Notes on the Nesting Biology of the Small Carpenter Bee Ceratina smaragdula (Hymenoptera: Apidae) in Northwestern Pakistan

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Notes on the nesting biology of the small carpenter bee *Ceratina smaragdula* (Hymenoptera: Apidae) in northwestern Pakistan

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Abstract

The nesting biology and some foraging activities of the familiar, brilliant metallic green, small carpenter bee *Ceratina* (*Pithitis*) *smaragdula* (F.) (Hymenoptera: Apidae) is documented from the northwestern-most extent of its natural distribution, as the species is a potentially important pollinator of leguminous and cucurbit crops in the region. Numerous nests around the village of Ismaila, Swabi, Khyber Pakhtunkhwa Province, Pakistan, were observed and sampled from Jun through Aug 2012. Nest details were recorded and foraging times on various floral species were documented, with bees preferentially nesting in wooden stalks of Ravenna grass (*Saccharum ravennae* L.; Poales: Poaceae), life cycles lasting 28 to 32 d, and conditions offering the potential for easy management. The importance of such studies on wild bees in Pakistan is stressed, as are the development of biotic surveys on bees and the training of regional melittologists, coupled with outreach activities.

Key Words: *Pithitis*; nest architecture; nesting biology; foraging; Pakhtunkhwa Province

Resumen

La biología de la anidación y algunas actividades de forrajeo de la pequeña abeja carpintera *Ceratina* (*Pithitis*) *smaragdula* (F.) (Hymenoptera: Apidae) de tipo familiar y brillante color verde metálico está documentado desde el punto mas noroeste de su distribución natural, ya que la especie es potencialmente un importante polinizador de legumbres y cucurbitáceas en la región. Se observaron numerosos nidos alrededor del pueblo de Ismaila, Swabi, Khyber Pakhtunkhwa Provincia, Pakistán, y se tomaron muestras desde junio hasta agosto del 2012. Los detalles de la anidación fueron registrados y se documentaron los tiempos de forrajeo sobre diversas especies florales, con las abejas preferentemente anidando en los tallos de madera de pasto de Rávena (*Saccharum ravennae* L.; Poales: Poaceae), los ciclos de vida duran de 28 a 32 dias, y las condiciones que ofrecen el potencial para un fácil manejo. Se destaca la importancia de este tipo de estudio sobre las abejas silvestres en Pakistán, igual que el desarrollo de sondeos bióticos sobre las abejas y la formación de melitólogos regionales, junto con actividades de extensión.

Palabras Clave: *Pithitis*; arquitectura de nido; biología de anidación; forrajeo; Provincia Pakhtunkhwa

The small carpenter bees (genus *Ceratina* Latreille) are a widespread and moderately diverse lineage of Xylocopinae (Hymenoptera: Apidae), with approximately 350 species, many of which are darkly metallic to black in coloration, although some, such as the more familiar members of the subgenus *Pithitis* Klug, can be brilliantly metallic (Hirashima 1969; Michener 2007). Individuals are often marked with yellow on the face, but such markings can be more extensively spread throughout the body (e.g., subgenus *Ceratinidia* Cockerell & Porter) (Michener 2007). Species typically nest in pithy stems, forming relatively simple linear nests therein (Michener 2007), making them ideal for observation of intra-nest behaviors and studies of social interaction (Rehan et al. 2009).

Ceratina (*Pithitis*) *smaragdula* (F.) is a widespread and familiar species of small carpenter bees throughout southern Asia, extending from Pakistan to Japan, and from northern China to the Lesser Sunda Islands of Indonesia (van der Vecht 1952; Hirashima 1969; Shiokawa & Sakagami 1969; Baker 1997). The species has also become established on the Hawaiian Islands (Arakaki et al. 2001; Snelling 2003) and at times been introduced elsewhere for purposes of managed pollination (Daly et al. 1971). Although the species is polylectic (Rahman 1940; Sakagami & Yoshikawa 1961; Batra 1967), it is an efficient pollinator of alfalfa and other crops (Kapil & Kumar 1969; Batra 1976a) and therefore of economic importance given the potential ease with which its nests may be managed. The biology of *C. smaragdula* has been examined at various times and incidentally at locations across its broad distribution (Kapil & Kumar 1969; Batra 1976b), most recently in regard to social interactions among females in nests (Rehan et al. 2009). Owing to its potential importance for crop pollination services in Pakistan and to these populations representing the westernmost extent of the species' distribution, we provide here notes on the nesting biology and some foraging activities of a population of *C. smaragdula* in northwestern Pakistan. This work is part of ongoing efforts to understand wild bee pollinators within the region and their possible economic use (Ali et al. 2014).

