

# Pollen Food Sources of the Stingless Bees *Trigona apicalis* Smith, 1857, *Trigona collina* Smith, 1857 and *Trigona fimbriata* Smith, 1857 (Apidae, Meliponinae) in Thailand

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**ABSTRACT.**– The pollen collected by three species of *Trigona*; *T. apicalis* Smith 1857, *T. collina* Smith, 1857 and *T. fimbriata* Smith, 1857 were studied at the Phitsanulok Wildlife Conservation Development and Extension Station in Thailand, from January to December 2004. Pollen loads were sampled from bee baskets of forager bees returning to their colonies. We created a pollen key for the variety of local plant species. Pollen samples were prepared for analysis by acetolysis. Having developed the key, we determined the origin of pollen loads carried by returning foragers. In total, 2,160 pollen loads from bee baskets of forager bees were identified into 29 plant species of 18 families; Acathaceae (*Ruellia tuberosa*), Agavaceae (*Agave angustifolia*), Alangiaceae (*Alangium salvifolium*), Arecaceae (*Caryota bacsonensis*), Asteraceae (*Tridax procumbens*), Bignoniaceae (*Rernandoa adenophylla*), Caesalpiniaceae (*Cassia bakeriana*, *Delonix regia* and *Senna siamea*), Convolvulaceae (*Ipomoea aquatica* and *Merremia vitifolia*), Cucurbitaceae (*Coccinia grandis*), Euphorbiaceae (*Croton roxburghii*), Lythraceae (*Lagerstroemia calyculata*, *L. macrocarpa* and *L. tomentosa*), Mimosaceae (*Mimosa pigra* and *M. pudica*), Papilionaceae (*Butea monosperma*, *Dalbergia lanceolaria*, *Erythrina stricta* and *Millettia brandisiana*), Rubiaceae (*Ixora grandifolia* and *Paederia linearis*), Scrophulariaceae (*Torenia fournieri*), Thunbergiaceae (*Thunbergia laurifolia*), Verbenaceae (*Tectona grandis*) and Zingiberaceae (*Costus speciosus* and *Zingiber officinale*). *T. collina* was by far the most polylectic species collecting 29 plant species, while *T. apicalis* foraged on 20 and *T. fimbriata* only 16. This suggests that the small *T. collina* is the most important pollinator among the three species.

**KEY WORDS:** pollen, stingless bees, *Trigona apicalis*, *T. collina*, *T. fimbriata*

## INTRODUCTION

Pollen is the male reproductive part of plants. It is transported by wind, animals and insects to the receptive female part or stigma

(Buchmann and Nabhan, 1996). The vast majority of the 300,000 known species of plants are specialized for pollination by insects. Insect pollination of plants has evolved along with the insect itself, so plant and insects are mutually dependent. For stingless bees, pollen is the main source of protein, lipids, vitamins, minerals and some carbohydrate (Grogan and

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Hunt, 1979; Wahurst and Goebel, 1995; Buchmann and Nabhan, 1996; O'Toole and Raw, 1999). Most bees feed their larvae with pollen, and adult bees nourish themselves on pollen and nectar mixtures. This source of proteinaceous nourishment for adult bees has been hypothesized to be fundamental to the many evolutions of social behavior in Apoidea (Hunt, 1982). The collection of pollen by bees also provides valuable pollination services for many plants, including economically valuable crops, ornamentals, and native plant species (Buchmann and Nabhan 1996). This study observed species of pollen collected as food sources by three species of the stingless bees; *T. apicalis* Smith 1857, *T. collina* Smith, 1857 and *T. fimbriata* Smith, 1857. These three species are common in tropical forests and are one of the important pollinators of wild plants in Thailand.

