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Harvesting the Gold Dust: Unravelling the Pollen Production Potential of Indian Honey Bees *Apis cerana indica* (Fabricius) and Optimizing Pollen Traps in Coconut Ecosystems

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ABSTRACT: Beekeeping is the practice of overseeing honey bee colonies to derive various advantages. In India, the Indian honey bee (*Apis cerana indica*) and Italian honey bee (*Apis mellifera*) are the main species under management. Bee-collected pollen is an important product which is harvested using a pollen trap. Bee pollen is rich in protein and provide essential nutrients for honey bees. This rich food is being effectively used as human nutrition. This study investigated the effect of pollen traps on pollen collection potential of Indian honey bee *Apis cerana indica* in a coconut orchard in Coimbatore, Tamil Nadu during Jan to May 2023 for a period of five months. The results showed that mean daily pollen collection in the pollen traps was 23.26 g/ hive when traps were placed once in seven days in a week (for a period of 2 h between 7 and 9 am). The daily pollen collection was 6.05, 12.53 and 19.11 g/ hive when traps were placed on all days of a week, alternate days and, once in 3 days. The mean weekly pollen collection was 44.58 g/ hive when traps were placed once in 3 days of a week. The mean weekly pollen collection was 42.33, 43.86 and 23.23 g/ hive when traps were placed on all days of a week, alternate days and once in seven days. It was concluded that placing pollen traps for a period of 2 h in a day between 7 and 9 am for 3 days in a week can be recommended in coconut ecosystem to get maximum pollen yield and without adversely affecting the honey bees. Pollen collection increased significantly after the acclimatization of honey bees to traps with highest collection in March and April. Understanding the pollen collection potential of Indian honey bees has implications for beekeeping, pollination studies, and agriculture. Further research is needed on environmental factors, seasonal variations, and long-term trap effects. Overall, this study provides valuable insights into Indian honey bee pollen collection potential and the possibility of collecting pollen in coconut ecosystem that can provide additional income to beekeepers.

Keywords: *Apis cerana indica*, Beekeeping, Pollen trap, Pollen collection, Honey bee colonies, Nutrients, Agriculture, Pollination, Climatic conditions.

INTRODUCTION

Apiculture, commonly referred to as beekeeping, is the practice of gathering, handling, and overseeing honey bee colonies of specific species in designated boxes at suitable locations to utilize both direct and indirect advantages. In India, the two predominant bee species under management are the Indian honey bee (*Apis cerana indica*) and the Italian honey bee (*Apis mellifera*). The Indian honey bee, *Apis cerana*, is extensively found across the country and boasts significant biological and economic traits, including a strong, docile, and hardworking temperament, as well as resistance to various diseases like parasites, mites, and *Nosema*.Currently, the products derived from the Indian honey bee (*A. cerana indica*) are gaining significant attention in various industries, much like the European honey bee (*Apis mellifera*), especially in the nutritional and pharmaceutical sectors. One such product is bee-collected pollen, which can be obtained using a pollen trap. The pollen trap serves as a valuable tool in beekeeping, enabling the collection of pollen from foraging bees as they return to the hive. Beekeepers find this tool beneficial as it allows them to harvest pollen for diverse purposes, such as selling it as a standalone product, providing a nutritional supplement for bee colonies, or conducting pollen analysis to study the bees' floral sources. The trap's design typically consists of a mesh or grid with small openings placed strategically at the hive's entrance, gently scraping off the pollen pellets attached to the hind legs of worker bees returning from their foraging flights. Pollen captured by pollen trap serves as the primary protein source for honey bee colonies, providing essential nutrients like protein, fat, vitamins, and minerals. It plays a crucial role in colony life,

especially in brood rearing. Studies conducted by (Ibrahim and Selim, 1974; and Shawer 1987) have shown a strong correlation between the amount of collected pollen and worker brood rearing. Similarly, Hussien (1981) observed a significant positive relationship between pollen collection and brood rearing. The availability of pollen and nectar significantly impacts brood rearing, which is a major factor in apiary production, as noted by Roman (2006). Colonies with pollen traps produce less honey and rear fewer broods compared to control colonies. As beekeeping activity increases, it becomes vital to identify the main pollen sources in a region and their value to bee colonies and pollen production, as emphasized by Andrada and Telleria (2005). Pollen serves as a natural source of crucial nutrients, including proteins, fats, minerals, and vitamins, benefiting both bee colonies (grubs and bees) and human nutrition (Cobo, 1984). Liebelt (1994) conducted a study revealing that the amount of bee pollen consumed, and gender factors influence its biological and psychological effects on bodily functions. Furthermore, Liebelt *et al.* (1994) demonstrated in another study that specific commercially available brands of bee pollen contain all the necessary nutritional elements to sustain three different inbred strains of mice in a healthy clinical state for periods of 1 year or longer when fed only with bee pollen and water. Nelson *et al*. (1987) studied the effect of continuous pollen trapping on sealed brood, honey production and gross income in Northern Alberta.

