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Distribution, Nesting Sites and Nest Structures of the Stingless Bee Species, *Trigona collina* Smith, 1857 (Apidae, Meliponinae) in Thailand

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ABSTRACT.– **The stingless bee species, *Trigona collina* Smith, 1857 is distributed throughout Thailand. From 640 colonies collected, nests were only found in the altitude range of 18 to 830 meters above sea level. Most nests were found in mixed deciduous forests at an altitude of less than 400 meters above sea level. Nesting sites can be conveniently divided into 4 main groups; 1) cavities in tree trunks (15.63%), 2) cavities in termite mounds (42.60%), 3) underground cavities (33.75%), and 4) cavities in buildings (7.96%). The nest of *T. collina* is comprised of 5 main components; 1) the external entrance tube, 2) batumen barrier, 3) honey pots, 4) pollen pots and 5) brood cells. The batumen is a multilayered cover of the brood chambers. We suggested that the variation in the number of batumen layers in the nest of *T. collina* is associated with temperature regulation of the nests.**

KEY WORDS: distribution, nesting sites, nest structures, stingless bees, *Trigona collina*

INTRODUCTION

Stingless bees are distributed throughout most tropical and some subtropical regions of the world (Michener & Grimaldi, 1988; Velthuis, 1997). They are classified into 50 genera, with about 400 described species (Velthuis, 1997; Michener, 2000). In Thailand, 32 species are currently described (Schwarz, 1939; Sakagami et al., 1985; Michener & Boongird, 2004; Klakasikorn, 2005).

Most stingless bee species nest in natural cavities within trees. A few species nest underground while a small number of African species construct nests in the open (Velthuis, 1997). All stingless bee species build elaborate nests, with structures that often have species-specific characteristics (Michener, 1974; Sakagami, 1982).

Here we report on the nest structures, nesting sites and distribution within Thailand of *Trigona collina* Smith, 1857. Currently there is little information on the biology of this species, despite the fact that they are among the most common flower-visiting insects in the canopy and the under-story of forests in Thailand, and are most likely critical pollinators (Thapyai, 1996; Tasen, 2001; Jongjitvimol & Wattana-chaiyingcharoen; 2006). *T. collina* nests are known to have a highly aggregated spatial

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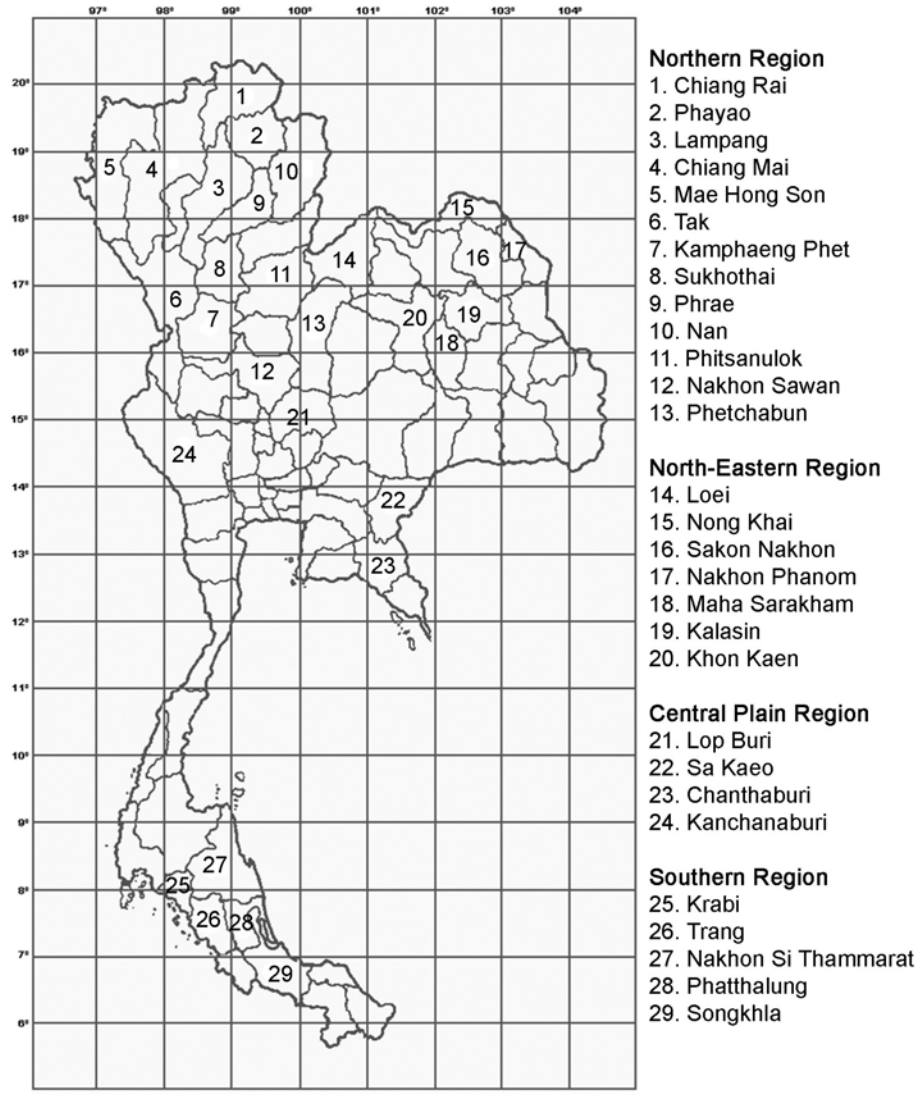