#### MATERIALS AND METHODS

We studied the pollen loads collected by three species of *Trigona*; *T. apicalis*, *T. collina* and *T. fimbriata* at the Phitsanulok Wildlife Conservation Development and Extension Station, Thailand during January to December 2004. In total, 20 returning pollen foragers from each colony of all species were captured at the nest entrances using a sweep net between 6.30 a.m. and 12.30 p.m. depending on weather conditions and foraging activity. Repeated samples were taken on three consecutive days every month. We modified the pollen key by studying the local flora which flowered during 6.30 a.m. to 12.30 p.m. Pollen was taken from flower buds (fresh material) and provided the key for pollen identification. Pollen was prepared by the standard acetolysis method (Erdtman, 1960). They were mounted in glycerin jelly for light microscopy (LM) observation. Pollen measurements and morphological observations were analyzed by an Olympus BX-41 microscope. For external morphological study, acetolysed pollen grains in 70% ethanol solution were pipetted directly

onto aluminum stubs with double sided cellophane tape, and air-dried at room temperature. Specimens were coated with gold, determined by a Leo 1455VP scanning electron microscopy; SEM and photographed.

#### RESULTS

From this study, we found 29 plant species of 18 families and 23 genera of plant species collected by three species of the stingless bees; *T. apicalis*, *T. collina* and *T. fimbriata* (Table 1). Figure 1 is the example of pollen collected by three *Trigona* species.

*Trigona collina* was observed, from pollen analysis, to be able to collect from 29 plant species. This is the highest number of plant species collected among the three species of stingless bees. *T. apicalis* is the second largest collector of pollen -20 species of plant. The last one, *T. fimbriata* was found to collect only 16 plant species. The percentage of pollen from each plant collected by individual species at the same time of every month shows in appendixes 1-3.

#### CONCLUSION AND DISCUSSION

A total of 2,160 pollen loads were collected by *T. apicalis*, *T. collina* and *T. fimbriata* at the Phitsanulok Wildlife Conservation Development and Extension Station in Thailand from January to December 2004. Their pollen food sources were identified into 29 plant species of 18 families and 23 genera. Part of the differences in pollen sources among the species may result from 1) relationship between sizes and structures of flowers and foragers, 2) foraging times and 3) foraging preferences or floral choice.

