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Pollen Species Resources for *Xylocopa* (*Nyctomelitta*) *tranquebarica* (F.) A Night-Flying Carpenter Bee (Hymenoptera: Apidae) of Southeast Asia

Michael Burgett,[a*] Prachaval Sukumalanand[b] and Günter Vorwohl[c]

[a] Department of Horticulture, Oregon State University, Corvallis, OR, 97331, USA.
[b] Department of Entomology, Chiang Mai University, Chiang Mai, 50200, Thailand.
[c] Landesanstalt für Bienenkunde, Universität Hohenheim, Stuttgart 70593, Germany.

* Corresponding author, E-mail: burgettm@science.oregonstate.edu

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ABSTRACT: In northern Thailand the pollen species resources for the nocturnally foraging carpenter bee *Xylocopa* (*Nyctomelitta*) *tranquebarica* (F.) were found to be primarily indigenous tree species. The presence of anthropogenic (exotic) species capable of providing pollen was also evident. *X.* (*N.*) *tranquebarica* displays polylecty in its pollen foraging with at least 27 plant families represented in sampled pollen stores from 15 foundress female bees.

KEYWORDS: Apidae, carpenter bee, pollen resources, *Xylocopa* (*Nyctomellita*) *tranquebarica*.

INTRODUCTION

The paleotropical night-flying carpenter bee *Xylocopa* (*Nyctomelitta*) *tranquebarica* was first described by Fabricius in 1804 as *Bombus tranquebarica*. The nocturnal foraging behavior of this solitary bee species was noted in the late 19th century[1,2]. Burgett & Sukumalanand[3] provided detailed descriptions of the obligatory nocturnal foraging and nest characteristics. In summary, *X.* (*N.*) *tranquebarica* foraging is limited to crepuscular and matinal periods and nocturnal flights that are accompanied by moonlight.

X. (*N.*) *tranquebarica* is a large carpenter bee (26 – 28 mm), and as with all known species within the genus, the females construct nesting tunnels within dead plant material[4]. Most carpenter bees species are solitary in habit[5]. *X.* (*N.*) *tranquebarica* exhibits primitive sociality at the level of intermediate-subsocial I[6], which is demonstrated by interactions by P_1 females with teneral F_1 adults within the nesting complex[3].

Nocturnal foraging is not common among Apoidea and this strategy brings forth several questions; one of which is, what are the selective advantages of this behavior? Burgett & Sukumalanand[3] hypothesize that the avoidance of diurnal predators and nectar/pollen competitors would be beneficial to a nocturnally foraging species. Another question concerns what pollen and nectar resources are available to a nocturnally foraging bee species. It is this question that we address in this report.

MATERIALS AND METHODS

Our approach was to examine the pollen masses from individual brood cells provisioned by fecund *X.* (*N.*) *tranquebarica* females. *X.* (*N.*) *tranquebarica* is a large carpenter bee with correspondingly large brood cells. A fully provisioned cell, shortly after oviposition, possesses a pollen mass that averages 2.25 g, contained in a brood cell with a volume of 3.95 cm^2. The pollen mass (a mixture of pollen moistened with nectar) initially occupies 40 to 50% of the cell's volume. Soon after a brood cell is fully provisioned with a pollen/nectar mass, the foundress female lays a single egg attached to the pollen. Following oviposition, the female

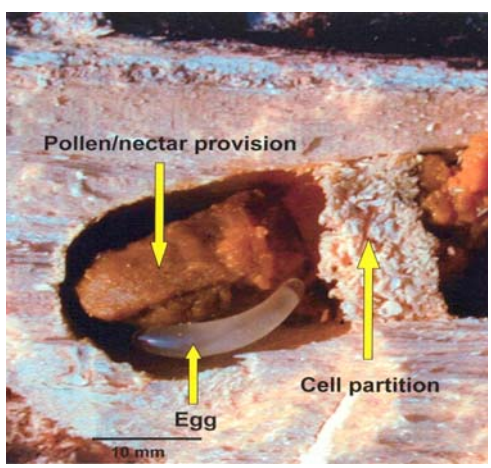

Fig 1. Fully provisioned brood cell with the pollen/nectar mass, an egg and cell partition.

constructs a cell partition composed of wood fragments (Fig 1).

Logs in which the solitary females had constructed their nests were collected and dissected in order to expose the brood cells and their accompanying pollen provisions.