FIGURE 1. Provinces surveyed for the presence of *T. collina* nests.

distribution, a potential adaptation to reducing inbreeding (Cameron et al., 2004; Jongjitvimol et al., 2005).

MATERIALS AND METHODS

We conducted surveys between May 2004 and May 2006 in all regions of Thailand. The methods of line transect and random samplings were used to locate colonies (Krebs, 1999). All the samples were identified by the key of Sakagami et al. (1990). The position and altitude of all discovered nests was determined by means of a Global Positioning System (GPS) receiver (Garmin). Plants visited by stingless bees were preliminary collected in the field by experienced forestry staff and then confirmed by comparing plant samples with the collection at the herbarium of the

FIGURE 2. Nest structure of *T. collina* comprises of 5 parts: A) the external entrance tube, B) batumen barrier (outter) and cerumen (inner), C) honey pots, D) pollen pots and E) brood cells.

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Ten underground colonies found in Phitsanulok (9 colonies) and Chiang Rai (1 colony) were excavated and dissected to observe the internal structures of the nests.

RESULTS

Distribution

We collected 640 colonies from 29 provinces of Thailand; 13 provinces in the Northern region, 7 provinces in the North-Eastern region, 5 provinces in the Central plain region and 5 provinces in the

Southern region (Fig. 1). Although the nests were located at the altitude range from 18 to 830 meters above sea level, over 90% of nests were found in mixed deciduous forests at altitudes lower than 400 meters (Appendix 1).

Nesting Sites

Nesting sites of *T. collina* are variable. They can be divided into 4 groups; 1) cavities in tree trunks, 2) cavities in termite mounds, 3) underground cavities and 4) cavities in buildings. We found that termite mounds are the most common sites accounting for 42.60% of all discovered nests. Subterranean cavities accounted for 33.75% of nests, and 15.63% were found in cavities of trunks of 14 tree species: *Caesalpinia sappan*, *Eugenia cumini*, *Ficus annulata*, *F. locor*, *F. religiosa*, *Herea brasiliensis*, *Hopea odorata*, *Irvingia malayana*, *Knema globulalia*, *Parkia speciosa*, *Shorea curtisii*, *Strychnos nux-vomica*, *Syzygium cumini* and *Tamarindus indica*. Only 51 nests were found in cavities of buildings (7.96%) (Appendix 1).

Nest Structures

Like most stingless bees, the nests of *T. collina* are enclosed by layers of batumen (Fig. 2B), layer comprising mud, resin and wax may be added (Michener, 1974; Roubik 1989; Roubik, 2006). Between the layers of batumen there is often black cerumen (Fig. 2B) which is made of mixture of wax, resins and gums collected from plants (Jones & Oldroyd, 2007).

