



## BEES AND THE QUEEN OF SPICES

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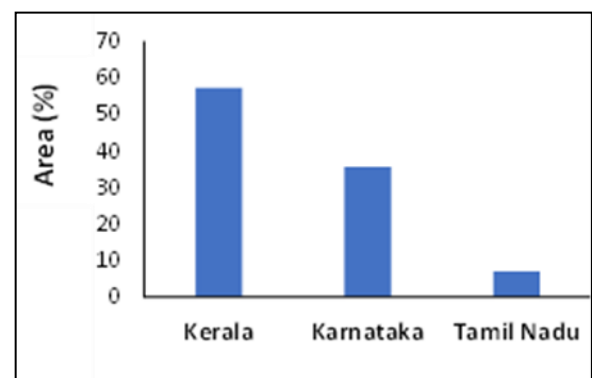
Cardamom (*Elettaria cardamomum* (L.) Maton), the Queen of Spices, also referred to as **small cardamom** or **true cardamom**, is native to the Western Ghats of India. It is considered as one of the world's oldest spices. Cardamom is the third most expensive spice in the world after saffron and vanilla. It was an important commodity of trade between India and Greece during 4<sup>th</sup> Century BC. Cardamom is mentioned in 3<sup>rd</sup> Century BC as a medicine for stomach and urinary disorders in Ayurvedic literature (Nair, 2006). It is also mentioned in both Charaka Samhita and Sushruta Samhita, the ancient Indian Ayurvedic texts written in the post-Vedic period (Nair, 2011).

The major cardamom producing countries in the world are India, Indonesia, Guatemala, Sri Lanka, Tanzania and Papua New Guinea. Guatemala, India and Indonesia are the major cardamom exporting countries. In India, cardamom is cultivated in Kerala, Karnataka and Tamil Nadu (Fig. 1) and cover an area of 70,410 ha with a production of 25,230 tonnes (Anon, 2024). Kerala with 57.29% of area produces 90.63% of cardamom. During 2023, India exported 8,000 tonnes of cardamom earning over 155 million USD (~1300 crores of INR).

### The Plant

Cardamom belongs to the ginger family (Zingiberaceae) and grows in clumps of 20 to 25

pseudostems (Fig. 2). It is cultivated under the shade of trees. Each pseudostem bears at the base one or two panicles that bear flowers. There are three types of cardamom – Malabar type (with prostrate panicles), Mysore type (with erect panicles) and Vazukka type (with semi-erect panicles). Malabar type is cultivated in Karnataka while Mysore and Vazukka types are more common in Kerala. Cardamom flowers are exclusively cross pollinated and depend on bees for pollination and fruit set.



**Fig. 1 Area under cardamom cultivation.**



**Fig. 2. Cardmom crop.**

## Cardamom Flower

The flower is hermaphrodite self-compatible, with three greenish sepals and petals (Fig. 3). The petals fuse at the base to form a nectar tube of about 23 mm long. The flower has a broad whitish lip like structure, referred to as labellum or flabellum that protrudes from the tip of the nectar tube and has pinkish nectar guide markings. Labellum acts as a landing platform for bees and the nectar guides lead bees to the nectar tube. According to Parameshwar and Venugopal (1974) the labellum is formed by the fusion of three modified anthers. Ovary is trilocular, each locule with nine ovules. There is a single style with an expanded stigma above the anther lobe. Anthers are herkogamous. Because of the location of stigma above the anther lobe (approach herkogamy), self-pollination is avoided. Further, pollen grains are sticky, and hence require an agent.



**Figure 3: Cardmom flower.**

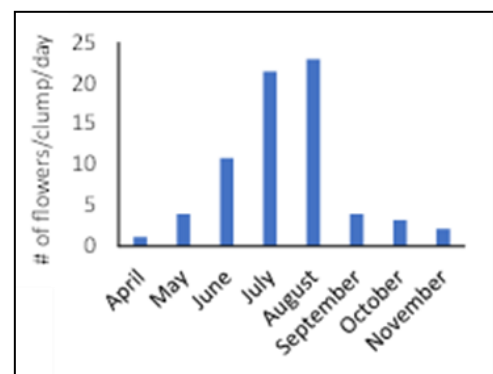
## Floral Biology

Flowering commences by last week of April and will continue till first week of November, with peak flowering between June – August. Anthesis (flower opening) occurs in the early morning between 4.30 and 6.30 am. Anthers dehisce and release pollen grains around 7.30 am. Pollen remains viable the whole day and though stigma is also receptive all through the day, peak receptivity is around 12 noon. Longevity of individual flowers is between 15 to 18 hours and should get pollinated on the same day of

