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— Short Communication —

EXPLOITATION OF *STROBILANTHES IXIOCEPHALA* (ACANTHACEAE) FLOWER BUDS BY BEES

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Abstract—Floral larceny by bees has been studied mostly in open flowers although it is also experienced in buds. Until now, only few studies have recorded larceny of unopened flowers. In this study, we present behavioural observations of *Apis* and non-*Apis* bees exploiting *Strobilanthes ixiocephala* (Acanthaceae) buds for floral rewards. The bees pierce open the anterior end of the unopened buds to access pollen and nectar.

Keywords: Floral larceny, flower buds, Strobilanthes ixiocephala, Western Ghats, India

INTRODUCTION

Pollinators are attracted to flowers through a combination of various advertising signals (Willmer 2011). Although there is a mutualistic interaction between plants and pollinators, this interaction is negatively affected when one partner starts exploiting the other or when third-party interactants consume rewards meant for pollinators (Boucher et al. 1982; Bronstein 1994). Floral visitors that cause pollination are legitimate but, in some cases, visitors bypass regular flower entrances, and exploit flower rewards through a hole chewed at the bottom of the flowers or by entering through existing punctures. This type of behaviour that negatively affects pollination service is termed floral larceny (Inouye 1980). In nectar robbing, nectar is generally obtained by making a hole at the base of the corolla and taking nectar directly from the nectary whereas nectar thieves obtain nectar by using apertures made by other animals (Inouye 1980; Irwin et al. 2010). Visitors might adopt such strategies due to competition between different floral visitors having varying foraging efficiency (Irwin et al. 2010).

Nectar robbing is often experienced by flowering plants with floral morphologies such as long corolla tubes or nectar spurs; in such species, some bees that cannot legitimately access nectar and pollen from the long tubular corollas due to morphological constraints tend to engage in nectar robbing (Inouye 1980; Irwin & Maloof 2002; Dedej & Delaplane 2005). Floral larceny is possible for visitors with specific morphological structures such as strong-toothed mandibles, maxillae or long proboscis lengths (Inouye 1983, Irwin et al. 2010, Bauder et al. 2011) such that rewards can be obtained without contacting floral reproductive organs.

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Most studies, so far, have focused on nectar robbery and thievery via holes at the bottom of corollas. Bees entering unopened flowers have not been well documented and this behaviour is understudied. Saunders (2017) recorded *Hylaeus perhumilis* (Colletidae) entering unopened flowers of *Corymbia ficifolia* (Myrtaceae). Recently, researchers have reported a new kind of pollination process mediated by insects at the breaking-bud stage. Yamaji & Osawa (2015) recorded small bees *Lasioglossum japonicum* entering half-opened flowers of *Lycoris sanguinea* var. *sanguinea* (Amaryllidaceae) and effecting pollination. This behaviour has been termed breaking-bud pollination. In this note we report on exploitation of nectar and pollen through unopened buds of *Strobilanthes ixiocephala* (Acanthaceae) by both *Apis* and non-*Apis* bees.

The aim of our study was to understand the difference in visitation rates by different bee species to flowers and unopened buds of *S. ixiocephala* and to document how different bee visitors approach the buds.

MATERIALS AND METHODS

The plant species and study site

Strobilanthes ixiocephala (Benth) (Acanthaceae) is a semi-erect shrub with a tubular corolla, endemic to the southern Western Ghats (Sahyadri Mountains), India. The study was conducted at Ira (5.71 acres) in Bhimashankar Wildlife Sanctuary, India (N19 04.616, E73 32.258). The zoomed in map of the study location was created using SimpleMappr (Shorthouse 2010) (Fig. 1). Ira is a rocky plateau with sparsely interspersed trees and *Strobilanthes* is found at the edges. Mass flowering of this species was observed from November 2016 until February 2017. The stigma of this species is touch-sensitive and curls backward when contacted by insects (P. Ambavane and N.P. More, unpub. observ). This stigma behaviour has been shown in *Strobilanthes kunthianus* to protect pollen acquired from a pollinator visit, and thus to discourage autogamy (Sharma et al. 2007). This stigma