The external entrance tube of *T. collina* (Fig. 2A) is cylinder-shaped, brittle, thin-walled (1-1.5 mm) with a smooth surface. Entrance tubes are located 1–90 cm (12.86 $\pm$18.23) above the ground, and slant slightly upward. The colour is yellow to brownish from resin and wax (Fig. 2A). The terminus of the tube is hard and sticky, made from propolis and has a diameter of 1-1.5 cm (1.2$\pm$0.22). The interior of the nest is decorated with black cerumen and resin (0.5 mm thick). The inside of the nest has 4 components; 1) brood cells, 2) storage pots; honey and pollen pots, 3) batumen and 4) nest entrance which covered by batumen (Fig. 3).

Brood cells are elliptical, and surrounded by sheaths of batumen which are made up of multiple layers of cerumen (a mixture of wax and resin). The comb of the brood cells is soft, thin, and yellow to dark in colour. New cells are brownish to dark but turn yellow as they age. Storage pots can be divided into 2 parts; honey pots (Fig. 2C) and pollen pots (Fig. 2D) for storing nectar and pollen. They are egg-shaped, soft and yellow to dark and are normally found clumped in more than one compact cluster. They are often arranged around a central set of horizontal brood chambers. Pollen pots are the largest cells and are covered by batumen. The average distance between the external entrance tube and the nest in termite mounds was 2.2 $\pm$0.5 meters.

Discussion and Conclusions

In this study, we found most *T. collina* nests in cavities within the mounds of *Macrotermes* spp. (42.60%). A further 100 nests were found to nest in the tree trunks of 14 species of plants. Three species in the genus *Ficus* (i.e. *F. annulata*, *F. locor* and *F. religiosa*) were the most common nest sites. Up to 10 nests were observed in any one tree probably because the trunks of mature *Ficus* contain many suitable hollows. *Trigona collina* colonies have a

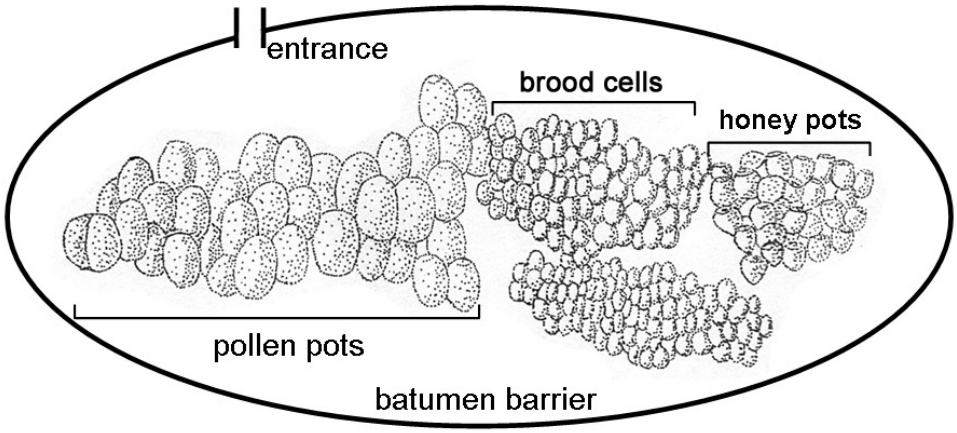

FIGURE 3. Stylized representation of *T. collina*'s nest structure.

highly aggregated spatial distribution (Jongjitvimol et al., 2005). The benefits of colony aggregation are postulated to be increased opportunities for outbreeding by virgin queens (Cameron et al., 2004).