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Materials and Methods

STUDY SITE

The study was carried out around the village of Ismaila, Swabi District (34.2306389°N, 72.2468056°E), Khyber Pakhtunkhwa Province, in northwestern Pakistan. Swabi is the 4th most populous district of the province and lies between the Indus and Kabul Rivers, and somewhat centrally between Kashmir and Afghanistan with a humid climate and heavy rains during the summer. The area is rich in cultivated plants, particularly alfalfa, Egyptian clover, sunflower, canola, and varied vegetable crops. During a quick sampling of bees around Ismaila, numerous nesting sites were discovered for large and small carpenter bees, particularly those of the latter, which were preferentially nesting in dead stalks of Ravenna grass (*Saccharum ravennae* L.; Poales: Poaceae) (Figs. 1 and 2). Ongoing surveys are focused on locating the nests of additional species of *Ceratina* and those of various ground-nesting bees that were also found (e.g., species of *Nomia* Latreille, *Pseudapis* Kirby, *Halictus* Latreille, *Lasioglossum* Curtis). Megachilines were also abundant in the area and represent another group of potential importance for regional crops (H. Ali, M. S. Engel, pers. obs.).

FLORAL SAMPLING

Bees were sampled by sweep netting cultivated flowers throughout the summer season (Jun through Aug) of 2012, with sampling taking place twice per week. Crops surveyed were okra (*Abelmoschus esculentus* [L.] Moench; Malvales: Malvaceae), sponge gourd (*Luffa acutangula* (L.) Roxb.; Cucurbitales: Cucurbitaceae), and pumpkin (*Cucurbita pepo* L.; Cucurbitales: Cucurbitaceae). Periods of activity were observed from 5 nests over a period of 5 d during the study period. All individuals were identified to species by the authors, and they were deposited in the King Saud University Museum of Arthropods (Riyadh, Saudi Arabia).

NEST SAMPLING

Twenty nests were sampled from 2 locations within the study area, separated by approximately 200 m. Nests were collected at dusk and after all foraging bees had returned to the nest. Entrances were closed with tape and the nest's height from the soil surface was measured. After collection, the nests were refrigerated for 8 to 10 h to kill the inhabitants. External nests (total length, entrance diameter) were measured before dissection. Nests were opened starting at the entrance and parallel to the length of the branch by slowly and gently splitting the stem with a sharp knife. Once nests were fully exposed, all contents were recorded (e.g., number of immature stages, presence of pollen masses) and photographs were taken with a Sony DSC 160 digital camera.

Results

NEST ARCHITECTURE

Of the 20 nests that were destructively sampled, no failed nests (i.e., abandoned over the season, filled with fungus) were observed, nor were parasites ever observed associated with nests. Nest entrances were guarded by a female that blocked the opening with her metasomal tergum (Fig. 2). For the 20 nests sampled, the branches containing the nests had an average (±SD) length of 16.22 ± 7.15 cm and an average diameter of 1.00 ± 0.28 cm. Nests had an average length of

Figs. 1 and 2. Photographs of nest entrances of *Ceratina* (*Pithitis*) *smaragdula* in Ravenna grass stems (*Saccharum ravennae*) in northwestern Pakistan (photos by Hussain Ali). 1. Two individual nest entrances. 2. Nest entrance with entrance blocked by the brilliant metallic green metasoma of a female guard.

12.73 ± 6.51 cm and an average internal diameter of 0.50 ± 0.09 cm. The nest entrance was on average 4.19 ± 0.41 mm wide. Each nest had on average 2.70 ± 1.87 cells (ranging from 1–7 cells), and cell lengths averaged 8.48 ± 4.31 mm (*n* = 54 cells) (Figs. 3 and 4). Cells were separated by pithy partitions constructed by the bees, the depth of which ranged from 0.3 to 0.6 mm. In some cases, empty cells were found between otherwise fully constructed cells.

LIFE CYCLE

The development time ranged from 28 to 32 d during the study period. Of the 54 brood cells dissected, 25 included a completed pollen mass with or without an immature bee; 15 had eggs (mean 0.75 ± 0.43 eggs per cell), 20 had larvae at various instars (mean 1.00 ± 0.77 larvae per cell), and 17 had pupae (mean 0.85 ± 0.65 pupae per cell). Nests had on average 2.25 ± 0.17 adults present, ranging from 1 to 4 at the time of sampling. Adults laid a small whitish egg on the top of the pollen mass. Pollen provisions were brownish, viscous, rounded, and soft, and ranged between 0.5 and 0.6 cm in length. Creamy yellowish colored larvae hatched from the eggs, initial instars ranging from 0.8 to 1.0 cm in length, and then gradually consumed the provisions before becoming pupae.