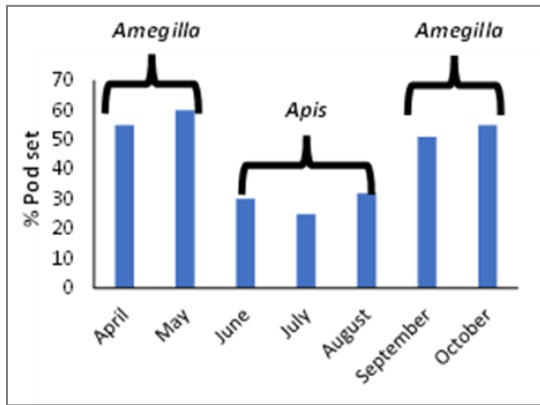
anthesis (Belavadi and Parvathi, 2000).

## Flower visitors

Cardamom flowers are visited by several species of bees including honey bees, stingless bees and solitary bees like the blue banded bees. Of these the honey bees, mainly *Apis cerana* and *A. dorsata* are the most frequent visitors, especially during the peak flowering months. Visitation frequency depends on the flower density (Belavadi et al., 1993). In the beginning and end of the season when the number of flowers per clump will be less than five (Fig. 4), honey bees ignore cardamom, as they have to spend more energy and have to visit more flowers distributed on several clumps. Since a forager bee gets only about 0.3  $\mu$ l in each flower (Belavadi and Parvathi, 2000). The crop (stomach) capacity of a foraging *A. cerana* is  $\sim$  40  $\mu$ l. Hence, to fill its crop it has to visit about 125 to 135 flowers. If the number of flowers per plant is 4, the bee has to fly around not less than 30 clumps and the spacing between clumps will be 1.8 m, which is both energy and time consuming. Foragers of *A. cerana* commence foraging by the end of May or in the beginning of June and their activity keeps away *Amegilla* spp. When the density/number of flowers per clump increases beyond 15 or 20, *A. dorsata* start appearing and they will replace the *cerana* bees. In the months of April, May and again from September to November, the flowers are mostly visited by the blue banded bees (*Amegilla* spp.) (Fig. 5).



**Fig. 4 Flower density in different months.**



**Fig. 5 Per cent fruit set by different flower visitors.**

This observation indicated two things – that the blue banded bees (*Amegilla* spp.) are more efficient pollinators than *Apis* spp. and that the population of *Apis* bees may not be sufficient enough to pollinate the available number of flowers in the peak season.

#### Are blue banded bees better pollinators?

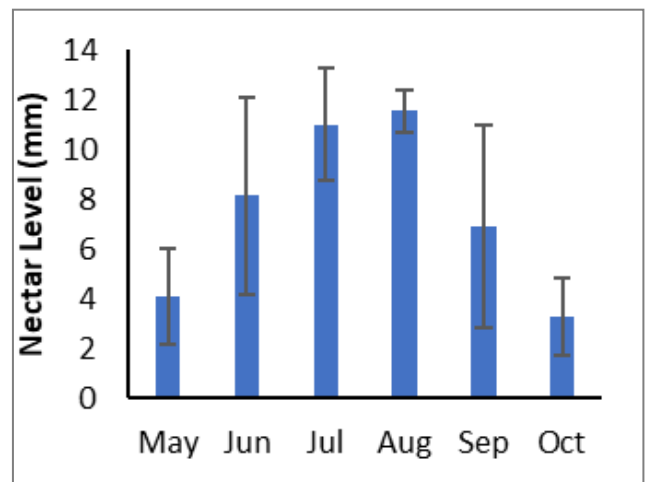
During the peak flowering, measurements of nectar level in the flowers showed that nearly half of the nectar remained unharvested, despite very high activity of honey bees (Fig. 6).