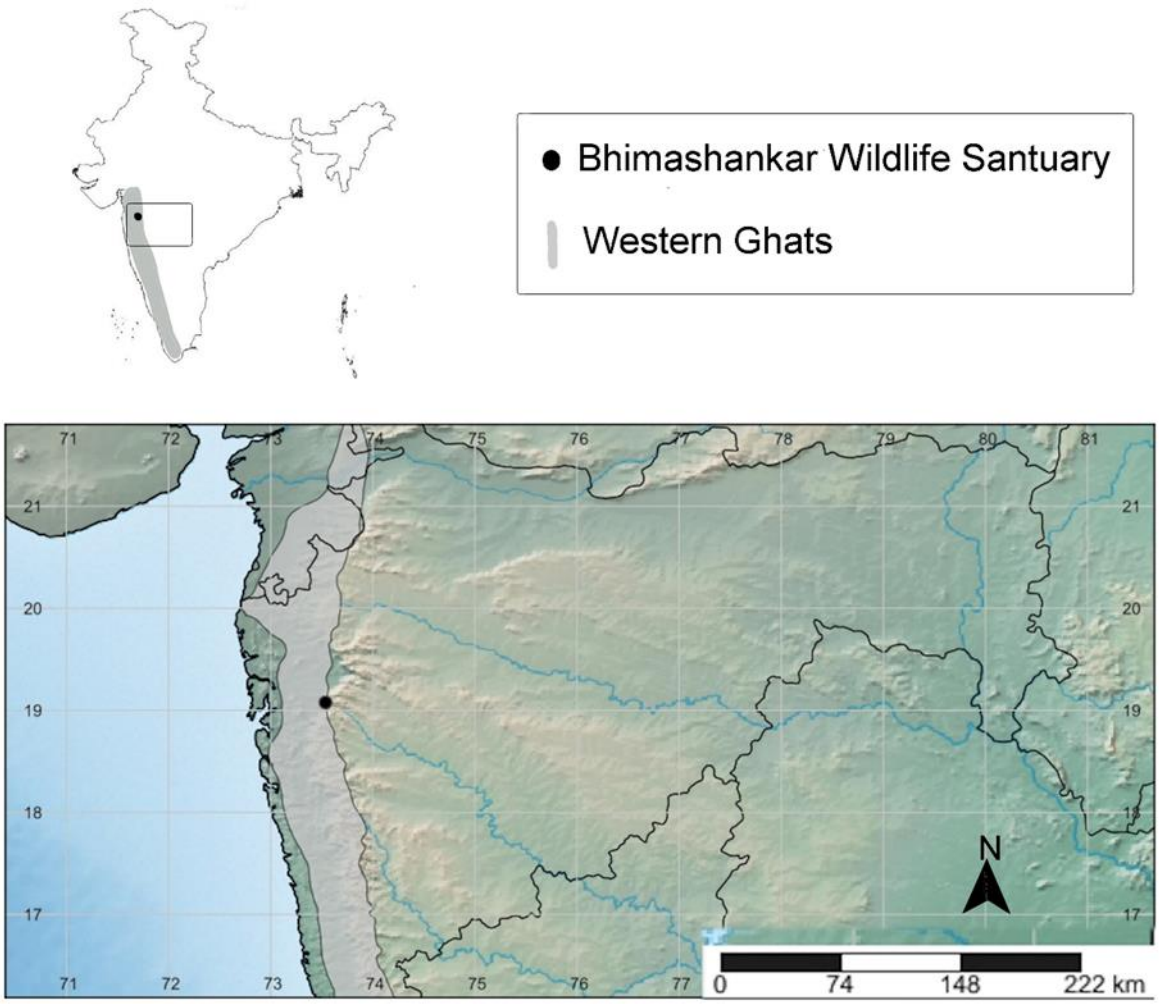

FIGURE 1. Site location of Bhimashankar Wildlife Sanctuary within the Western Ghats of India.

movement has also been observed in other families such as Scrophulariaceae, Bignoniaceae, Martyniaceae, Acanthaceae, and Lentibulariace (Newcombe 1922, 1924) and is considered an example of movement herkogamy (Webb & Lloyd 1986).

