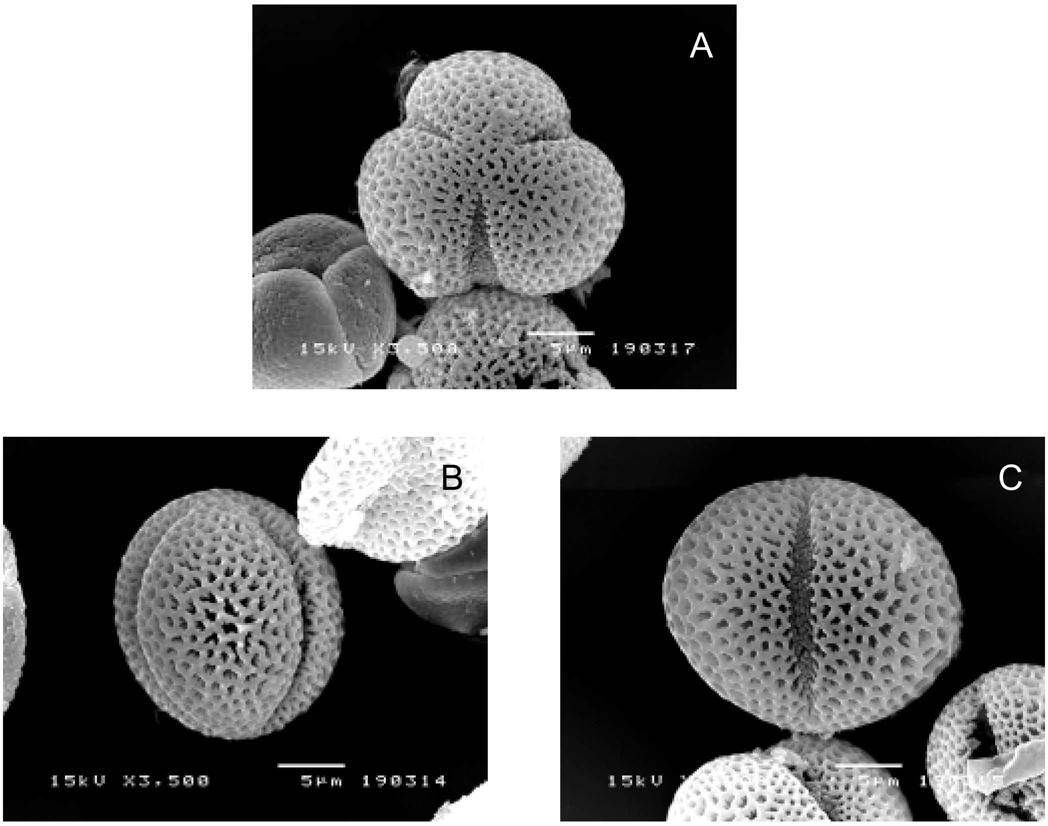

Figure 4.65 SEM micrographs of Unknown 23

A. Polar view B. Equatorial view

C. Aperture and Sculpturing

49. Unknown 24

Pollen class:	3- colporate
Pollen unit:	monad
Polarity:	isopolar
P/E ratio:	1.85
Shape class:	subspheroidal
Size class:	small grain
Outline:	semi angular
Aperture:	colporate
Sculpturing:	-

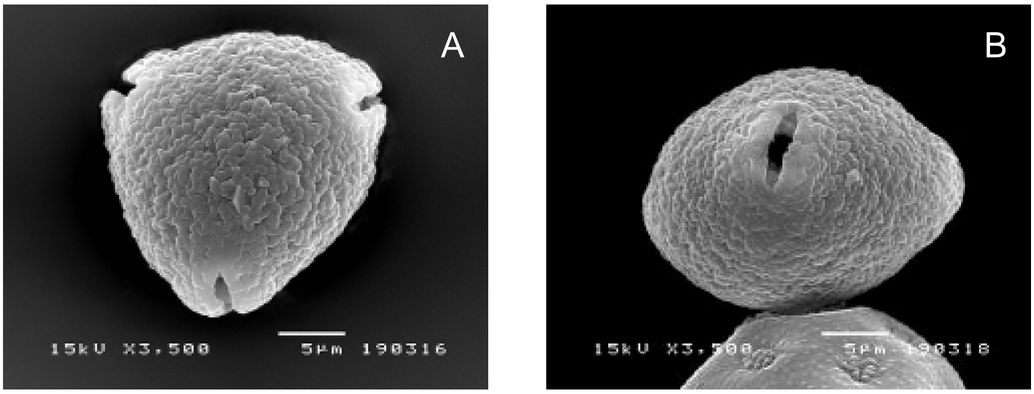

Figure 4.66 SEM micrographs of Unknown 24

A. Polar view B. Aperture and Sculpturing

50. Unknown 25

Pollen class:	5- zonotricolpate
Pollen unit:	monad
Polarity:	isopolar
P/E ratio:	1.03
Shape class:	subspheroidal
Size class:	small grain
Outline:	circular
Aperture:	stephanocolpate
Sculpturing:	perforate

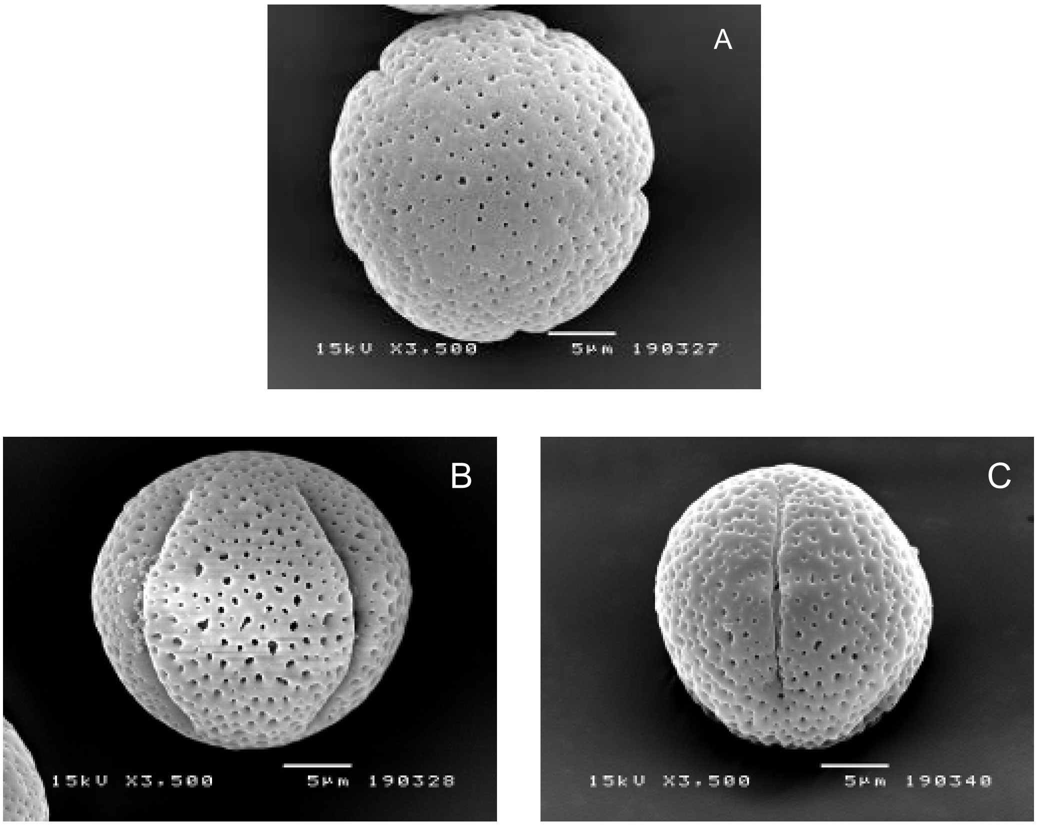

Figure 4.67 SEM micrographs of Unknown 25

A. Polar view B. Equatorial view

C. Aperture and Sculpturing

51. Unknown 26

Pollen class:	3-zonocolporate
Pollen unit:	monad
Polarity:	isopolar
P/E ratio:	1.25
Shape class:	subspheroidal
Size class:	small grain
Outline:	circular lobate
Aperture:	tricolporate
Sculpturing:	scabrate