The pollen masses were individually removed and placed under refrigeration until shipment to Germany where the pollen was identified by one of us (GV). The pollen collections represent foraging by foundress *X.* (*N.*) *tranquebarica* females during the dry season (December, January, February and March) in northern Thailand. All sample collections were done in the months of January, February and March. This is coincident with the primary foraging season of this bee species in northern Thailand. A total of 35 pollen analyses, from 42 pollen masses, were made from 15 sampled nests, *i.e.*, 15 foundress female bees. Nest collections were done over a 4 year period (1998, 2000, 2001, 2002). The nests originated within a 5 km radius of the Chiang Mai University Pakia Research Station (19º 19' N, 98º 50' E) at an elevation of 1,500 m located on the Doi Chiang Dao massif in northern Thailand. This montane region is characterized as a highland rain forest, with a defined dry period in the winter[7,8,9]. The specific collection area is described as a hill evergreen forest type.[9]

Pollen was prepared for analysis by placing an individual pollen mass into a vial and filling with distilled water. The vial was shaken until the pollen mass was dispersed. From this homogenous pollen suspension ten drops were removed and placed on microscopic slides and each aliquot was spread to an area of *ca*. 20 x 20 mm. To keep the pollen grains homogenously dispersed, the vial was shaken between each pollen aliquot removal. Following drying, the pollen was covered with a drop of glycerine jelly and a cover slip put into place. Five slides, each with two pollen sample aliquots, were used for examination. Normally a minimum of 75 pollen grains were counted from each of 8 pollen samples to provide a total pollen count of at least 600 grains from a single pollen mass.

Pollen keys for Asian plant species are not exhaustive and no published keys are known for endemic species found in northern Thailand. Pollen identifications were supported by the voucher specimen collections in the Landesanstalt für Bienenkunde at Hohenheim University. Plant identifications for northern Thailand were assisted by botanical keys for the region[9,10,11].

Results:

From the pollen identifications, species representing 27 plant families are identified (Tables 1-2). Nineteen plant families are considered as "major" pollen resources, *e.g.*, at least one pollen mass possessed a minimum of ≥1% pollen from a species within that

Table 1. Pollen species summary: frequently encountered species (≥1% of grains from a given pollen mass).

Family	Genus	Species	Frequency (% of samples)
Casuarinaceae	*Casuarina*	?	40
Fagaceae	*Castanopsis* group	?	43
	Lithocarpus group	?	20
	Quercus group	?	6
Fabaceae	Faboideae	?	29
	intine thick	?	3
Rosaceae	*Prunus* group	?	11
	Pyrus group	?	6
Moraceae	?		3
Meliaceae	?		20
Myrtaceae	?		23
Lauraceae	?		3
Sonneratiaceae	*Duabanga*	*grandiflora*[1]	43
Ulmaceae	*Trema*	*orientalis*	6
Bignoniaceae	*Oroxylum*	*indicum*	14
Bombacaceae	*Ceiba*	*pentandra*	3
Anacardiaceae	*Spondias*	*pinnata*[2]	6
Sapotaceae	?		17
Euphorbiaceae	*Phyllanthus* group	?	3
	Croton group	?	3
Acanthaceae	*Barleria*	?	3
Rutaceae	*Zanthoxylum* group	?	11
Brassicaceae	?		3
Combretaceae	?		3
Unknowns	$U\text{-}_1$ small tricolpate		20
	U_2 small tricolpate, smooth, triangular, spherical		26
	U_3 tricolpate, reticulate, onci		3

[1]Only one species recorded for northern Thailand (Gardner et al. 2000).
[2]Only two species in the genus recorded for northern Thailand (Gardner et al. 2000).
S. pinnata has a bloom period coincident with the *X.*(*N.*) *tranquebarica* foraging season.

Table 2. Pollen species summary: rarely encountered species (< 1% of grains from given pollen mass).

Family	Genus & species
Bignoniaceae	?
Bombacaceae	*Bombax ceiba*
Fabaceae, Mimosoideae	*Albizzia* group
Euphorbiaceae	*Phyllanthus* type, small
Lamiaceae	?
Theaceae	?
Thymelaeaceae	?
Loranthaceae	?
Araceae	?
Convolvulaceae	*Ipomoea* sp.
Asteraceae	*Vernonia* sp.
Ericaceae	?
Unknown	U_4 very small tricolpate

family. Species from an additional 8 families are considered as "rare" meaning that pollen encountered from species in those families was infrequently encountered and when found, < 1% of a pollen mass. Rarely encountered pollen also came from additional species within 4 plant families ranked as major pollen sources.

For the 19 plant families classified as major pollen resources, pollen identification allowed us to identify 15 pollen types to the generic level and 5 to species. Three pollen species remain unidentified at any taxonomic level. From the pollen species classified as rare (12 families, 8 of which are families outside of the major pollen resources) 5 genera and 1 species were identified, along with one unidentified pollen species.