MATERIALS AND METHODS

Location. The present study was conducted in the Coconut orchard at Tamil Nadu Agricultural University (TNAU) in Coimbatore, Tamil Nadu.

Honey bee colonies. The research work commenced with four Indian honey bee (*Apis cerena indica*) colonies, representing four replications for each treatment. There were five treatments in the present study namely, keeping the pollen trap on all days (T1), alternate days (T2), once in 3 days (T3), once in 7 days (T4) and no pollen trap (T5- control). Each colony was structured according to the Newton beehive model. To ensure consistency, all the beehives were balanced in terms of strength, brood, and food reserves. Additionally, the colonies were led by queens of the same age, ensuring uniformity in the experimental setup.

Description of pollen trap. The pollen traps were procured from a bee hive manufacturing firm in Odisha. The pollen traps used in the research were similar to the ones normally used in *A. mellifera* but were of smaller size and with smaller holes to suit the *A. cerana indica*. The traps were constructed of wooden planks and featured three distinct polypropylene structures (Plate 1.). One of these structures consisted of four rows of holes, which served as entry points for the foragers to return to the hive. The diameter of the holes in the vertical polypropylene plate in the pollen trap (through which the bees squeeze themselves while returning to the hive) was measured under stereo zoom microscope (LEICA M205A) to be 0.920 to 0.927 mm. The second horizontal polypropylene plate in the pollen trap featured six rows of narrow rectangular holes through which the pollen from the bees fall to the third polypropylene box kept underneath. This polypropylene box kept underneath allowed for the convenient collection of pollen that was carried by the foragers on their hind legs.

Plate 1. Pollen trap.

Pollen collecting activity. Pollen traps were fixed at the hive entrance of each colony in the experiment during the year 2023 (Plate 2). The pollen traps were placed for a period of 2 h in a day between 7 and 9 am. The experiment was designed with five treatments based on the pollen collection intervals as explained with four replications. Control was not installed with any pollen trap. Pollen collection behaviour was observed for five months (January to May 2023) and mean monthly data of pollen weight was taken. The weight of the pollen was recorded after shade drying the pollen for 2 days under ambient conditions (Plate 3).

Plate 2. Pollen trap installed with Indian beehive in coconut orchard.

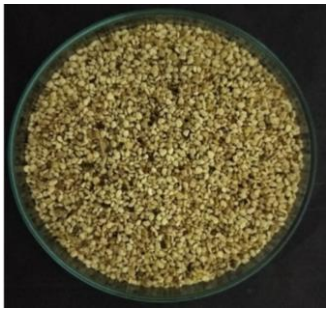

Plate 3. Pollen collected by Indian bee by installing pollen trap.

Statistical Analysis. Statistical analysis of the data was conducted using a Factorial Completely Randomized Design (FCRD). To compare the means, a critical difference (CD) was employed by analyzing the data using Statistical Package for the Social Sciences (SPSS) version 22.0.

RESULTS AND DISCUSSION

A. Per day pollen collection

Table 1 and Fig. 1 illustrate the impact of pollen traps on the daily pollen collection of Indian honey bee *A. cerana indica*. The highest mean per day pollen collection of 23.26 g/ hive occurred when pollen was collected once every 7 days. Followed by this, the mean daily collection was 19.11 g/ hive when collected once every 3 days, and 12.53 g/ hive when collected on alternate days. The peak pollen collection was recorded during the second week of March, with an overall mean of 13.98 g/ hive (Fig. 2). The subsequent highest collections were in the first week of March, averaging 13.68, and the third week of March with a mean 13.58 g/ hive. On the other hand, the lowest pollen collection occurred in the first week of January, with a mean of 9.50, followed by the third week of January, averaging 9.94, and the second week of January, averaging 10.01 g/ hive.