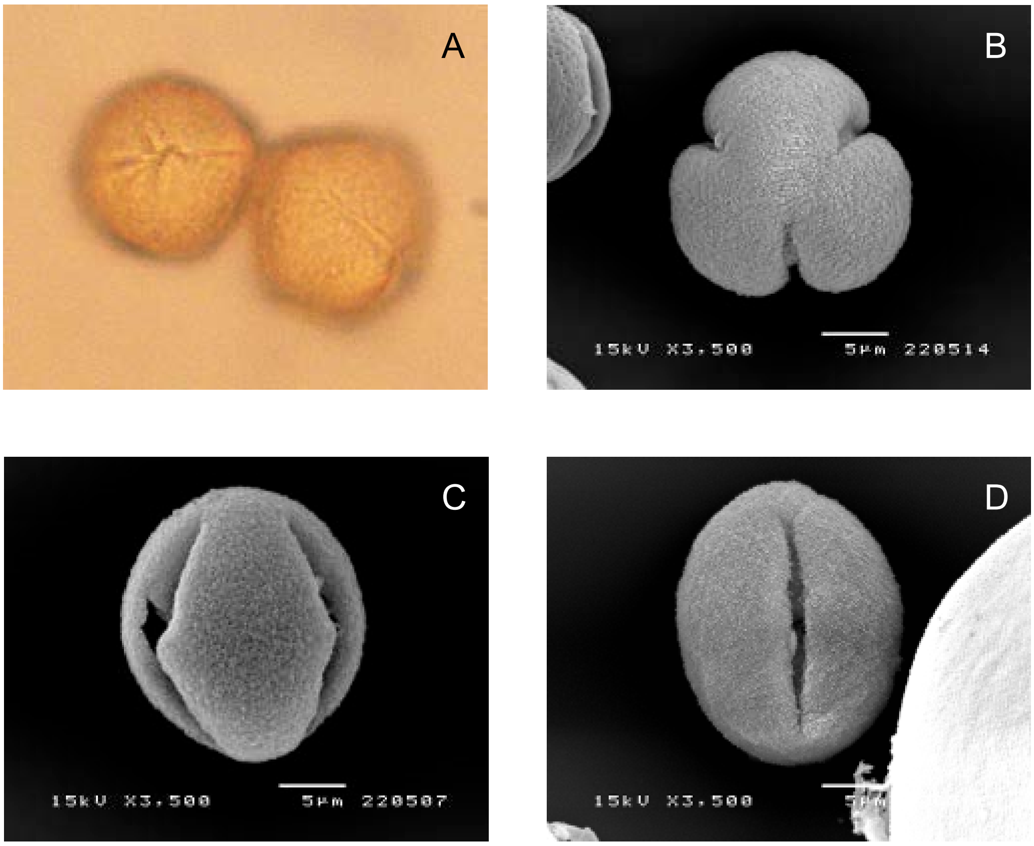

Figure 4.68 SEM micrographs of Unknown 26

A. Polar view B. Equatorial view

C. Aperture and Sculpturing

52. Unknown 27

Pollen class:	3-zonocolpate
Pollen unit:	monad
Polarity:	isopolar
P/E ratio:	1.11
Shape class:	prolate spheroidal
Size class:	small grain
Outline:	circular lobate
Aperture:	tricolpate
Sculpturing:	regulate

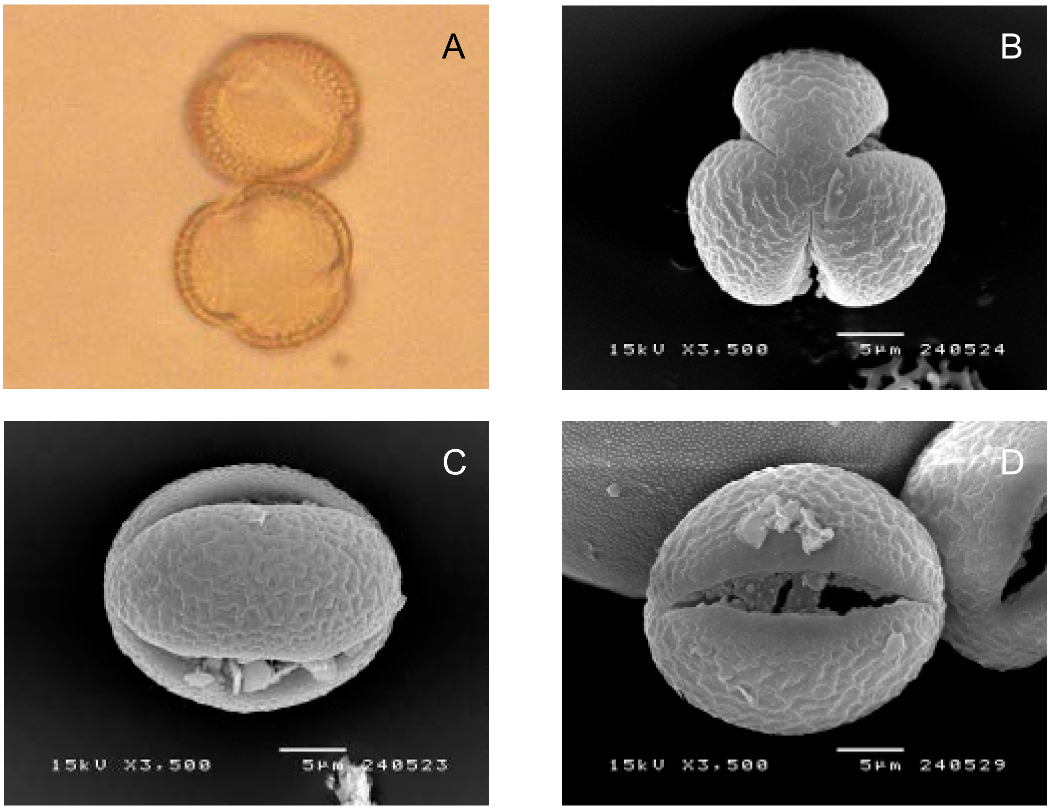

Figure 4.69 LM and SEM micrographs of Unknown 27

A. Polar view B. Equatorial view

C. Aperture and Sculpturing

53. Unknown 28

Pollen class:	4- zonocolpate
Pollen unit:	monad
Polarity:	isopolar
P/E ratio:	1.55
Shape class:	prolate
Size class:	medium grain
Outline:	circular
Aperture:	stephanocolpate
Sculpturing:	perfolate

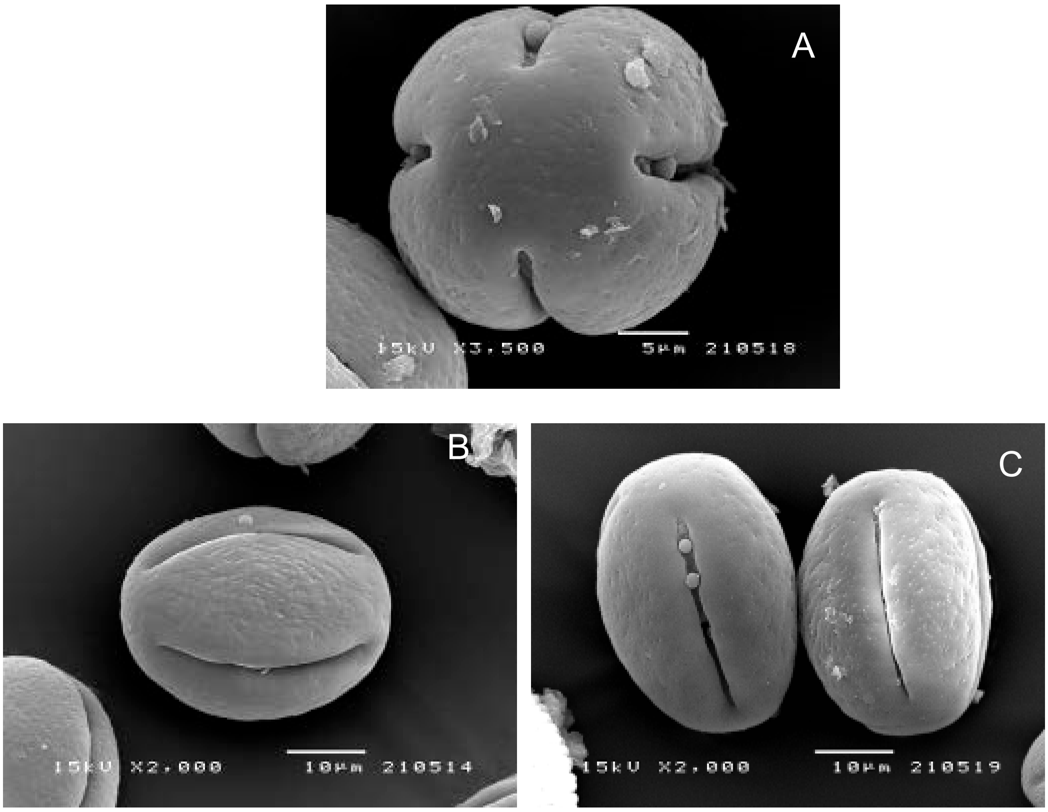

Figure 4.70 SEM micrographs of Unknown 28

A. Polar view B. Equatorial view

C. Aperture and Sculpturing

54. Unknown 29

Pollen class:	3-zonocolporate
Pollen unit:	monad
Polarity:	isopolar
P/E ratio:	1.67
Shape class:	prolate
Size class:	medium grain
Outline:	circular
Aperture:	tricolporate
Sculpturing:	reticulate