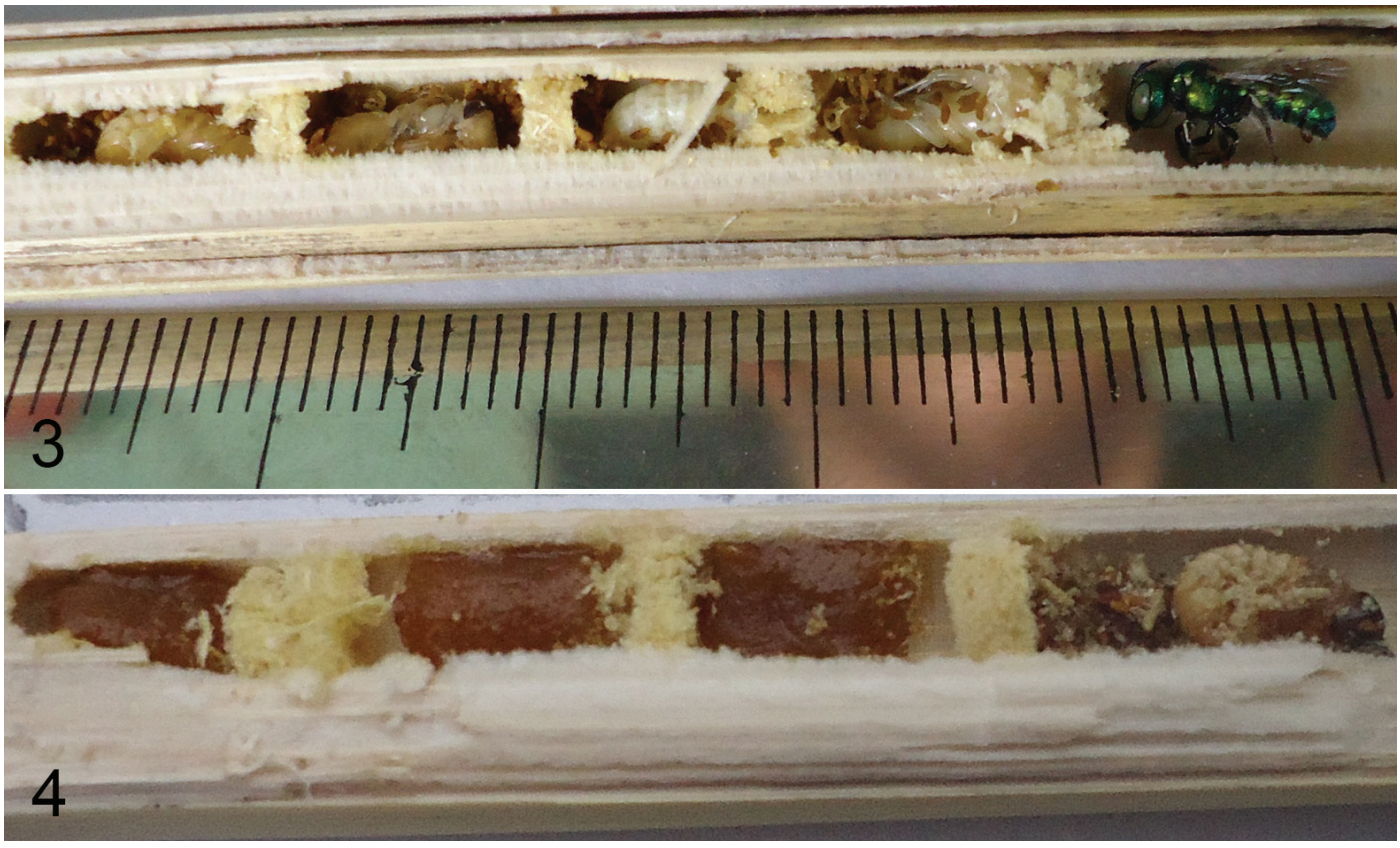
FORAGING

Ceratina smaragdula is polylectic and therefore may be found visiting numerous and diverse floral resources. Near the nesting area, individuals were found foraging on a variety of cultivated crops, including alfalfa and oil seed rape. Most important for the region, we recorded the species visiting flowers of 3 important vegetable crops, namely, okra, sponge gourd, and pumpkin. During the investigation period, bees started flying in the early morning around 6:54 a.m. ± 23 min and spent an average (±SD) 25.4 ± 7.1 s on each flower, ending their daily foraging bouts in the late afternoon around 4:47 p.m. ± 35 minutes (Table 1).