B. Total pollen collected in a week

Table 2 and Fig. 3 provides insights into the impact of pollen traps on the weekly pollen collection of Indian honey bee *A. cerana indica*. The highest mean weekly pollen collection of 44.58 g/ hive occurred when pollen was collected once every 3 days, followed by a mean of 43.86 g/ hive when collected on alternate days, and 42.33 g/ hive when collected every day. Pollen traps were placed consecutively for five months to gather data from the bee colonies. During the study period, the peak pollen collection was observed in the second week of March, with a mean of 35.83 g/ hive. The subsequent highest collections were in the first week of March, averaging 35.14, and the third week of March, averaging 34.63 g/ hive. However, it is noteworthy that despite the highest collection occurring in the second week of March, it did not surpass the values obtained for the total mean pollen collection per week (once in 3 days > alternate days > all days > once in 7 days > control). Conversely, the lowest pollen collection was recorded in the first week of January, with a mean of 22.76 g/ hive, followed by the third week of January with an mean of 23.55, and the second week of January with an mean of 24.19 g/ hive.

The study investigated the impact of different pollen trap collection intervals on the pollen production potential of Indian bees *A. cerana indica* in coconut ecosystems. The results showed that the highest pollen collection occurred during March, followed by April, May, and February, while January had the lowest pollen count. While considering the pollen trap collection intervals, the highest mean daily pollen collection happened when traps were used once every 7 days, closely followed by traps set to collect once every 3 days and then traps set to collect on alternate days. This indicated that giving bees more time between collections (once every 7 days) resulted in higher pollen collection, likely due to reduced disturbance and stress on the bee colonies. For weekly pollen collection, the most effective strategy was to set traps to collect once every 3 days, followed by traps set to collect on alternate days and then traps set to collect daily. Frequent pollen collection (once every 3 days) proved to be the best approach for maximizing weekly pollen collection. Despite consistently observing the highest pollen collection during the second week of March, the weekly mean collection for this interval (once every 3 days) did not surpass the weekly mean of some other intervals (alternate days and all days). This highlighted the importance of considering long-term mean pollen collection data rather than solely focusing on peak collection days for optimizing pollen trap intervals. The study emphasized that the choice of the ideal pollen trap collection interval depends on the specific goals of beekeepers and pollen collectors. For those seeking the highest daily pollen collection on a single day, setting traps to collect once every 7 days would be preferable. On the other hand, to maximize pollen collection over longer periods, traps should be set to collect once every 3 days. It's worth noting that the study took measures to minimize disturbance to the bee colonies during the experiment, including installing pollen traps for only three weeks in a month out of 4-5 weeks and replacing some colonies to ensure consistent results throughout the research period.

The available literature offers limited information on the pollen collection capacity of the Indian honey bee species (*A. cerana indica*) through the utilization of pollen traps. Nonetheless, there exist records detailing the potential for pollen collection in the Italian bee (*A. mellifera*). Elsayh and Hebat Allah (2012) observed significant pollen quantities, specifically 1061.77 g/colony/year and 826.36 g/ hive /year in the years 2009 and 2010. This phenomenon was noted when the traps were utilized during both the spring months (April, May, and June) and the summer months (July, August, and September). Similar outcomes were reported by Ismail *et al.* (2013), who documented a total amount of trapped pollen (measured by fresh weight) at 2354.89 g/ hive /year (with a mean of 588.72 g/ hive /season). Peaks in pollen collection were apparent during the summer and spring seasons, while collection rates dropped during the autumn and winter seasons. These findings align with those of Fathy (2008), who also highlighted the spring period (April, May, and June) as the most optimal for pollen collection, with an average of 316.68 g/ hive, constituting 38.18% of the total collection. In contrast, Fathy observed that the winter months (December to February) exhibited the least favourable collection season, with an average of 88.97 g/colony (10.73%). Additionally, Mahfouz, H.M. (2016) documented the most substantial pollen accumulation in April for the Italian bee, followed by the Carniolan race during the same month, with mean quantities of 165 g/ hive and 155 g/ hive, respectively.

Table 1: Quantity of pollen collected by Indian honey bee (*Apis cerena indica*) / hive / day in various months.