Observations

Flower visitors were recorded in November 2016 from 8:30 am till 11:00 am on different days; these time periods coincided with peak bee activity. During each 10 min observation period ($N = 26$ time intervals), a single plant was viewed from a fixed point by one observer and the activity of visitors and their identity were recorded.

RESULTS

Floral visitation

Flowers of *Strobilanthes ixiocephala* open between 0800–1000 hrs. We recorded activity for a patch of 13 plants. We observed four species of bees visiting *S. ixiocephala* flowers (Fig. 2A–E). Bees were observed actively feeding on pollen and nectar from 0830 hr onwards. The initial visitors were *Apis dorsata* (Apidae) and *Apis cerana* (Apidae) followed by solitary bees such as *Megachile lanata* (Megachilidae) and *Seladonia* sp. (Halictidae). *Apis dorsata* visited open flowers at a higher frequency than other bee species (1.73 flowers ± 1.61 per 10 min observation interval); three such visits were illegitimate. *Megachile* was exclusively an illegitimate visitor, only entering buds while *Apis cerana* only visited open flowers (Fig. 3). Both *Megachile lanata* and *Seladonia* sp. visited flowers between 1000–1100 hrs and were thus late arrivals.

Behaviour of bees at flower buds

Bees were observed exploiting various stages of buds from tightly closed ones to those that were slightly open. During their visit they entered through the distal end of the bud. All the bees moved around the bud before entering it. *Apis dorsata* is larger than the other three species and was observed to prise open the tightly enclosed bud with their mouthparts (Fig. 2A, B). They cut through the petals and entered the bud. On the other hand, *Megachile lanata* and *Seladonia* entered through slightly opened buds. We recorded *Seladonia* clinging onto the stigma of the flower and feeding on pollen in one of the observations (Fig. 2E). Pollen was seen on the body of the *Apis dorsata*, *Megachile lanata* and *Seladonia* sp.