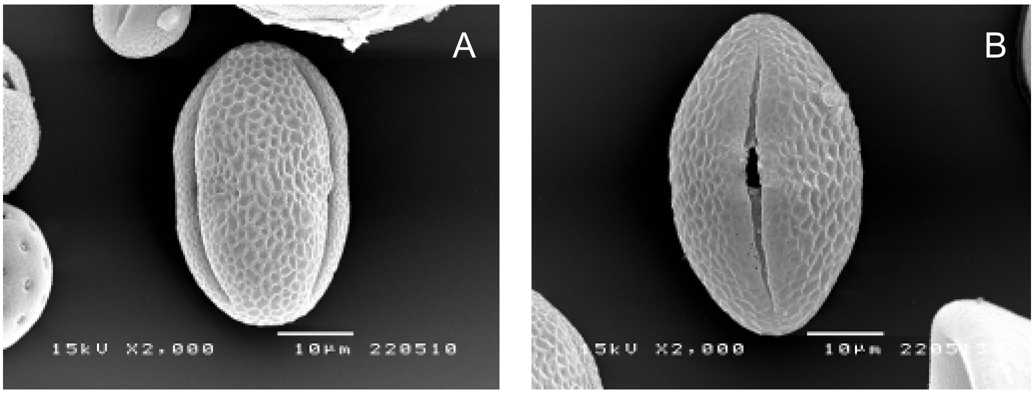

Figure 4.71 SEM micrographs of Unknown 29

A. Equatorial view

B. Aperture and Sculpturing

55. Unknown 30

Pollen class: 3-zonocolporate

Pollen unit: monad

Polarity: isopolar

P/E ratio: 1.31

Shape class: subspheroidal

Size class: small grain

Outline: circular lobate

Aperture: tricolporate

Sculpturing: reticulate

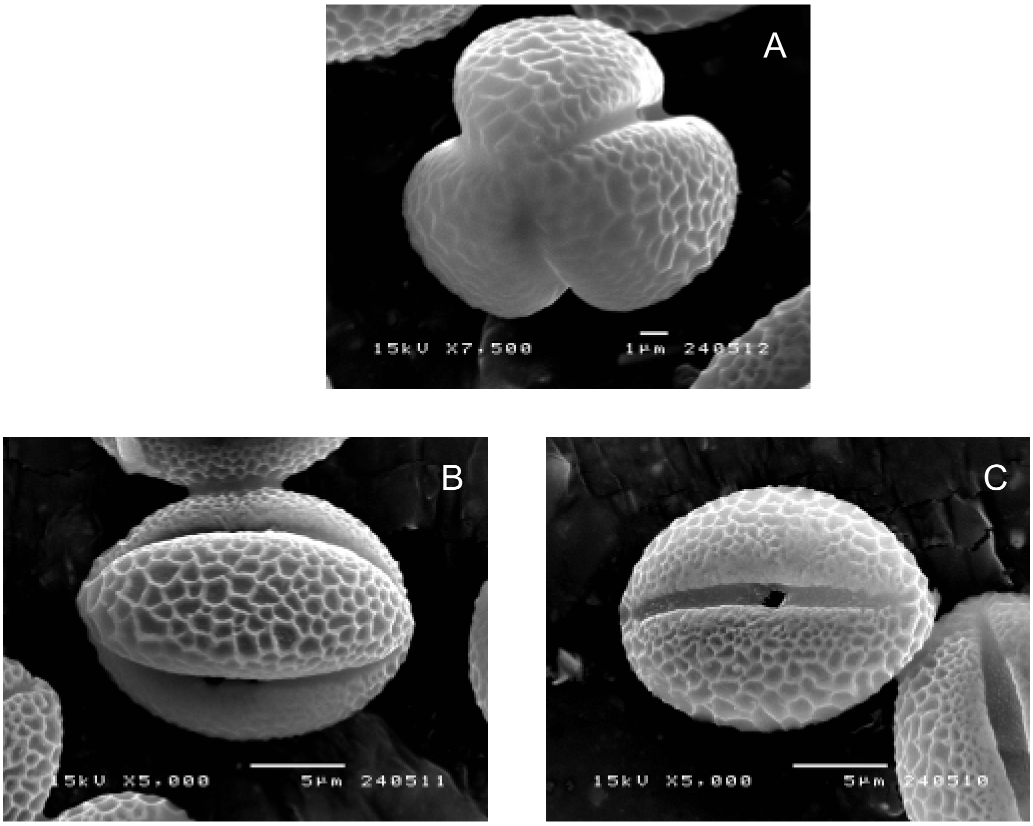

Figure 4.72 SEM micrographs of Unknown 30

A. Polar view B. Equatorial view

C. Aperture and Sculpturing

56. Unknown 31

Pollen class:	inaperture
Pollen unit:	monad
Polarity:	apolar
P/E ratio:	1.04
Shape class:	subspheroidal
Size class:	medium grain
Outline:	circular
Aperture:	inaperture
Sculpturing:	echinate

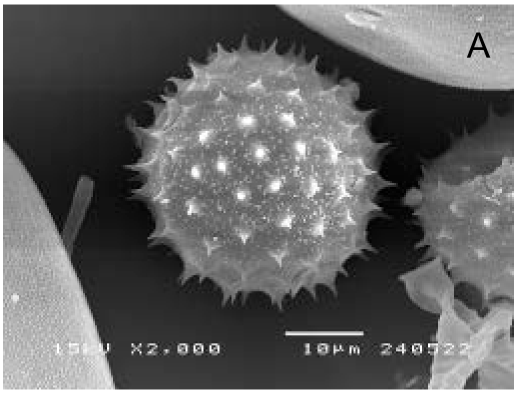

Figure 4.73 SEM micrographs of Unknown 31

A. Grian and sculpturing

57. Unknown 32

Pollen class:	3-zonocolporate
Pollen unit:	monad
Polarity:	isopolar
P/E ratio:	1.11
Shape class:	subprolate
Size class:	medium grain
Outline:	circular
Aperture:	tricolporate
Sculpturing:	reticurate