For pollen foraging *X.* (*N.*) *tranquebarica* demonstrates a wide range of plant hosts and can therefore be considered as a polylectic/polyphagic species. Not only does the species display polylecty, but individual females also exhibit a broad plant host range when foraging for pollen (Table 3). This female (Nest #1) utilized at least 7 plant species for the pollen required to provision the 9 examined brood cells. Pollen from *Casuarina* sp. and *Castanopsis* sp. were the dominant pollen species (60% and 23% respectively). Table 3 also shows that even the pollen provisions in individual brood cells display multiple pollen species; up to 6 pollen species (cells #3 and #6). While individual pollen masses most often present multiple pollen species, on occasion a single pollen/nectar mass was dominated by pollen from a single plant species, *e.g.*, Nest 10, cells #1 and #3 with *Duabanga grandiflora* pollen at levels of 99% and 98% respectively.

Major pollen resources

Casuarina sp. (Casuarinaceae): This frequently encountered pollen species is not native to northern Thailand, but two species, *C. equisetifolia* J.R. & G. Forst. and *C. junghuniana* Miquel, have been planted for reforestation, erosion control and wind breaks throughout Thailand. At the primary study site on Doi Chiang Dao *Casuarina* is not common, but specimen trees are known to occur within a few km of the area where the majority of *X.* (*N.*) *tranquebarica* nests were collected. In the analysis of 9 pollen masses collected from a single nest (one female) in early February 1998, *Casuarina* pollen was present in all 9 pollen masses occurring at a frequency of 18 to 83% of the pollen grains in a given pollen mass (average of 60% of all pollen in the 9 samples.) *Casuarina* was also observed in 2 of 3 pollen cells collected from the same location in March 2001, and 3 of 7 cells collected in January 2002.

Castanopsis and *Lithocarpus* (Fagaceae): There are numerous species of *Castanopsis* and *Lithocarpus* throughout S.E. Asia, especially in the montane regions. Seven species of *Castanopsis* are recorded for northern Thailand, 6 of which are reported to bloom during the dry winter period[9]. Pollen from the *Castanopsis* group was frequently a major species component in pollen masses. Together with *Duabanga grandiflora* (Sonneratiaceae) pollen from the *Castanopsis* group was the most frequently encountered pollen species in the study. Eleven species of *Lithocarpus* are known from northern Thailand, 4 of which have a winter period bloom[9] concurrent with the major foraging period of *X.* (*N.*) *tranquebarica* females. From 7 pollen masses examined from the January 2002 collection, pollen from *Lithocarpus* species was dominant, occurring in all 7 samples at frequencies ranging from 48 to 99% of the pollen in a given pollen mass.

The single most frequently encountered pollen was from *Duabanga grandiflora* (Sonneratiaceae), which was found in 15 of the 35 pollen analyses. Nine of the 15 examined bee nests possessed this pollen species. *D. grandiflora* is recorded as having a flowering period during the dry winter period[9]. *D. grandiflora* is a large tree up to 60 m in height and is often the largest tree in the forests throughout northern Thailand.

An unidentified species in the genus *Prunus* (Rosaceae) was encountered in 11.4% (4 of 35) of the examinations, but only from nest #1 which represents

Table 3. Pollen species frequency from a single nesting *X.* (*N.*) *tranquebarica* female[1]

Pollen type	Cell 1%	Cell 2%	Cell 3%	Cell 4%	Cell 5%	Cell 6%	Cell 7%	Cell 8%	Cell 9%	Σx_{ave} %
Casuarina sp.	79	64	83	18	66	70	40	60	60	60
Fagaceae *Castanopsis* group	9	-	1	63	19	8	39	26	35	23
Fabaceae Faboideae	11	-	2	2	11	20	17	7	5	8
Rosaceae *Prunus* type	2	32	13	7	-	1	-	-	-	6
Meliaceae	2	2	2	-	-	-	-	-	-	2
Myrtaceae	-	-	1	-	<1	<1	1	3	-	1
Lauraceae	-	3	-	-	-	-	-	-	-	<1

[1] Nest collected in early February 1998 – pollen represents foraging *ca.* December 1997 & January 1998.

a December/January foraging period. *P. cerasoides*, an indigenous species with a recorded December/January blooming period, is known from the study area and is also cultivated for its ornamental value throughout northern Thailand[9]. *Prunus arborea* is also a recorded montane species in northern Thailand, but its bloom period is during the wet season (August/September.)

Pollen species from the families Meliaceae and Myrtaceae were common components of *X.* (*N.*) *tranquebarica* pollen provisions (20% and 22% of the samples respectively.) Both are large families of almost exclusively tropical tree species. In northern Thailand there are 5 genera and 40 species in the family Myrtaceae, and 12 genera with 20 species in the family Meliaceae.

Several pollen types were from the family Fabaceae (Leguminosae), the most predominant being of the subfamily Faboideae, occurring in 10 of the 35 analyses. In northern Thailand legumes are the most abundant tree family with 30 genera and 73 species known[9].