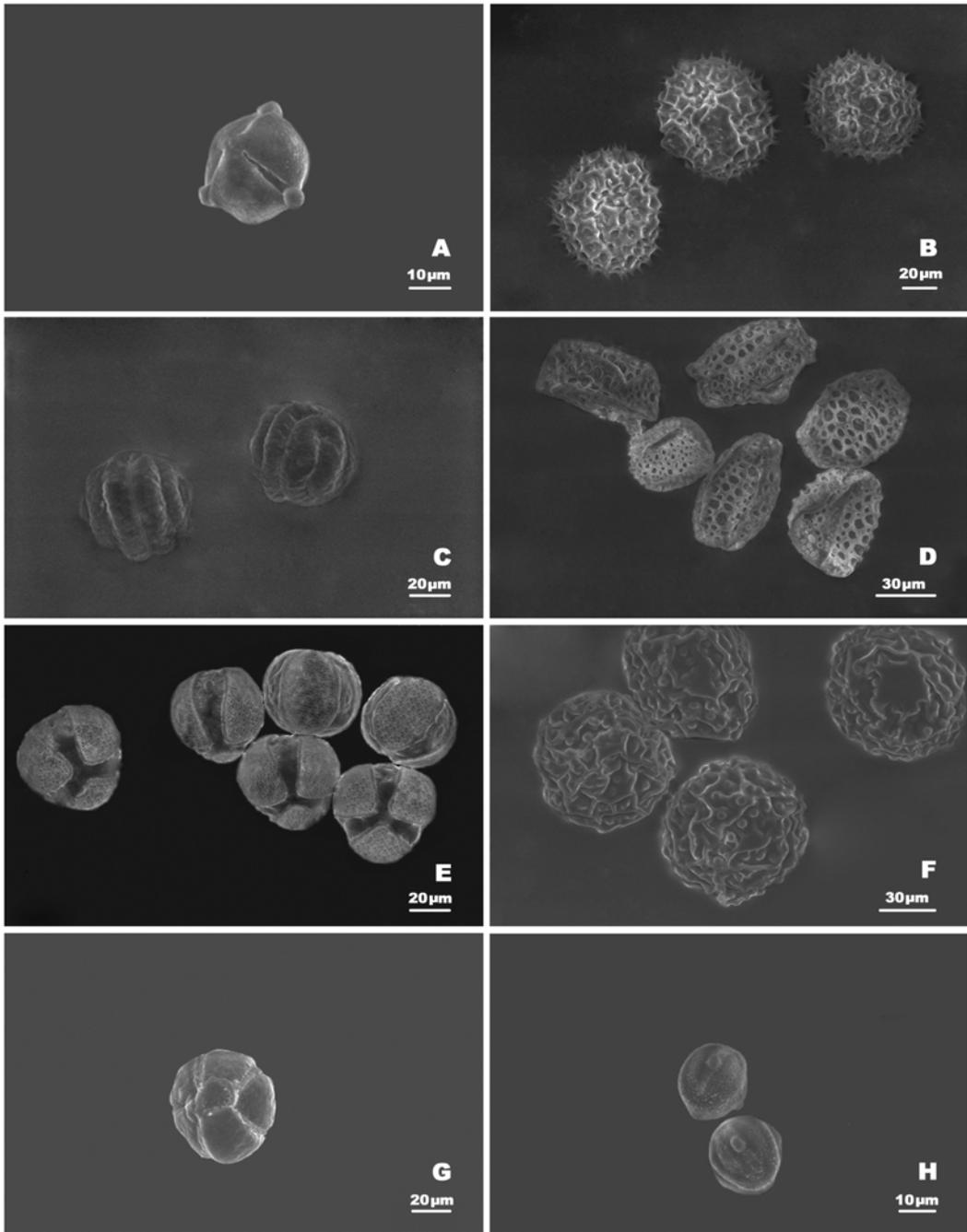
From the pollen analysis, four plant species of three families; *T. procumbens* (Asteraceae), *M. pigra* and *M. pudica* (Mimosaceae) and *T. grandis* (Verbenaceae) are the main food sources of *T. apicalis*. Five plant species of four families; *T. procumbens* (Asteraceae), *R. adenophylla* (Bignoniaceae), *M. pigra* and *M.*

**TABLE 1.** Pollen food sources were collected by three species of the stingless bees at Phitsanulok Wildlife Conservation Development and Extension Station, Thailand during January to December 2004.