No exposed nests were found. The use of cavities for nesting may help colonies regulate nest temperatures, and provide protection from predators. Nest temperatures above 46 ºC are lethal for *T.* (*Tetragonanula carbonaria*) (Amano, 2005). From the study of nest structure of *T. collina*, we found that *T. collina* have multi-layer batumen which covers the brood cells. The function of batumen is to stabilize the temperature within the brood cells. Our observations on ten nests of *T. collina* showed that the batumen contains 1-4 layers. We postulate that colonies modify the thickness of the batumen layer as a thermoregulatory mechanism. Such behaviour has been demonstrated in *T. ventris flavibis* in north Vietnam (Chin et al., 2004) where the number of involucrum layers is increased in winter, and reduced in summer. In winter, the thicker layer may act as an insulator for the brood cells and the temperature inside the nest are controlled at an optimal threshold for broods. Similarly, in neotropical stingless bee, *Scaptotrigona postica*, the layers of the involucrum provide effective insulation during cool nights, the temperature difference between the outer and inner layers of the involucrum (a distance of 1 cm) can be as much as 5 ºC (Engels et al., 1995). However, a reduced number of involucrum layers during high temperatures in summer may provide the ventilation of air between the inside and outside of the nest. We suggest that the variation in the number of batumen layers in the nest of *T. collina* is involved in temperature regulation, like in involucrum of other species. Furthermore, the batumen sheaths may be important in preventing direct access to the brood by parasites and predators such as ants, termites and other flies.

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APPENDIX 1. Distribution of nest sites of *T. collina*.

Nest sites	Regions	Locations	Number of nests	Altitude (msl.)	Collectors
Cavities in tree trunks	Northern	- Pang Da Royal Station, Chiang Mai			
		- *Eugenia cumini*	1	702	Sakampan, K.
		- Doi Suthep-Pui N.P., Chiang Mai			
		- *Ficus religiosa*	4	482	Jongjitvimol, T.
		- Phran Kratai District, Kamphaeng Phet			
		- *Ficus annulata*	3	89	Boontawon, K.
		- Kamphaeng Phet Historical Park, Kamphaeng Phet			
		- *Ficus annulata*	3	123	Jongjitvimol, T.
		- Pai District, Mae Hong Son			
		- *Ficus religiosa*	3	550	Jongjitvimol, T.
		- Muang District, Mae Hong Son			
		- *Ficus annulata*	1	389	Jongjitvimol, T.
		- Doi Busarakham, Phayao			
		- *Ficus annulata*	4	558	Jongjitvimol, T.
		- Long District, Phrae			
		- *Strychnos nux-vomica*	8	242	Jongjitvimol, T.
		- *Caesalpinia sappan*	5	216	Jongjitvimol, T.
		- *Ficus religiosa*	4	232	Boontawon, K.
		- Si Samlong District, Sukhothai			
		- *Ficus annulata*	3	84	Jongjitvimol, T.
		- Lan Sang N. P., Tak			
		- *Ficus annulata*	2	307	Boontawon, K.
	North-Eastern	- Ubonrat Dam, Khon Kaen			
		- *Ficus annulata*	1	197	Jongjitvimol, T.
		- Erawan District, Loei			
		- *Tamarindus indica*	1	175	Jongjitvimol, T.
		- Chiang Yun District, Maha Sarakham			
		- *Ficus religiosa*	6	168	Boontawon, K.
		- Wat Phra That Bang Phuan, Nong Khai			
		- *Tamarindus indica*	2	177	Boontawon, K.
		- Muang District, Sakhon Nakhorn			
		- *Irvingia malayana*	1	173	Jongjitvimol, T.
	Central Plain	- Makham District, Chanthaburi			
		- *Herea brasiliensis*	1	50	Ubol, A
	Southern	- Thung Song District, Nakhon Si Thammarat			
		- *Syzygium cumini*	2	80	Ubol, A
		- *Knema globulalia*	2	85	Ubol, A
		- *Parkia speciosa*	2	87	Ubol, A
		- Khao Nam Khang N. P., Songkhla			
		- *Shorea curtisii*	3	273	Wattanatheera-
		- Sadao District, Songkhla			prasong, J.
		- *Ficus lacor*	8	39-65	
		- *Ficus annulata*	27	50	Wattanatheera-
		- *Hopea odorata*	2	45	prasong, J.
		- Haui Yot District, Trang			
		- *Ficus annulata*	1	60	Ubol, A
			100	**39-702**	

APPENDIX 1. (Cont.)