Collectively the 3 pollen species classified as unknowns were present in 17 of the 35 pollen analyses (49% of the pollen samples examined). We were unable to assign these 3 morphologically distinct species to any taxonomic level. The paucity of published literature for pollen species of southern Asia, specifically for the montane regions of South-east Asia, is highlighted by the inability to classify these pollen species to even the family level. These unknowns were major contributors to the pollen resources available to *X.* (*N.*) *tranquebarica*, at times representing nearly half of the pollen making up several individual pollen masses, *e.g.*, Nest 5, cell 1; Nest 6, cell 1; Nest 12 cell 2.

Discussion

From an examination of the plant species providing pollen for *X.* (*N.*) *tranquebarica* females, it is evident that indigenous tree species collectively serve as the primary pollen "reservoir" for foraging female bees. Additionally, introduced (exotic) plants species are shown to be important pollen sources, *e.g.*, *Casuarina*, when available. But for our study area, where anthropogenic plant introductions have taken place over the past several decades, the importance of introduced species could easily overstate the significance of these exotic plant resources relative to the far greater forest areas of northern Thailand that remain relatively "unpolluted" by anthropogenic exotic species.

The foraging distance of *X.* (*N.*) *tranquebarica* is unknown; however, Burgett & Sukumalanand[3] report an average foraging flight time of 11.5 minutes with a range of less than one minute to more than one hour. This would suggest a relatively large foraging range probably encompassing an area of at least 300 km^2 assuming a flight speed of 24 km/hr, the recorded flight speed for the European honey bee, *Apis mellifera* L.[12]. From a study of one nesting female over 13 nights of foraging, the bee was observed to return with an external pollen load on 13 of 61 foraging flights *i.e.*, 21% of flights[3].

A number of the primary pollen sources utilized by *X.* (*N.*) *tranquebarica*, *i.e.*, *Casuarina*, *Castanopsis* and *Lithocarpus* are known to be wind pollinated[13] (anemophily). Others, such as *Ceiba* and *Bombax* are known to rely on birds as primary pollen vectors[13]. At least concerning these plant taxa, the carpenter bee has most likely assumed the role of a secondary pollinator, if not the status of pollen thief.

In summary *X.* (*N.*) *tranquebarica* is a polyphagic species with a broad host range of plant species from which it harvests pollen for nest provisioning; dependent primarily upon indigenous tree species that permit nocturnal pollen foraging by bees.

References

1. Bingham CT (1894) On new and little known Hymenoptera from India, Burma, and Ceylon. *Journal of the Bombay Natural History Society* **8**, 358-90.
2. Bingham CT (1897) Hymenoptera. Vol. I: Wasps and bees. In: Blandford, W.T. *The Fauna of British India, including Ceylon and Burma*. Taylor and Frances, London, UK.
3. Burgett DM and Sukumalanand P (2000) Flight activity of *Xylocopa* (*Nyctomelitta*) *tranquebarica*: a night flying carpenter bee (Hymenoptera: Apidae). *Journal of Apicultural Research* **39(1-2)**, 75-83.
4. Gerling D, Velthius HH and Hefetz A (1989) Bionomics of the large carpenter bees of the genus *Xylocopa*. *Annual Review Entomology* **34**, 163-90.
5. Hurd PD (1978) An annotated catalog of the carpenter bees (Genus *Xylocopa* Latreille) of the Western Hemisphere (Hymenoptera: Anthophoridae). Smithsonian Institution Press, Washington, D.C.
6. Michener CD (1969) Comparative social behavior of bees. *Annual Review of Entomology* **14**, 299-342.
7. Smitinand T (1966) The vegetation of Doi Chiengdao, a limestone massive in Chiengmai, north Thailand. *Natural History Bulletin Siam Society* **21**, 93-128.
8. Santisuk T (1998) Doi Chiang Dao, a mountain of concern: rare and endangered plants. *The Botanical Garden Organization Newsletter* No. 6, 11-3.
9. Gardner S, Sidisunthorn P and Anusarnsunthorn V. (2000) *A Field Guide to Forest Trees of Northern Thailand*. Kobfai Publishing, Bangkok.
10. Smitinand T (2001) *Thai Plant Names (rev. ed.)*. Royal Forestry Department, Bangkok.
11. Hanum JF and van der Maesen LJG (eds) (1977) *Plant resources of South East Asia, No. 11, Auxiliary Plants*. Backhuys Publishers, Leiden.
12. Seeley TD (1985) *Honeybee Ecology: A Study of Adaptation in Social Life*. Princeton University Press, Princeton, NJ.
13. Faegri K and van der Pijl L (1979) *The Principles of Pollination Ecology (3rd ed.)*. Pergamon Press, NY.