Families of plants	Species of plants	Local name of plants	Species of stingless bees		
			<i>T. apicalis</i>	<i>T. collina</i>	<i>T. fimbriata</i>
Acathaceae	<i>Ruellia tuberosa</i>	Toiting	✓	✓	✓
Agavaceae	<i>Agave angustifolia</i>	Son narai	✓	✓	
Alangiaceae	<i>Alangium salviifolium</i>	Pru	✓	✓	
Arecaceae	<i>Caryota bacsonensis</i>	Taorang		✓	
Asteraceae	<i>Tridax procumbens</i>	Tin tukkae	✓	✓	✓
Bignoniaceae	<i>Rernandoa adenophylla</i>	Kae hang khang	✓	✓	✓
Caesalpiniaceae	<i>Cassia bakeriana</i>	Kanlanpa phruek		✓	✓
	<i>Senna siamea</i>	Khilek	✓	✓	✓
	<i>Delonix regia</i>	Hang nokyaung	✓	✓	
Convolvulaceae	<i>Merremia vitifolia</i>	Chingcho lueang	✓	✓	✓
	<i>Ipomoea aquatica</i>	Phakbung	✓	✓	✓
Cucurbitaceae	<i>Coccinia grandis</i>	Tamlueng	✓	✓	
Euphorbiaceae	<i>Croton roxburghii</i>	Plaoyai	✓	✓	
Lythraceae	<i>Lagerstroemia calyculata</i>	Tabaek		✓	✓
	<i>L. tomentosa</i>	Salao		✓	✓
	<i>L. macrocarpa</i>	Inthanin		✓	✓
Mimosaceae	<i>Mimosa pudica</i>	Maiyarap	✓	✓	✓
	<i>M. pigra</i>	Maiyarap ton	✓	✓	✓
Papilionaceae	<i>Dalbergia lanceolaria</i>	Chingchan		✓	
	<i>Butea monosperma</i>	Thongkwao		✓	✓
	<i>Erythrina stricta</i>	Thonglang	✓	✓	✓
	<i>Millettia brandisiana</i>	Kraphi chan	✓	✓	
Rubiaceae	<i>Ixora grandifolia</i>	Khem	✓	✓	
	<i>Paederia linearis</i>	Totmu totma	✓	✓	
Scrophulariaceae	<i>Torenia fournieri</i>	Wao mayura	✓	✓	
Thunbergiaceae	<i>Thunbergia laurifolia</i>	Rangchute		✓	✓
Verbenaceae	<i>Tectona grandis</i>	Sak	✓	✓	
Zingiberaceae	<i>Zingiber officinale</i>	Khing		✓	✓
	<i>Costus speciosus</i>	Ueang maina	✓	✓	
Total: 18 families		29 species	20 species	29 species	16 species

*pudica* (Mimosaceae) and *T. grandis* (Verbenaceae) are the main food sources of *T. collina*. Five plant species of two families; *L. calyculata*, *L. macrocarpa* and *L. tomentosa* (Lythraceae) and *M. pigra* and *M. pudica*

(Mimosaceae) are the main food sources for *T. fimbriata*. In this case, we found nine plant species; *R. tuberosa* (Acathaceae), *T. procumbens* (Asteraceae), *R. adenophylla* (Bignoniaceae), *S. siamea* (Caesalpiniaceae), *I.*



**FIGURE 1.** Pollen (A: *S. siamea*, B: *I. aquatica*, C: *T. laurifolia*, D: *A. angustifolia*, E: *D. regia*, F: *C. speciosus*, G: *L. calyculata* and H: *M. vitifolia*) collected by three *Trigona* species.

*aquatica*, *M. vitifolia* (Convolvulaceae), *M. pigra*, *M. pudica* (Mimosaceae) and *E. stricta* (Papilionaceae) are general food sources

because all *Trigona* species can collect their pollens, and two plant species; *C. bacsonensis* (Arecaceae) and *D. lanceolaria* (Papilionaceae)

are specific food plants of *T. collina* because of the bee's body size related to the size and structure of the flowering plants more than other species. The *T. collina*'s ability to collect pollen from many plant species may be due to their tiny size ( $6.208 \pm 0.072$  mm.). Hence, they are able to enter the corolla or calyx tube, even though the tubes are small or narrow, and filaments of anther are short. This suggests that the small *T. collina* is the most important pollinator of the three species in this study. It seems likely that this polylectic species has been able to adapt itself to fit into the morphological structures of most plant species and vice versa.

In our study, foraging times among three species of stingless bees are non-overlapping. The foraging period of *T. apicalis* was from 08.00 to 09.30 a.m., while *T. collina* was from 09.30 to 11.00 a.m. and *T. fimbriata* was from 06.00 to 08.30 a.m. Given the difference between total of food plants and foraging times, all stingless bee species have food resource partitioning. This topic was explained by Oldroyd et al. (1992) who reported pollen resource partitioning by *Apis dorsata*, *A. cerana*, *A. andreniformis* and *A. florea* in Thailand.