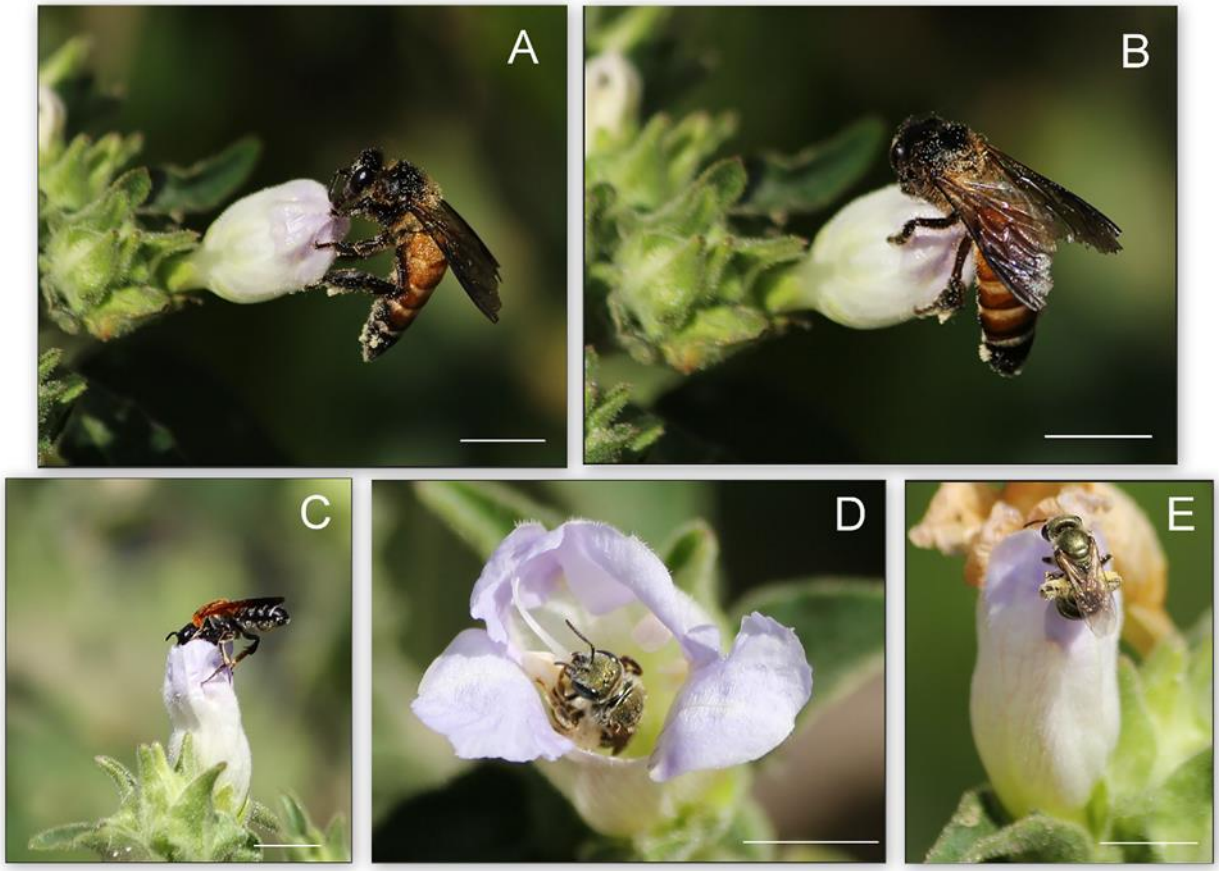

FIGURE 2. The floral visitors engaging in larceny of *Strobilanthes ixiocephala* buds. (A) and (B) *Apis dorsata* piercing open the fully enclosed bud from the top. (C) *Megachile lanata* entering from the top of the bud which is partially open. (D) and (E) *Seladonia* sp. entering through the partially opened bud and clinging to the stigma. Scale bar: 0.5 cm.

DISCUSSION

Observations of visitation to unopened flowers by animals are less common since unopened flowers are rarely studied during plant–pollinator studies. Pollinators are mostly attracted to the flower through advertising signals. This study suggests that different visitors may visit different stages of buds for the purpose of robbing. Visitation rates to buds may also vary from species to species. Bees cut open buds through the top at the anther level to gain access to the pollen. Previously *Trigona amalthea* was observed making a hole in the center of the bud to access pollen in *Passiflora ligularis* Juss (Gutiérrez-Chacón et al. 2018). Nicholls et al. (2014) suggest that bees such as bumblebees can discriminate between different pollen qualities based on floral cues. They use these cues to efficiently select quality pollen required for their larvae thus allowing them to effectively select the best available pollen rewards. Thus, getting easy access to pollen from the freshly opened bud could cause bees to enter buds, even though they are capable of legitimate entry after anthesis. *Apis dorsata* was more intrusive than other bees since they caused damage to the buds. In other systems, bumble bees, which are the legitimate pollinators, did not avoid robbed flowers while honey bees avoided such flowers (Richardson 2004). Whether damaged flowers are visited again by conspecific or other smaller bees and whether visits of legitimate pollinators to rob flowers is affected by such behaviour is still unknown in this system and needs further investigation.

It is well known that floral odour and morphology act as floral advertisements along with various visual traits to attract visitors and guide their foraging decisions (Faegri & Pijl 1979; Raguso 2008; Wright & Schiestl 2009). Floral traits that attract illegitimate visitors, especially at the bud stage, are understudied. In buds, anthers are enclosed and also lack the advertisement arising from floral pigmentation. It will be interesting in the future to study bud traits and cues that elicit robbing from buds. It is unclear whether the bees can detect cues of floral scent released at the damaged site or whether bees leave scent behind when they rob flowers. It is also possible they can detect nectar availability in robbed flowers using such cues (Stout & Goulson 2001). Bees may also learn to engage in floral larceny by observing other bees. In bumblebees, social interaction within the species influences nectar robbing (Leadbeater & Chittka 2008; Goulson et al. 2013). Prior experience with certain types of foraging behaviour might therefore decide whether the bee will forage legitimately or engage in robbing. Bees will eventually learn to use behaviours which are more beneficial (Barker et al. 2018).