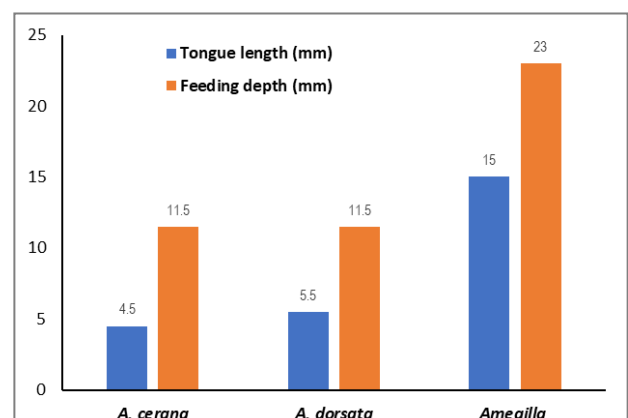
**Figure 6: Cardamom flower with 50% nectar remaining after a bee visit.**

In the beginning and towards the end of flowering season the nectar level was very much lower, when the blue banded bees will be active compared to the peak flowering time (Fig. 7). Observations on the tongue lengths of these bees and how deep they could access for nectar in the flowers revealed that, despite their shorter tongue

lengths of 4.5 and 5.5 mm, the honey bees, could to draw nectar upto 11.5 mm (Belavadi et al., 1997) while *Amegilla* spp. with their longer tongue could exhaust all the nectar available in the flower (Fig. 8). This lead to a hypothesis that *Amegilla* spp. were probably the original pollinators of cardamom. In the wild, the population of cardamom plants will be low and probably *Amegilla* do the job, while under cultivated conditions, the plant population and flower density will be high, and honey bees being opportunistic flower visitors, compete and replace solitary bees, but can take only upto ~50% of available nectar. In the cardamom variety Mudigere- 1, on which most of the observations were made, the corolla length is 23 mm and can hold 4  $\mu$ l of nectar when the flower is prevented from bee visits. Hence, in each flower, nearly 2  $\mu$ l of nectar remains which may go waste.

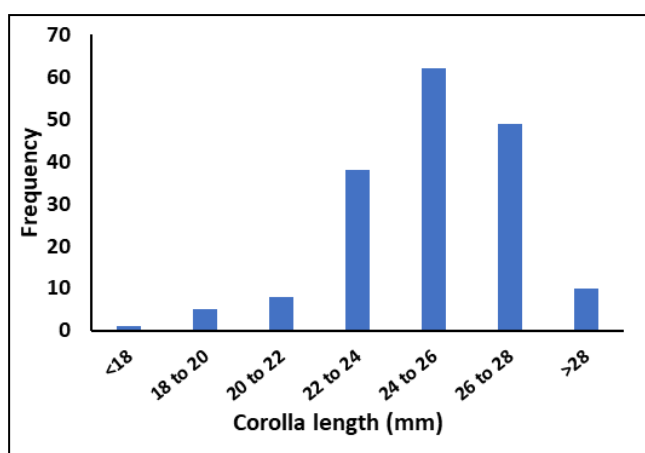


**Figure 7: Nectar level in corolla tube.**



**Figure 8: Tongue length and feeding depth by bees.**

Nectar production is costly and the plant has to spend lot of energy (Pyke, 1991; Pyke and Ren, 2023). Hence, one can hypothesize that if corolla length is shorter, the plant may spend less energy in nectar production and invest the saved energy in producing more flowers. Measurement of the corolla lengths of 173 entries in the germplasm collection including the released varieties, at the Zonal Agricultural Research Station, Mudigere, revealed significant variation (Fig. 9). Interestingly, all high yielding cultivated varieties fall to the left of the distribution, indicating that, corolla length can be used as a trait for selection by the cardamom breeders.