Discussion

In northwestern Pakistan, *C. smaragdula* was found nesting in only the pithy stalks of Ravenna grasses. This observation differs from the variety of plants used elsewhere in its range, such as mulberry (*Morus alba* L.; Rosales: Moraceae) and Siam weed (*Chromolaena odorata* [L.] R. M. King & H. E. Robins.; Asterales: Asteraceae) (Malaipan 1992), the latter being common nesting locations for other southern Asiatic *Ceratina* (Yogi & Khan 2014). Overall, the nest construction did not differ from that described for the species elsewhere and within other plant hosts (Batra 1976b; Malaipan 1992; Rehan et al. 2009) or for other Asiatic species of *Ceratina* (Okazaki 1992). The development time from egg to adult ranged between 28 and 32 d, a duration that closely agrees with observations on the species in Thailand (26–34 d) (Malaipan 1992). Nest entrances were guarded by females that used their metasomal terga to block the passage. The bees were not easily disturbed, and the nests were quite hearty over the course of the season, with no observed parasites during the period.

As noted previously, *C. smaragdula* is polylectic, typical for a species with such a broad ecological and distributional range, and is likely an important pollinator in Pakistan, with the potential for use in agroecosystems on legumes and cucurbits as has been done elsewhere (Kapil & Kumar 1969; Daly et al. 1971; Batra 1976a). *Ceratina smarag-*



Figs. 3 and 4. Photographs of nests of *Ceratina* (*Pithitis*) *smaragdula* in Ravenna grass stems (*Saccharum ravennae*) from northwestern Pakistan (photos by Hussain Ali). 3. Section of a nest with adult female and cell partitions with a series of pupae (scale in mm). 4. Section of nest with completed cell partitions containing characteristic pollen masses (not to same scale).

Table 1. Time of foraging activity for *Ceratina* (*Pithitis*) *smaragdula* (F.) in northwestern Pakistan (Jun through Aug 2012). The foraging females were timed from their departure from the nest until their return, laden with pollen.

Nest No.	Foraging starting time (a.m.)	Foraging ending time (p.m.)	Average time on foraging bouts (s)
1	6:40	4:20	20
2	7:00	4:10	16
3	6:35	4:40	25
4	6:45	4:55	30
5	6:50	5:10	36
Mean ± SD	—	—	25.40 ± 7.09

dula would be an ideal candidate for managed pollination services in Swabi, with the ease of finding and trapping the bees making it likely to encourage use by local farmers. Pithy stalks of *Saccharum bengalense* Retz. (Poales: Poaceae) (NPCS Board of Consultants & Engineers 2007: under the synonymous name of *Erianthus munja* [Roxb.] Jeswiet) have been used successfully as artificial nesting substrates in India, and use of the local Ravenna grass in Pakistan seems applicable for future managed nesting operations. Farmers could be encouraged to place such stalks horizontally above the surface of the ground (150.9 ± 59.4 cm) in accordance with the natural nests we observed, and to conserve natural habitats for wild bees surrounding crop environments.

Although there is a remarkable diversity of species of *Ceratina* in Asia (Michener 2007), there have been comparatively few studies on their nesting biology and floral associations outside of Japan, most having been undertaken on a subset of relatively common taxa (Batra 1976b; Malaipan 1992; Rehan et al. 2009; Yogi & Khan 2014). This is in stark contrast to the more extensive literature on the co-occurring, Asiatic, large carpenter bees, genus *Xylocopa* Latreille, obviously reflecting a researcher bias toward conspicuous and robust species that are easily observed and often nest in human constructions (Kapil & Dhaliwal 1968, 1969; Raju & Rao 2006; Boontop et al. 2008; Punekar et al. 2010; Hannan et al. 2012; Hongjamrassilp & Warrit 2014). Here, we attempt to draw the attention of regional melittologists to the smaller bees of Swabi, of which *C. smaragdula* is still on the larger end of the size range, and to the natural history of such taxa vital in the support of natural and potentially agricultural environments. Given that there are at least 263 species of pollinating and cleptoparasitic bees in Pakistan (Ascher & Rasmussen 2010), with numerous more to be documented, the potential is great for nesting and pollination studies throughout the varied habitats and elevations of the country. These realities stress the importance of preserving and protecting natural habitats in Pakistan, with such endeavors vital to the country's agricultural production and broader ecosystem health. Local educational and outreach programs are needed to educate farmers, who often operate at a small scale within isolated villages, of the need to conserve natural areas, particularly those bordering crop fields. Although there are already robust apicultural traditions in the region, investments are needed for the training of a new generation of Pakistani melittologists to undertake biotic inventories and develop species-level hypotheses, revisions, and methods of modern identification for the country's melittofaunal resources (Engel 2011; Gonzalez et al. 2013). These are necessary steps toward understanding and improving pollination services throughout this meeting point between Central Asia, South Asia, and the Middle East.

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