These are preliminary findings, so the data should be considered with caution. But this study provides evidence for a new flower handling tactic used by bees on *S. ixiocephala* floral buds. Only few studies have observed flowers before

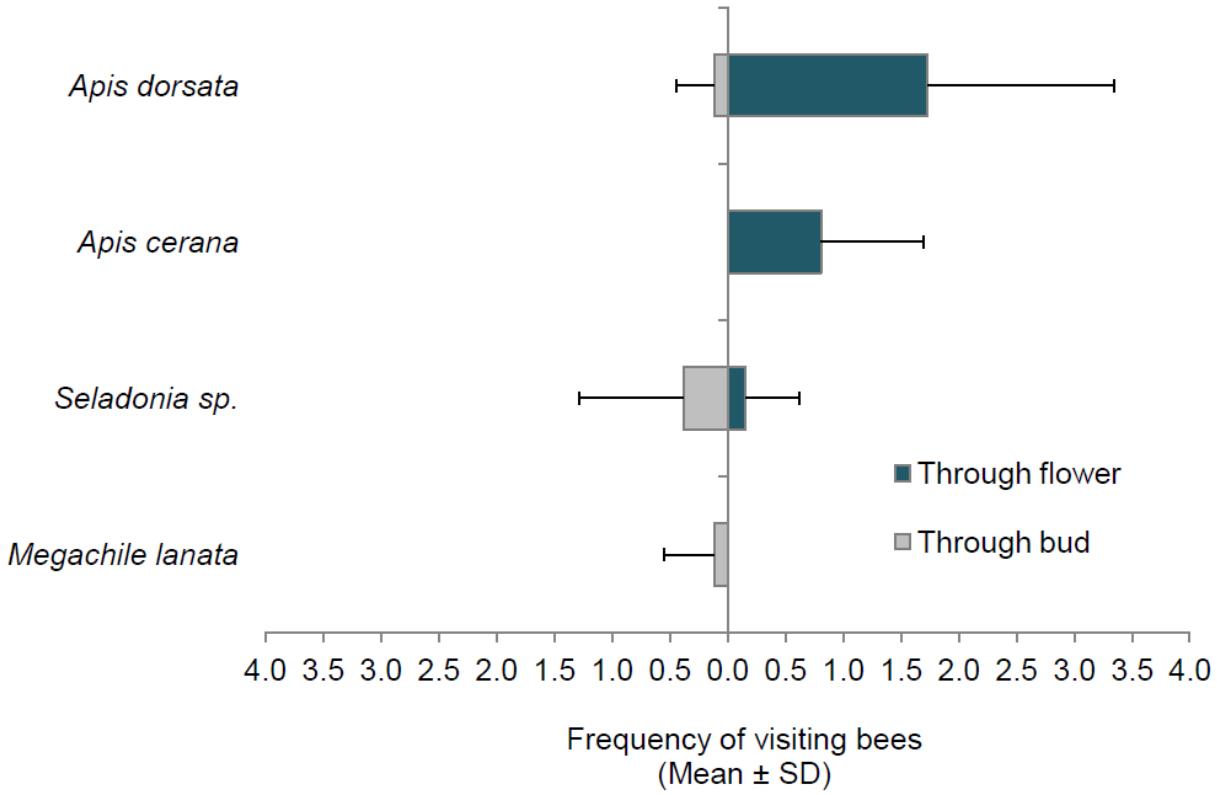

FIGURE 3. Comparative visitation by bees (frequency per 10 min observation period) legitimately through opened flowers or illegitimately through unopened buds of *Strobilanthes ixiocephala* (n=26 time intervals, each of 10 min duration)

anthesis. Bud larceny may be a costly behaviour but the quantity and quality of pollen received in a single visit may select for such behaviour. The cost of larceny in terms of handling time may also vary with body size. Therefore, smaller bees may not invest the time to completely open buds and may prefer to enter half-opened buds or may involve in secondary robbing. It will be interesting to address the following questions in the future. When do bee visitors start exploiting the buds? Does this behaviour depend on resource availability leading to competition? For example, large and more numerous pollinators such as *A. dorsata* aggressively exploit open and closed floral resources (floral buds) leaving fewer rewards for smaller and less numerous bees and this may explain why the smaller bees such as *Megachile* and *Seladonia* come later after visits by *A. dorsata* and engage in floral larceny. Alternatively, this may be purely an opportunistic behaviour. In general, the context and frequency of bud exploitation requires further investigation.

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