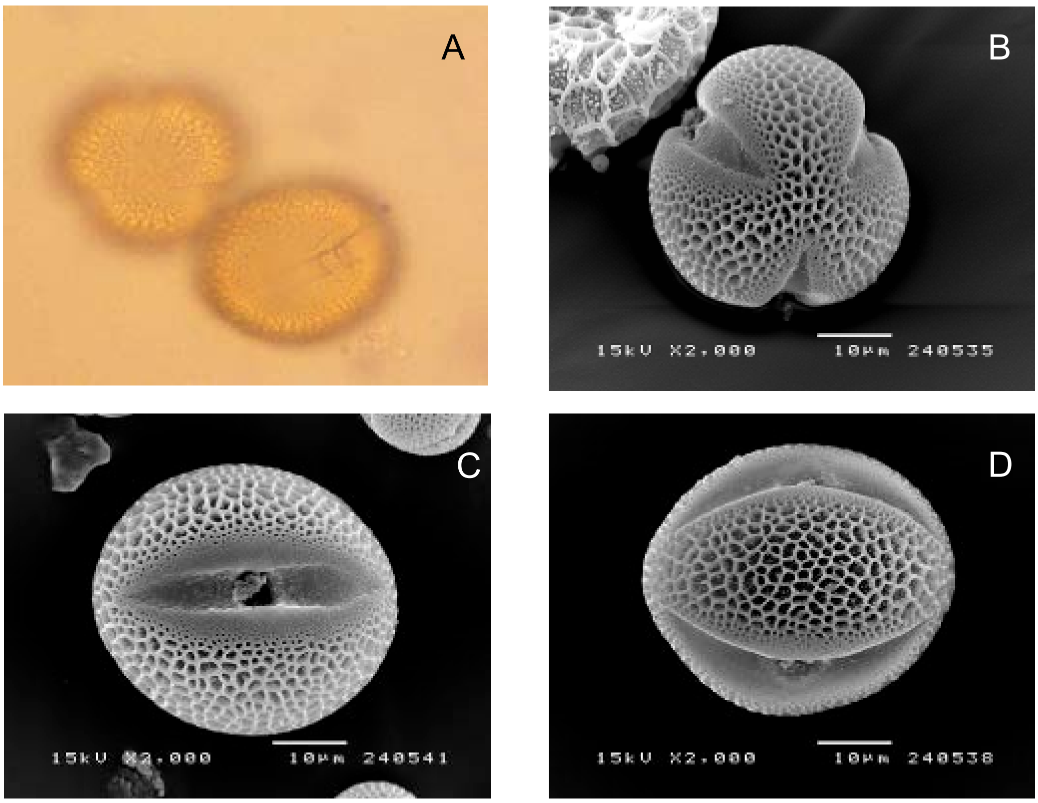

Figure 4.74 LM and SEM micrographs of Unknown 32

A. Equatorial view and Polar view B. Equatorial view

C. Aperture and Sculpturing

58. Unknown 33

Pollen class:	3-zonocolpate
Pollen unit:	monad
Polarity:	isopolar
P/E ratio:	0.98
Shape class:	oblate spheroidal
Size class:	medium grain
Outline:	circular
Aperture:	tricolpate
Sculpturing:	reticurate

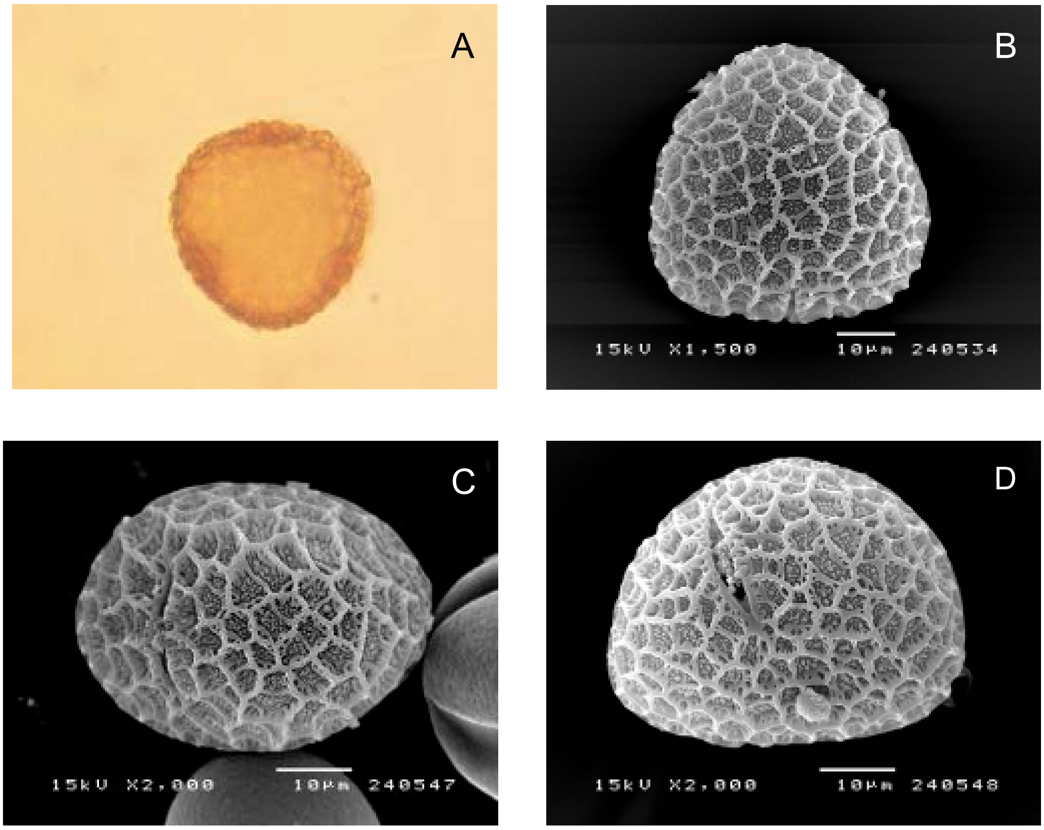

Figure 4.75 LM and SEM micrographs of Unknown 33

A.-B. Polar view C. Equatorial view

D. Aperture and Sculpturing

59. Unknown 34

Pollen class:	3-colpate
Pollen unit:	monad
Polarity:	isopolar
P/E ratio:	1.05
Shape class:	prolate spheroidal
Size class:	small grain
Outline:	semi angular
Aperture:	colpate
Sculpturing:	perforate with micro echinate

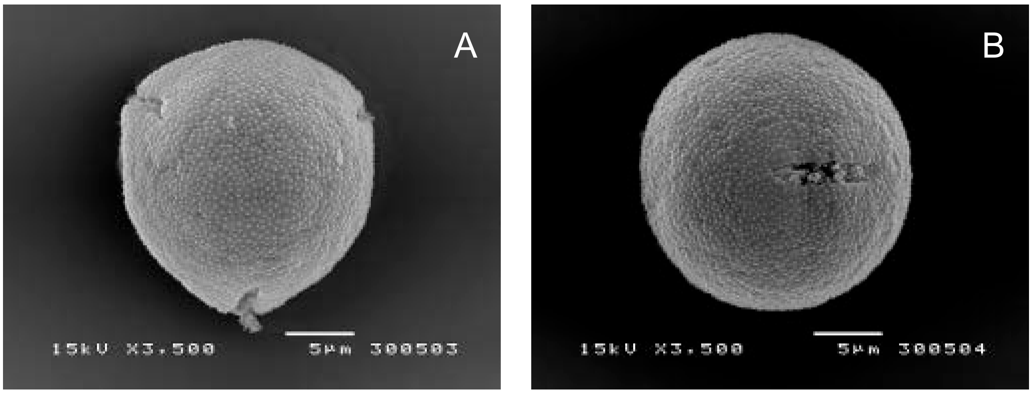

Figure 4.76 SEM micrographs of Unknown 34

A. Polar view

B. Aperture and Sculpturing

4.3 Discussion

Pollen food sources of *Tetragonilla collina* and *Tetrigona apicalis*

The study presents the pollen food sources were collected by two stingless bees species in Chulalongkorn University Forest and Research Station at Lai Nan sub district, Wiang Sa district, Nan province during September 2010 - August 2011. A total of 59 pollen types were identified in the samples, with the represented 21 families being: Asteraceae (5 pollen types), Caesalpinioideae (4 pollen types), Poaceae(3 pollen types), Convolvulaceae, Euphorbiaceae, Lythraceae, Mimosaceae (2 pollen types each), Apiaceae, Anacardiaceae, Amaranthaceae, Apocynaceae, Bombacaceae, Boraginaceae, Hypericaceae, Malvaceae, Passifloraceae, Rosaceae, Sapindaceae, Solanaceae, Tiliceae (1 type each). Jongjitwimol and Wattanayingcharoen (2006) reported that the pollen food sources of three species of stingless bees, *Tetrigona apicalis, Tetragonilla collina* and *Homotrigona fimbriata* at Phitsanulok Wildlife Conservation Development and Extension Station in Thailand. They found plant species of 18 families, 29 species; Acathaceae, Agavaceae, Alangiaceae, Arecaceae, Asteraceae, Bignoniaceae, Caesalpiniaceae, Convolvulaceae, Cucurbitaceae, Euphorbiaceae, Lythraceae, Mimosaceae, Papilionaceae, Rubiaceae, Scrophulariceae, Thunbergiaceae, Verbenaceae and Zingiberaceae. *Tetragonilla collina* collected 29 plant species, whereas *Tetrigona apicalis* collected 20 and *Homotrigona fimbriata* collected 16 plant species. This suggested that the *Tetragonilla collina* is the most important pollinator among the three species. The same families are represented by 8 pollen types in the present study, from the total of 59 pollen types found and the mainly number of pollen food sources were collected by *Tetragonilla collina*. Dejtisakdi (2005) studied pollens of six stingless bees species, *Tetrigona apicalis, Tetragonilla collina*, *Homotrigona fimbriata*, *Tetragonula pagdeni*, *Lepidotrigona terminata*, and *Lepidotrigona ventralis*. Of the 78 flowering plant species, 19 pollen types were found in *Tetragonilla collina*, and 15 pollen types were found in *Lepidotrigona ventralis*. The same results, the total number of flowering species was 52, but the number of pollen food sources by *Tetragonilla collina* and *Tetrigona apicalis* were 26 types. The total pollen types of stingless bees studied by Dejtisakdi (2005), three pollen were found in present study, *T. procumbens*, *C. frutescens*, and *M. pigra*. *T. procumbens* is well known as a widespread weed and pest plant.