Nest sites	Regions	Locations	Number of nests	Altitude (msl.)	Collectors
Cavities in termite mounds	Northern	- Pang Da Royal Station, Chiang Mai	5	700-830	Lhadang, P.
		- Sri Lan Na N. P., Chiang Mai	71	265-552	Neakum, C.
		- Wiang Pa Pao District, Chiang Rai	23	350-550	Jongjitvimol, T.
		- Pai District, Mae Hong Son	23	400-650	Jongjitvimol, T.
		- Chiang Klang District, Nan	5	352- 420	Kaewthong, S.
		- Nam Nao N. P., Phetchabun	8	837	Boontawon, K.
		- Nature Education Center, Phitsanulok	25	106-180	Jongjitvimol, T.
		- Nakhon Thai District, Phitsanulok	8	227	Jongjitvimol, T.
		- Phu Hin Rong Kla N. P., Phitsanulok	3	350	Boontawon, K.
		- Wat Phra That Chom Chaeng, Phrae	1	213	Jongjitvimol, T.
	North-Eastern	- Lam Pao Dam, Kalasin	26	153	Jongjitvimol, T.
		- Chiang Yun District, Maha Sarakham	1	167	Boontawon, K.
		- Wat Phra That Bang Phuan, Nong Khai	13	177	Jongjitvimol, T.
		- Muang District, Sakon Nakhon	51	177	Jongjitvimol, T.
		- Phu Phan District, Sakon Nakhon	6	270	Jongjitvimol, T.
	Central Plain	- Sup Lung Ka Wildlife Conservation, Lop Buri	4	187	Ruangridee, A.
			273	**153-830**	
Cavities in undergro und or under tree base	Northern	- Pang Da Royal Station, Chiang Mai	1	710	Lhadang, P.
		- Sri Lan Na N. P., Chiang Mai	64	265-552	Kongquamsue, S.
		- Doi Suthep-Pui N. P., Chiang Mai	5	350	Boontawon, K.
		- Kamphaeng Phet Historical Park, Kamphaeng Phet	52	120	Jongjitvimol, T.
		- Mae Mo District, Lampang	2	358	Jongjitvimol, T.
		- Mae Tha District, Lampang	6	346	Boontawon, K.
		- Mae Sariang District, Mae Hong Son	1	350	Tansila, H.
		- Mae Wong District, Nakhon Sawan	1	250	Jongjitvimol, T
		- Chiang Klang District, Nan	2	352	Jongjitvimol, T
		- Nature Education Center, Phitsanulok	12	180	Chutiyarat, S.
		- Wat Phra That Chom Chaeng, Phrae	5	217	Jongjitvimol, T
		- Bhumibol Dam, Tak	6	250	Jongjitvimol, T
	North-Eastern	- Khon Kaen University, Khon Kaen	10	216	Jongjitvimol, T
		- Ubonrat Dam, Khon Kaen	20	197-206	Jongjitvimol, T
		- Lam Pao Dam, Klalasin	10	153	Boontawon, K.
		- Chiang Yun District, Maha Sarakham	1	167	Jongjitvimol, T
		- Pang Sida N. P. Sakaeo	15	220	Buayai, A.
	Central Plain	- Sai Yok Noi Waterfall, Kanchanaburi	1	124	Jongjitvimol, T.
		- Sup Lung Ka Wildlife Conservation, Lop Buri	1	187	Sripromma, M
	Southern	- Bang Kaeo District, Phatthalung	1	18	Wattanatheera-prasong, J.
			216	**18-710**	

APPENDIX 1. (Cont.)

Nest sites	Regions	Locations	Number of nests	Altitude (msl.)	Collectors
Cavities in the buildings	Northern	- Kamphaeng Phet History Park, Kamphaeng Phet	32	120	Jongjitvimol, T.
		- Doi Busarakham, Phayao	5	476	Boontawon, K.
	North-Eastern	- Khon Kaen University, Khon Kaen	5	196-216	Boontawon, K.
		- Wat Phra That Bang Phuan, Nong Khai	2	210	Jongjitvimol, T.
	Southern	- Khao Phanom District, Krabi	2	44-50	Meesiri, W.
		- Sadao District, Songkhla	1	45	Meesiri, W.
		- Huai Yot District, Trang	4	35-82	Meesiri, W.
			51	**35-476**	