Finally, part of the difference in pollen sources among species may result from foraging preferences or floral choice (e.g. stratum preferences, color preference, etc.) rather than taste. Nagamitsu et al. (1999) studied flower visitation of 11 stingless bees in a rain forest in Sarawak with the help of a canopy observation system. Their report supports the hypothesis that a preference in visiting flowers in a different location leads to pollen resource partitioning.

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APPENDIX 1. Pollen food sources were collected by *T. apicalis*

Families of plants	Species of plants	Percentage of collected pollen from each month (%)												Total (%)
		1	2	3	4	5	6	7	8	9	10	11	12	
Acathaceae	<i>R. tuberosa</i>	3.3											5.0	0.7
Agavaceae	<i>A. angustifolia</i>	33.3	36.7	40.0										9.2
Alangiaceae	<i>A. salviifolium</i>	5.0										8.3	10.0	1.9
Asteraceae	<i>T. procumbens</i>				30.0	25.0	16.7	13.3	15.0	30.0	28.3			13.2
Bignoniaceae	<i>R. adenophylla</i>	10.0	30.0										13.3	4.4
Caesalpiniaceae	<i>D. regia</i>							5.0	6.7	3.3	5.0	0.0		1.7
	<i>S. siamea</i>	1.7	5.0	3.3	3.3	5.0							3.3	1.8
Convolvulaceae	<i>I. aquatica</i>	6.7						8.3	5.0	8.3	6.7	6.7		3.5
	<i>M. vitifolia</i>											5.0		0.4
Cucurbitaceae	<i>C. grandis</i>	3.3							8.3	11.7	13.3	10.0		3.9
Euphorbiaceae	<i>C. roxburghii</i>	25.0												2.1
Mimosaceae	<i>M. pigra</i>	5.0	13.3	21.7	33.3		16.7	15.0	13.3	21.7	16.7	28.3	20.0	17.1
	<i>M. pudica</i>	3.3	11.7	25.0	25.0		13.3	18.3	16.7	28.3	21.7	30.0	18.3	17.6
Papilionaceae	<i>E. stricta</i>	1.7	3.3	6.7										1.0
	<i>M. brandisiana</i>			3.3	8.3	6.7								1.5
Rubiaceae	<i>I. grandifolia</i>	1.7									6.7	3.3	3.3	1.3
	<i>P. linearis</i>					21.7	11.7				3.3	5.0	5.0	3.9
Scrophulariaceae	<i>T. fourneri</i>						5.0	8.3	3.3					1.4
Verbenaceae	<i>T. grandis</i>				41.7	35.0	41.7	33.3						12.6
Zingiberaceae	<i>C. speciosus</i>						1.7	3.3	5.0					0.8