Trigona spinipes collected *Eucalyptus* spp. (Myrtaceae), *Aloe* sp. (Liliaceae) *Archontophoenix* sp. (Palmae). Among these families, Myrtaceae is the main prefer flowers (Laurino and Ramalho, 1988). The major food sources for highly eusocial bee colonies are *Milkania* and *Verninia* (Asteraceae), *Myrcia* and *Eugenia* (Myrtaceae), *Bathysa* and *Psychotria* (Rubiaceae) (Wilms *et al*., 1996).

The present study, the highest number of pollen food sources occurred in *Tetragonilla collina*. Unknown 1 of Apiceae, *B. acuminate, C. argentea*, *I. cyclindrical* and *L. glauca* are predominant pollen for *Tetragonilla collina*. *I. cyclindrical* was found in pollen samples of *Tetragonilla collina*, only one type of *I. cyclindrical* was found in June 2011, while the flowering plants were found in June 2011 with sixteen species. The number of pollen types and number of flowering plants were not related.

Unknown 2 of Bombacaceae, Unknown 4 of Euphorbiaceae, *C. formosum*, *I. cylindrical*, *J. gossypifolia*, *L. glauca*, *L. macrocarpa* are predominant pollen for *Tetrigona apicalis*. Fourteen pollen types are general food sources of two stingless bees species. From the results, pollen food sources in among stingless bee species and between two stingless bee species were found the represent and percentage of pollen types are difference and are similar. Nagamitsu and Inoue (1997) suggested that sitngless bee species are able to partition floral resources of the same plant species. Among stingless bee species are shared pollen and nectar sources of various plant species (Inoue *et al*., 1985). Nagamitsu *et al*. (1999) reported that the preference in flower visits and floral resources portioning represented in among stingless bee species. Some floral resource partitioning appears between closely associated species of social bees in tropical habitats (Sommeijer *et al*., 1983; Nagamitsu *et al*. 1999).

Novais (2009) suggested that the different in the plant species and amount of pollens due to the accessibility of particular plant resources during the specific sampling days, or to the distance between the plant resources and nest. Villanueva

(2002) reported that the morphology, coloration, and odour of plant could be dependable for these qualitative and quantitative differences in pollen percentage. The results of this study showed that two stingless bee species collected pollen from different plants, and reported that there was a partitioning pollen food sources in these stingless bees species.

In addition, the foraging times between species of stingless bees with non-overlapping due to differences of food plants and food resource partitioning (Jongjitvimol *et al*., 2006). The foraging period of *Tetrigona apicalis* was from 08.00 to 09.30 a.m. whereas *Tetragonilla collina* was from 09.30 to 11.00 a.m.

Some plant food sources were found specific in *Tetragonilla collina* or *Tetrigona apicalis* as a result of the body size of stingless bees related to the size and morphology of flowering plant (Nagamitsu *et al*., 1999; Jongjitwimol *et al*., 2004; Jongjitwimol and Wattanayingcharoen, 2006).

The highest pollen types represented in September 2010, November, 2010 December 2010, January 2011 to April 2011, these month are low of rainfall rate, with high temperature period (Figure 4.16 and 4.17). These same months, January 2011 to April 2011 period found the highest number of the pollen types occurred in *Tetragonilla collina* and *Lepidotrigona ventralis* and the predominant of flowering plants not related with pollen food sources (Dejtisakdi, 2005). This topic was explained by preference behavior of the stingless bees in above. In January 2011 foraging of *Tetragonilla collina* (C3) not occurred, while foraging behavior in *Tetrigona apicalis* not represented in September 2010, May 2011 and July 2011. During the rainy season, these stingless bees could not foraged food sources. Roubik (1989) and Jongjitwimol *et al*. (2004) suggested that physical factors (temperature, relative humidity and light intensity) affect the foraging behaviors of stingless bee.

Furthermore, Ciar *et al*. (2009) suggested that the three factors considered were distance of the food source from the hive, directionality of the food source, and height of the food source from the ground affect the foraging behavior of *Trigona biroi*. Eckles, Roubik and Nieh (2012) suggested that the stingless bees forage at different tropical forest canopy levels, ranging up to 40 m. The flight height above ground may be important for this stingless bee and others that compete for resources located at heights ranging from ground level to the high tropical forest canopies.

Villanueva (2002) suggested that trees and shrubs were important sources to the diets of *Apis mellifera* since they normally represent sources of pollen all over the year. These same plant sources represented in this study.

The present study suggested that unknown pollen type may be due to the range of foraging behavior over 300 m, the researcher errored in flowering plant collections, not cover every site for the reason that some time could not collected in overgrown site and sloping of study site.

Pollen types that could be identified to species with 25 species and 34 pollen types could not be identified. Of these 34 unknown, 9 pollen types could be identified to the family level. Pollen type of Unknown 1 should be classify in the family Apiceae because of its pollen was prorate grain and aperture with tricolporate. Pollen type of Unknown 2 should be classify in the family Bombacaceae because of its pollen was colpate aperture located between angle and ornamentation is reticulate. Pollen type of Unknown 3 should be classify in the family Convolvulaceae because of its pollen was very large grain and sculpturing with echinate and micro echinate. Pollen type of Unknown 4 should be classify in the family Euphorbiaceae because of this pollen was medium circular grain, inaperture and sculpturing with croton pattern. Pollen type of Unknown 5 should be classify in the Myrtaceae because of aperture is syncolpolate, this aperture is specific this family. Pollen of Unknown 6 and Unknown 7 should be classify in the family Poaceae because of this family easily distinguished from other family. The monoporate aperture with annulus is a specific morphological for identified to family and difficult for species. Pollen type of Unknown 8 should be classify in the family Rosaceae because of this pollen was 3-zonocolporate, circular lobate and sculpturing with strinate. Pollen type of Unknown 9 should be classify in the family Sapindaceae because of this pollen was 3- zonocolporate, small grain, semi angular and sculpturing with strinate. Other Unknown pollen types should be classified in the dicot plants because the number of aperture of pollen morphology of most dicot plants are tricolpate and tricolporate, whereas the number of aperture of monocots are single pore. These Unknown pollen types need more information for identify to species level because some Unknown pollen type are predominant pollen.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

Five genera and six species of stingless bees (*Tetragonilla collina, Tetrigona apicalis*, *Homotrigona fimbriata*, *Lepidotrigona terminata, Tetrigona melanoleuca* and *Tetragonula pagdeni*) were recorded. *Tetragonilla collina* was the most dominant species.

Tetragonilla collina built their nests in the termite mound and in underground with aggregation nesting. *Tetrigona apicalis* built their nests in live tree hollows, dead trees and wooden poles. *Homotrigona fimbriata* and *Tetrigona melanoleuca* built their nests in live tree hollows.

D. tuberculatus, I. malayana, *P. macrocarcus*, *S. obtuse* and *S. siamensis* were nested by stingless bees.

The number of pollen food sources of *Tetragonilla collina* and *Tetrigona apicalis*, were 51 and 22 pollen types, respectively. Apiceae, Unknown 1; Anacardiaceae, *M. indica*; Amaranthaceae, *C. argentea*; Apocynaceae, *W. arborea*; Asteraceae*, A. oleracea*, *B. alba C. odoratum*, *M. divaricatum*, *T. procumbens*; Boranginaceae, *C. sebestena*; Caesalpinioideae, *B. acuminate, L. glauca*, *C. fistula*, *C. siamea*; Lythraceae, *L. floribunda*; Convolvulaceae, *Merramia umbellata*, Unknown 3; Euphorbiaceae, Unknown 4, Malvaceae, *U. lobata*; Mimosaceae, *M. pigra*, *M. pudica* Passifloraceae, *P. foetida*; Poaceae, *I. cylindrical*, Unknown 6, Unknown 7; Rosaceae, Unknown 8; Sapindaceae, Unknown 9; Solanaceae, *C. frutescens*; Tiliceae, *M. calabura*;; Unknown 10; Unknown 11; Unknown 12; Unknown 13; Unknown 14; Unknown 15; Unknown 16; Unknown 17; Unknown 18; Unknown 19; Unknown 20; Unknown 21; Unknown 22; Unknown 23; Unknown 24; Unknown 25; Unknown 26; Unknown 27; Unknown 28; Unknown 29, Unknown 30 and Unknown 31 were determined as pollen food sources for *Tetragonilla collina*.