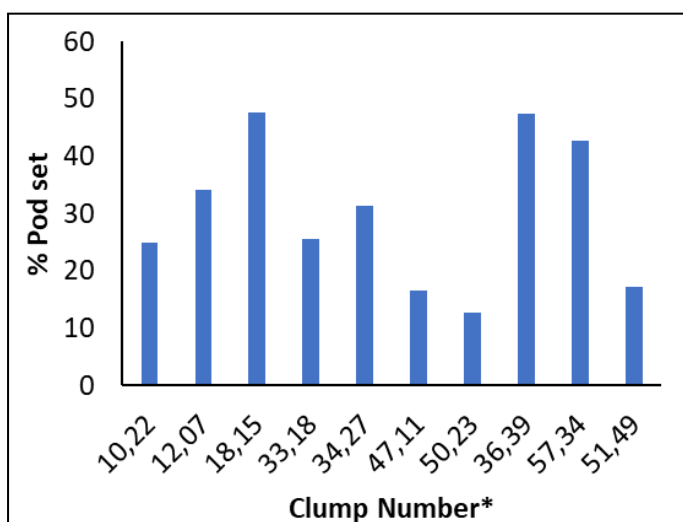
**Figure 9: Corolla length of cardamom entries in germplasm collection (n = 173).**

### Is there a pollinator deficit?

In a study, all flowers produced by ten randomly selected clumps of cardamom were counted from the first day of flowering till the last day and the number of capsules set in each clump was recorded. The number of flowers per clump ranged from 615 to 1700 with a mean of 1170 and the number of flowers setting capsules ranged from 200 to 590 with a mean pod set of 30 per cent (Fig. 10).

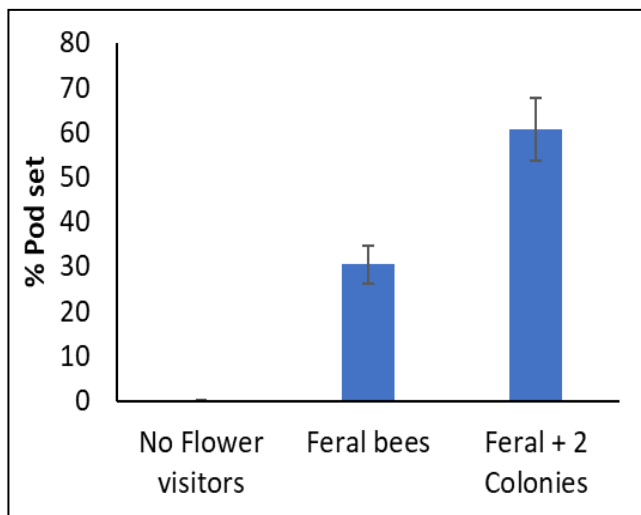
If this low pod set is due to pollinator deficit (low population of foragers), can the population of bees be increased and by how much. Based on earlier studies on the foraging behaviour of

individually marked *A. cerana* bees (Parvathi et al., 1993), following information was available. a) A single bee visits as many as 130 flowers in one visit; b) A single flower required at least 20 visits to set capsule; c) On an average, there will be 20 flowers/clump every day; d) There are 3000 clumps/ha, e) So, there will be 60,000 flowers in an hectare requiring bee visits and f) Number of visits required per day is 1,200,000. Based on this, it was estimated, that at least 9000 foragers are required per ha (Belavadi and Parvathi, 1998).



**Figure 10: Per cent pod set in cardamom (\*first two digits refer to row number and the next two digits to the plant number – 10<sup>th</sup> row 22<sup>nd</sup> plant).**

Considering the available information on the normal colony size of a 8-frame hive to range between 12,000 to 15,000 workers and about one-third of the workers will be foraging (Inoue et al, 1990; Dyer and Seeley, 1991), a field trial was conducted with two colonies per ha, assuming that there will be at least 4000 to 4500 foragers in a colony. There were three treatments – 1. No flower visitors; 2. Open pollination (feral bees) and 3. Two colonies of *A. cerana*/ha. The results clearly indicated that the cardamom pod set can be more than doubled by introduction of two colonies and the pollinator deficit can be overcome.



**Figure 11: Overcoming pollinator deficit.**

### Economic value of pollinators in cardamom

Economic value of insect pollination service is determined by multiplying the pollinator dependency index (Pdi) with total economic value of the crop (TVC). TVC is the total production multiplied by the market value per unit. Since pollinators are essential for the pod set in cardamom, the Pdi for cardamom is taken as 0.95. Total production of cardamom in 2023-24 was 25,230 tonne and the lowest market value in 2024 was Rs. 1000/- per kg. The EVIP for cardamom is Rs. 2396.85 crores.

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