APPENDIX 2. Pollen food sources were collected by *T. collina*

Families of plants	Species of plants	Percentage of collected pollen from each month (%)												Total (%)
		1	2	3	4	5	6	7	8	9	10	11	12	
Acathaceae	<i>R. tuberosa</i>	3.3	5.0	1.7								3.3	5.0	1.5
Agavaceae	<i>A. angustifolia</i>	23.3	25.0											4.0
Alangiaceae	<i>A. salviifolium</i>	5.0	3.3	3.3								3.3	1.7	1.4
Arecaceae	<i>C. bacsonensis</i>	3.3					1.7	3.3						0.7
Asteraceae	<i>T. procumbens</i>				30.0	33.3	25.0	16.7						8.8
Bignoniaceae	<i>R. adenophylla</i>	13.3	15.0									25.0	30.0	6.9
Caesalpinaceae	<i>C. bakeriana</i>	3.3	1.7	3.3								1.7	3.3	1.1
	<i>D. regia</i>									3.3	5.0	1.7	1.7	1.0
	<i>S. siamea</i>	3.3	1.7	3.3	3.3	3.3	3.3							1.5
Convolvulaceae	<i>I. aquatica</i>	3.3	3.3	3.3				6.7	10.0	13.3		8.3	3.3	4.3
	<i>M. vitifolia</i>	5.0	8.3								13.3	3.3	5.0	2.9
Cucurbitaceae	<i>C. grandis</i>	1.7	1.7					3.3	3.3	3.3	3.3	1.7	1.7	1.7
Euphorbiaceae	<i>C. roxburghii</i>	15.0												1.3
Lythraceae	<i>L. calyculata</i>		3.3	1.7	3.3	3.3	1.7							1.1
	<i>L. macrocarpa</i>		1.7	5.0	5.0	1.7	1.7							1.3
	<i>L. tomentosa</i>			3.3	6.7	3.3	3.3							1.4
Mimosaceae	<i>M. pigra</i>	8.3	10.0	25.0	25.0	28.3	13.3			25.0	28.3	16.7	25.0	17.1
	<i>M. pudica</i>	5.0	6.7	30.0	20.0	20.0	11.7			28.3	30.0	23.3	20.0	16.3
Papilionaceae	<i>B. monosperma</i>	1.7	1.7	3.3										0.6
	<i>D. lanceolaria</i>		1.7	5.0	5.0	3.3								1.3
	<i>E. stricta</i>	1.7	1.7	1.7										0.4
	<i>M. brandisiana</i>			3.3										0.3
Rubiaceae	<i>I. grandifolia</i>	1.7	3.3			1.7					3.3	1.7	1.7	1.1
	<i>P. linearis</i>		1.7	3.3						25.0	16.7			3.9
Scrophulariaceae	<i>T. fourneri</i>						1.7	8.3	8.3					1.5
Thunbergiaceae	<i>T. laurifolia</i>	1.7	3.3	3.3	1.7							10.0	1.7	1.8
Verbenaceae	<i>T. grandis</i>						33.3	58.3	76.7					14.0
Zingiberaceae	<i>C. speciosus</i>						1.7	1.7						0.3
	<i>Z. officinale</i>					1.7	1.7	1.7	1.7	1.7				0.7

APPENDIX 3. Pollen food sources were collected by *T. fimbriata*

Families of plants	Species of plants	Percentage of collected pollen from each month (%)												Total (%)
		1	2	3	4	5	6	7	8	9	10	11	12	
Acathaceae	<i>R. tuberosa</i>	3.3	5.0						3.3	3.3	1.7	8.3	1.7	2.2
Asteraceae	<i>T. procumbens</i>				8.3	6.7	8.3	5.0	6.7	3.3				3.2
Bignoniaceae	<i>R. adenophylla</i>	20.0	25.0										13.3	4.9
Caesalpinaceae	<i>C. bakeriana</i>	5.0	15.0									16.7	5.0	3.5
	<i>S. siamea</i>	3.3		3.3	10.0	8.3						13.3	6.7	3.8
Convolvulaceae	<i>I. aquatica</i>	16.7								15.0	11.7		8.3	4.3
	<i>M. vitifolia</i>	20.0						3.3	5.0		1.7		3.3	2.8
Lythraceae	<i>L. calyculata</i>			18.3	25.0	26.7	21.7	13.3	16.7	13.3	16.7			12.6
	<i>L. macrocarpa</i>			13.3	20.0	23.3	41.7	36.7	36.7	11.7	15.0			16.5
	<i>L. tomentosa</i>			11.7	30.0	30.0	25.0	41.7	31.7	23.3	16.7			17.5
Mimosaceae	<i>M. pigra</i>	13.3	20.0	20.0						16.7	20.0	25.0	25.0	11.7
	<i>M. pudica</i>	11.7	30.0	25.0						13.3	13.3	31.7	30.0	12.9
Papilionaceae	<i>B. monosperma</i>	1.7		3.3	3.3	3.3								1.0
	<i>E. stricta</i>	3.3		5.0								5.0	3.3	1.4
Thunbergiaceae	<i>T. laurifolia</i>	1.7	5.0								3.3		3.3	1.1
Verbenaceae	<i>Z. officinale</i>				3.3	1.7	3.3							0.7