Bombacaceae, Unknown 2; Caesalpinioideae, *C. siamea*, *L. glauca*; Euphorbiaceae, *J. gossypifolia*, Unknown 4; Hypericaceae. *C. formosum*; Lythraceae, *L. macrocarpa*; Mimosaceae, *M. pigra*, *M. pudica*; Poaceae, *I. cylindrical*, Unknown 6; Sapindaceae, Unknown 9; Unknown 10; Unknown 12; Unknown 14; Unknown 18; Unknown 20; Unknown 21; Unknown 26.Unknown 32; Unknown 33 and Unknown 34 were identified as pollen food souces for *Tetrigona apicalis*.

The predominant pollen food sources of two stingless bees are Unknown 1 of Apiaceae, Unknown 2 of Bombacaceae, Unknown 4 of Euphorbiaceae, Unknown 6 of Poaceae, Unknown 9 of Sapindaceae, *B. acuminate, C. argentea*, *C. formosum*, *I. cyclindrical*, *J. gossypifolia*, *L. glauca*, *L. macrocarpa*, unknown 10, Unknown 12, Unknown 14, Unknown 18, Unknown 20, Unknown 21, unknown 22, unknown 26, unknown 27*,* Unknown 32, Unknown 33 and Unknown 34.

The study of stingless bees diversity and pollen food sources will provide basic information essential for the advancement of the meliponiculture and useful for the conservation management of this stingless bee species and plant species as pollen food sources. These stingless bees will use artificially constructed hives and may also be a useful pollinator of many crops.

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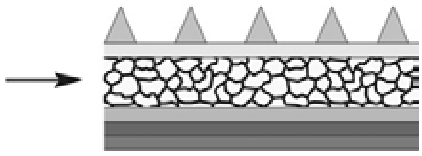
APPENDIX

Glossary

Glossary of pollen and spore terminology (Shivanna and Rangaswamy, 1992; Punt *et al*., 2007).

Acetolysis

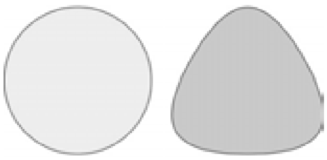
A widely used technique for preparing pollen and spore exines for study.



Alveolate (adj.) (Van Campo, 1971)

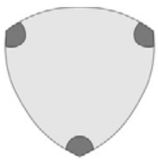
Describing a type of sexine/ ectexine structure, in which the infratectal layer is characterised by partitions forming compartments of irregular size and shape.

Amb



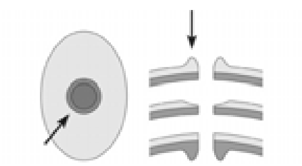
The outline of a pollen grain or spore seen in polar view.

Angulaperturate



Describing an equatorially aperturate pollen grain with the apertures situated at the angles of the outline in polar view.

Annulus (pl. annuli, adj. annulate)

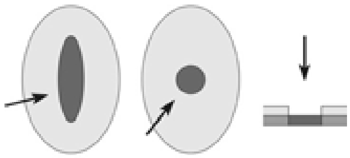


An area of the exine surrounding a pore that is sharply differentiated from the remainder of the exine, either in ornamentation or thickness

Aperture (adj. aperturate)

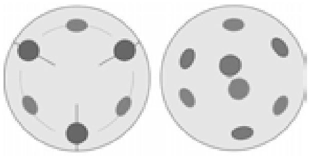
A specialized region of the (sporoderm, that is thinner than the remainder of the sporoderm and generally differs in ornamentation and/or in structure.

Aperture membrane



The exine which forms the floor of an ectoaperture.

Apolar (adj.)



Describing pollen and spores without distinct polarity.

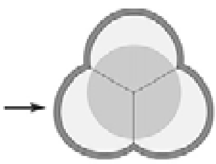
Atectate (adj.)

Describing pollen grains that have an exine with little or no internal structure.

Bilateral (adj.)

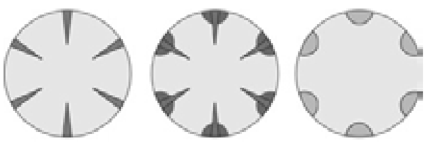
Describing pollen and spores having a single, principal plane of symmetry.

Calymmate (adj.)



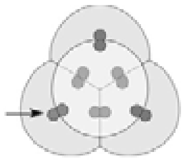
Describing tetrads or polyads in which the sexine/ectexine of each monad is well differentiated and forms a continuous envelope around the unit.

Circumaperturate (adj.)



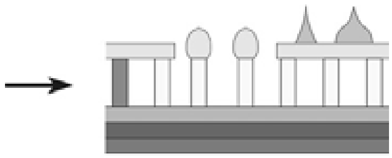
Describing a pollen grain with equatorial apertures that are regularly arranged around a circular outline.

Coaperturate (adj.)



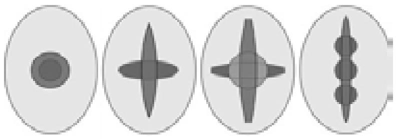
Describing permanent tetrads in which the apertures of neighbouring monads join.

Columella (pl. columellae, adj. columellate)



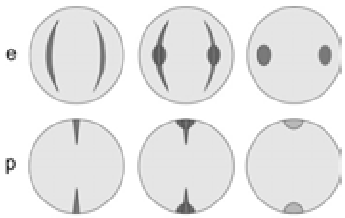
A rod-like element of the sexine/ectexine, either supporting a tectum or a caput.

Compound aperture



An aperture with two or more components that are situated in more than one wall layer.

Dicolpate, dicolporate, diporate (adj.)



Describing pollen grains with two ectocolpi, two compound apertures or two pores.

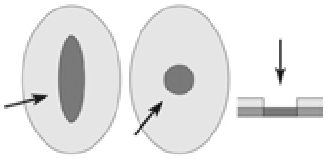
Dispersal unit

The morphological unit in which mature pollen grains or spores are shed, which may range from individuals (monads), to pairs (dyads), groups of four (tetrads), or groups of more than four (polyads). Larger, indeterminate numbers of pollen grains or spores may also be dispersed as pollinia or massulae.

Distal (adj.)

A common descriptive term used in contrast to proximal, applied in palynology to features on the surface that face outward in the tetrad stage.

Ectoaperture

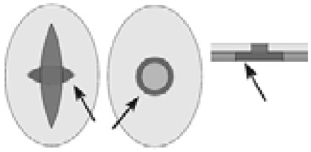


An aperture in the outer layer of the sporoderm.

Comment: Examples: ectocolpus, ectopore.

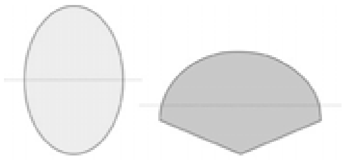
See also: endoaperture, mesoaperture.

Endoaperture



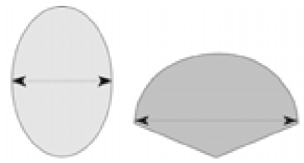
An aperture in the inner layer of the sporoderm, often the inner aperture of a compound aperture.

Equator



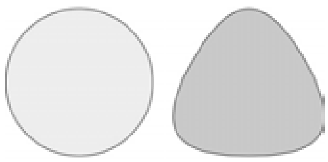
The dividing line between the distal and proximal faces of a pollen grain or spore.

Equatorial diameter



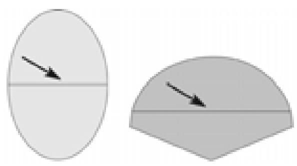
A line, lying in the equatorial plane, perpendicular to the polar axis and passing through it.

Equatorial outline



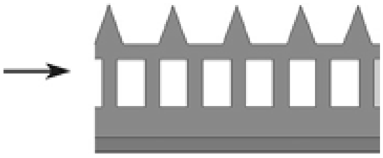
General description of the equator when a pollen grain is seen in polar view.

Equatorial plane



The plane perpendicular to the polar axis and lying midway between the poles.

Exine (pl. exines, adj. exinal, exinous)

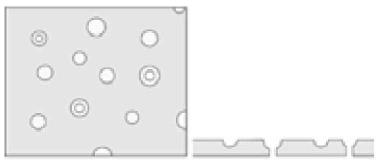


The outer layer of the wall of a palynomorph, which is highly resistant to strong acids and bases, and is composed primarily of sporopollenin.

Fossula (pl. fossulae, adj. fossulate)

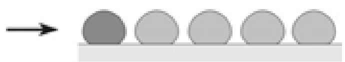
A feature of ornamentation consisting of an elongated, irregular groove in the surface.

Foveola (pl. foveolae, adj. foveolate)



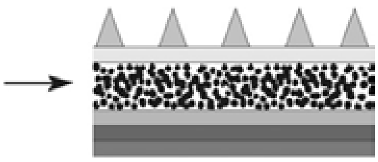
A feature of ornamentation consisting of more or less rounded depressions or lumina more than 1 μm in diameter. The distance between foveolae is greater than their breadth.

Gemma (pl. gemmae, adj. gemmate)



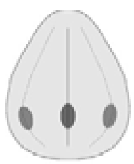
A sexine element which is constricted at its base, higher than 1 μm, and that has approximately the same width as its height.

Granular exine



A type of exine stratification in which the infratectal layer is composed of more or less rounded, granules rather than of columellae or other structures.

Heteropolar (adj.)

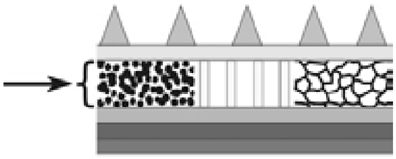


Describing pollen or spores in which the distal and proximal faces of the exine are different, either in shape, ornamentation or apertural system.

Inaperturate (adj.)

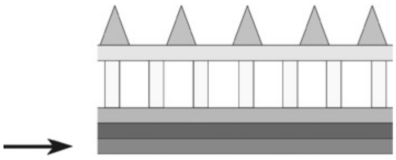
Describing a pollen grain or spore without apertures.

Infratectum (pl. infratecta, adj. infratectate)



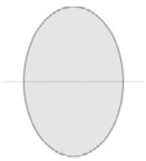
A general term for the layer beneath the tectum, which may be alveolar, granular, columellar, or structureless.

Intine



The innermost of the major layers of the pollen grain wall underlying the exine and bordering the surface of the cytoplasm.

Isopolar (adj.)



Describing a pollen grain or spore in which the proximal and distal faces of the exine are alike.

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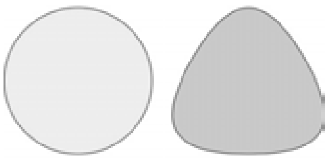
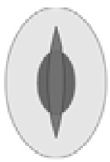
Limb



Synonym of equatorial outline.

Lolongate (adj.)



Describing the shape of a longitudinally elongated endoaperture.

Microreticulum (adj. microreticulate)

A reticulate ornamentation consisting of muri and lumina smaller than1 µm.

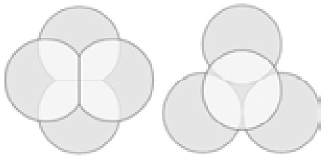
Microspore

A general term for the smaller spores of heterosporous plants, that is, the spores from which the microgametophyte develops.

Monad

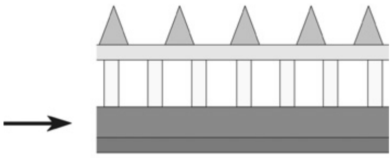
A pollen grain or spore dispersed as an individual unit, rather than in association with others, such as in a dyad, tetrad or polyad.

Multiplanar tetrad



A tetrad in which the individual members are arranged in more than one plane.

Nexine

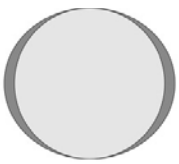


The inner, non-sculptured part of the exine which lies below the sexine.

Oblate (adj.)

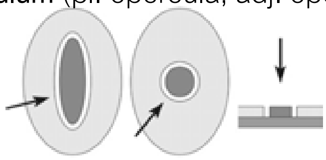
Describing the shape of a pollen grain or spore in which the polar axis is shorter than the equatorial diameter.

Oblate spheroidal (adj.)



Describing the shape of a pollen grain or spore in which the ratio between the polar axis and the equatorial diameter is 0.88–1.00.

Operculum (pl. opercula, adj. operculate)



A distinctly delimited sexineectexine structure which covers part of an ectoaperture and which is completely isolated from the rest of the sexine.

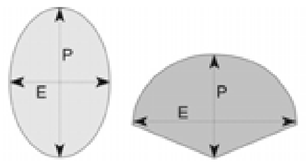
Optical (cross-) section

The image seen in optical microscopy when the plane of focus is half way through a palynomorph.

Ornamentation

A general term that is useful for describing the organisation of features.

P/E ratio

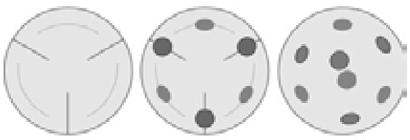


The ratio of the length of the polar axis (P) to the equatorial diameter (E).

Palynology

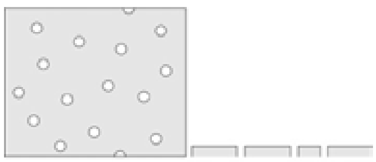
The study of pollen grains and spores and of other biological materials that can be studied by means of palynological techniques.

Pantoaperturate (adj.)



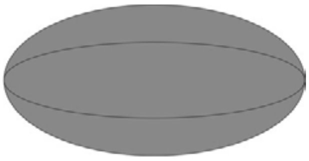
Describing a pollen grain with apertures spread over the surface sometimes forming a regular pattern.

Perforate (adj.)



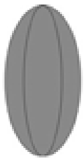
A general adjective indicating the presence of holes, applied in palynology to holes less than 1 μm in diameter and generally situated in the tectum.

Peroblate (adj.)



Describing the shape of a pollen grain or spore in which the ratio between the polar axis and the equatorial diameter is less than 0.50.

Perprolate (adj.)

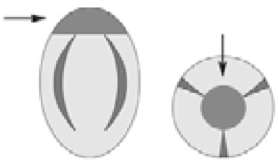


Describing the shape of a pollen grain or spore in which the ratio between the polar axis and the equatorial diameter is more than 2.

Planaperturate (adj.)

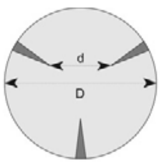
Describing a pollen grain with an angular outline, in which the apertures are situated in the middle of the sides when seen in polar view, rather than at the angles.

Polar area



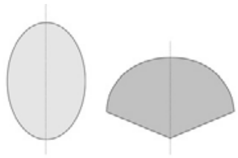
Synonym of apocolpium.

Polar area index (PAI) (pl. polar area indices)



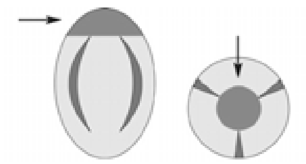
Synonym of apocolpium index.

Polar axis (pl. polar axes)



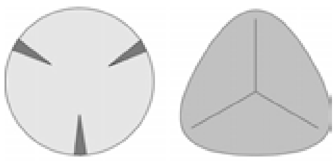
The straight line between the distal and proximal poles of a pollen grain or spore.

Polar field



Synonym of apocolpium.

Polar view

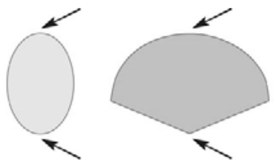


A view of a pollen grain or spore in which the polar axis is directed towards the observer.

Polarity

The condition of having distinct poles.

Pole



Either of the two extremities of the polar axis.

Pollen

The microgametophyte of seed plants, developed from the microspore.

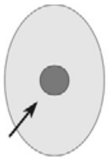
Pollen analysis

The study of assemblages of dispersed palynomorphs such as those isolated from samples of peat.

Pollen type

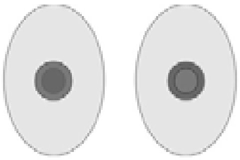
A pollen morphological category, subsidiary to a pollen class, and including pollen grains which can be distinguished either by one distinct character or by a unique combination of characters.

Pore (pl. pores, adj. porate)



A general term, applied in palynology to a circular or elliptic aperture with a length/breadth ratio less than 2.

Pororate (adj.)

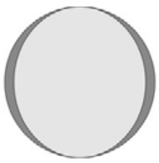


Describing a pollen grain with compound apertures in which both the ectoaperture and the endoaperture are pores and the two are not congruent.

Prolate

Describing the shape of a pollen grain or spore in which the polar axis is larger than the equatorial diameter.

Prolate spheroidal



Describing the shape of a pollen grain or spore in

Pseudoaperture (adj. pseudoaperturate)

A thinning of the exine which, although superficially resembling an aperture, is not associated with a thickening of the intine and is presumed not to function as an exitus.

Pseudocolpus (pl. pseudocolpi, adj. pseudocolpate)

A colpus-like pseudoaperture.

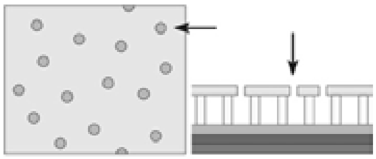
Pseudopore (pl. pseudopores, adj. pseudoporate)

A pore-like pseudoaperture.

Psilate (adj.)

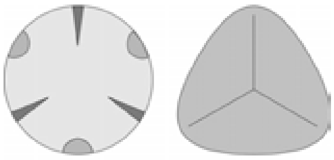
Describing a pollen or spore with a smooth surface.

Punctum (pl. puncta, adj. punctate)



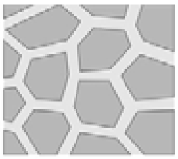
A rounded or elongate tectal perforation, less than 1 μm in length or diameter.

Radially symmetric (adj.)



Describing a pollen grain or spore with two or more vertical planes of symmetry, but, if only two such planes are present, then their axes are of equal length.

Reticulum (pl. reticula, adj. reticulate)



A network-like pattern consisting of lumina or other spaces wider than 1 μm bordered by elements narrower than the lumina.

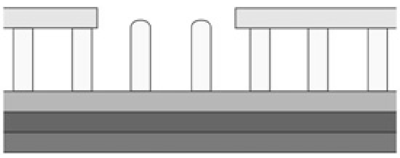
Scabrate

Describing elements of ornamentation, of any shape, smaller than 1 μm in all directions.

Sculpturing (adj. sculptured)

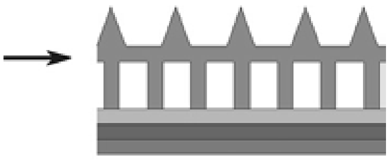
The surface relief, or topography, of a pollen grain or spore.

Semitectum (adj. semitectate)



A partially discontinuous tectum in which the tectal perforations are equal to or wider than the muri and usually larger than 1 μm in diameter.

Sexine



The outer, sculptured layer of the exine, which lies above the nexine.

Shape classes (pl.)

Categories of pollen and spore shape based on the relations between polar axis (P) and equatorial diameter (E). See also: oblate, oblate spheroidal, P/E ratio, peroblate, perprolate, prolate, prolate spheroidal, suboblate, subprolate.

Spheroidal

Describing the shape of a pollen grain or spore in which the polar axis and the equatorial diameter are approximately equal.

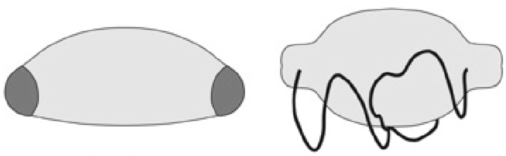
Sporopollenin

The name given to the acetolysis resistant biopolymers which make up most of the material of the exine.

Stenopalynous (adj.)

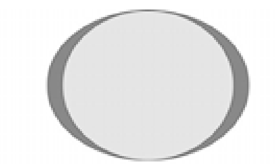
Describing plant taxa characterized by only a slight variation in their palynomorphs.

Subisopolar (adj.)



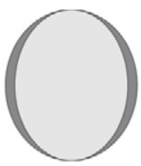
Describing a pollen grain or spore in which the proximal and distal faces are slightly different.

Suboblate, (adj.)



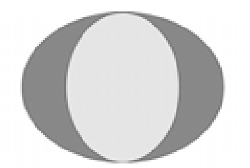
Describing the shape of a pollen grain or spore in which the ratio between the polar axis and the equatorial diameter is 0.75–0.88.

Subprolate (adj.)



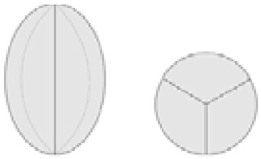
Describing the shape of a pollen grain or spore in which the ratio between the polar axis and the equatorial diameter is 1.14–1.33.

Subspheroidal (adj.)



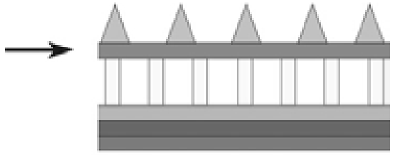
Describing the shape of a pollen grain or spore in which the ratio between the polar axis and the equatorial diameter is 0.75–1.33.

Syncolp(or)ate (adj.)



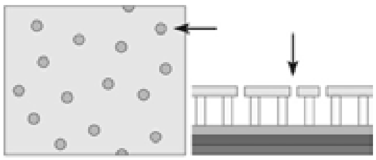
Describing a pollen grain with two or more simple (or compound) colpi the ends of which anastomose at the pole.

Tectum (pl. tecta, adj. tectate)



The layer of sexine, which forms a roof over the columellae, granules or other infratectal elements.

Tectum perforatum (adj. tectate perforate)

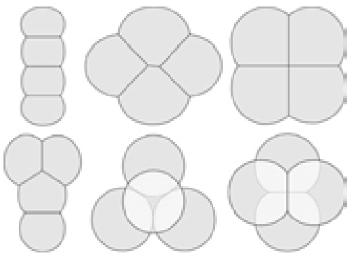


A tectum with perforations smaller than 1 µm in diameter.

Tectum imperforatum (adj. tectate imperforate)

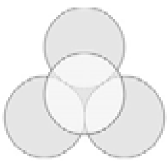
A multiplanar tetrad in which each member is in contact with a continuous tectum, without perforations.

Tetrad



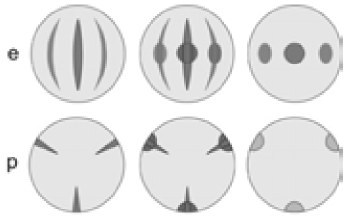
A general term for a group of four united pollen grains or spores, either as a dispersal unit or as a developmental stage.

Tetrahedral tetrad



A multiplanar tetrad in which each member is in contact with three others, so that the centres of the grains define a tetrahedron.

Tricolpate, tricolporate, triporate (adj.)

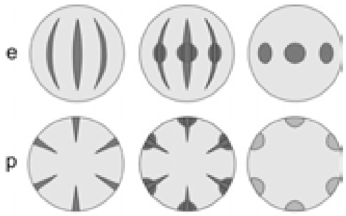


Describing pollen grains with three ectocolpi, three compound apertures or three pores.

Verruca (pl. verrucae, adj. verrucate)

A wart-like sexine element, more than 1 μm wide, that is broader than it is high and is not constricted at the base.

Zonoaperturate (adj.)



Describing a pollen grain with apertures situated only at the equator.

Table 1-A Equatorial shape of pollen

Shape classes	P/E	100 x P/E
Peroblate	< 4/8	< 50
Oblate	4/8-6/8	50-75
Subsperoidal	6/8-8/6	75-133
Suboblate	6/8-7/8	75-88
Oblate speroidal	7/8-8/8	88-100
Prolate speroidal	8/8-8/7	100-114
Subprolate	8/7-8/6	114-133
Prolate	8/6-8/4	133-200
Perprolate	>8/4	>200

Table 2-A Size classes of pollen

Size classes	Length of the longest axis (μm)
Minute grain	<10
Small grain	10-24
Medium grian	25-49
Large grain	50-99
Very large grain	100-199
Gigantic	>/= 200

BIOGRAPHY

Miss Nungruthai Wichaikul was born on November 9, 1986 in Nakhon Nayok province, Thailand. She graduated a Bachelor's Degree of Science, Department of Biology, Faculty of Science, Chulalongkorn University, Thailand in 2008. After that continued her studying in Master's Degree of Science, Program in Zoology, Department of Biology, Faculty of Science, Chulalongkorn University that supported by a scholarship from Science for locale Project under the Chulalongkorn University Centenary Academic Development Plan 2008-2012.