Collection Intervals	Quantity of pollen (gm) / hive/ day collected using pollen trap from Indian honey bee (*Apis cerena indica*) in Coconut ecosystem															
	January			February			March			April			May			
	1st Week	2nd Week	3rd Week	1st Week	2nd Week	3rd Week	1st Week	2nd Week	3rd Week	1st Week	2nd Week	3rd Week	1st Week	2nd Week	3rd Week	Mean
All days	3.73	4.03	3.6	3.9	4.94	4.98	7.41	7.47	6.94	6.96	6.75	7.49	6.66	7.62	7.15	**6.05[d] (d)**
Alternate day	9.34	10.24	10.3	10.5	11.05	11.02	13.96	14.57	14.52	14.49	13.19	14.43	12.55	14.62	12.83	**12.53 (c)**
Once in 3 days	15.45	15.87	15.6	16.3	18.44	18.36	20.96	21.00	20.47	20.23	20.19	20.78	19.55	21.35	20.09	**19.11(b)**
Once in 7days	19.01	19.91	20.3	22.7	22.73	21.83	26.07	26.83	25.99	24.65	25.64	25.58	21.95	21.95	23.81	**23.26 (a)**
Control	0.00	0.00	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00 (e)**
Mean	9.50 J	10.01 H	9.94 I	10.69 G	11.43 F	11.24 F	13.68 B	13.98 A	13.58 B	13.27 C	13.15 C	13.66 B	12.14 E	13.11 C	12.78 D	
CD @0.05	Treatments: 0.17, Period: 0.29, T x P: 0.66															

Note: Mean of 4 replications. In a column the means followed by a common lower case alphabet are not significantly different at p=0.05. In a row, the means followed by a common upper case alphabet are not significantly different at p=0.05.

Table 2: Quantity of pollen collected by Indian honey bee (*Apis cerena indica*) / hive / week in various months.

Collection Intervals	Quantity of pollen (gm) / hive/ week collected using pollen trap from Indian honey bee (*Apis cerena indica*) in Coconut ecosystem															
	January			February			March			April			May			
	1st Week	2nd Week	3rd Week	1st Week	2nd Week	3rd Week	1st Week	2nd Week	3rd Week	1st Week	2nd Week	3rd Week	1st Week	2nd Week	3rd Week	Mean
All days	26.09	28.19	25.2	27.4	34.59	34.83	51.84	52.31	48.56	48.75	47.27	52.45	46.64	53.31	50.07	**42.33 (c)**
Alternate day	32.67	35.84	35.9	36.7	38.68	38.57	48.87	51.01	50.83	50.72	46.17	50.51	43.94	51.17	44.89	**43.86 (b)**
Once in 3 days	36.04	37.03	36.3	38.0	43.03	42.85	48.91	49.01	47.77	47.19	47.11	48.48	45.62	49.82	46.88	**44.58 (a)**
Once in 7days	19.01	19.91	20.3	22.7	22.73	21.83	26.07	26.83	25.99	24.65	25.64	25.58	21.95	21.95	23.81	**23.26 (d)**
Control	0.00	0.00	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00 (e)**
Mean	22.76	24.19	23.55	24.98	27.81	27.61	35.14	35.83	34.63	34.26	33.24	35.40	31.63	35.25	33.13	
CD @0.05	Treatments: 0.38, Period: 0.65, T x P: 1.45															

Note: Mean of 4 replications. In a column the means followed by a common lower case alphabet are not significantly different at p=0.05.

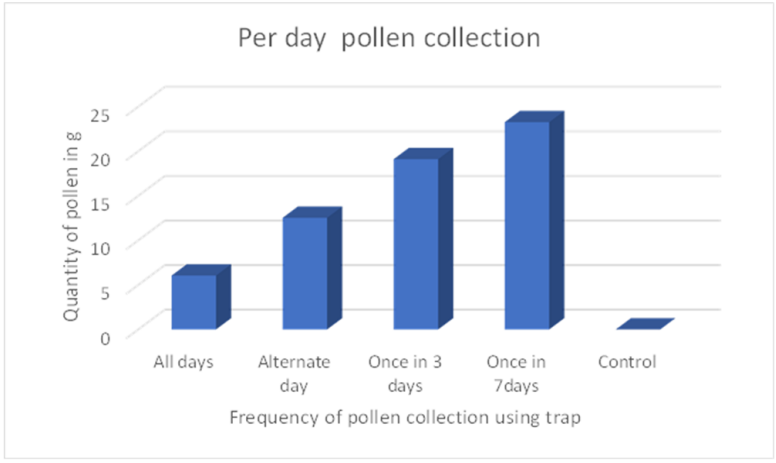

Fig. 1. Mean daily pollen collection.

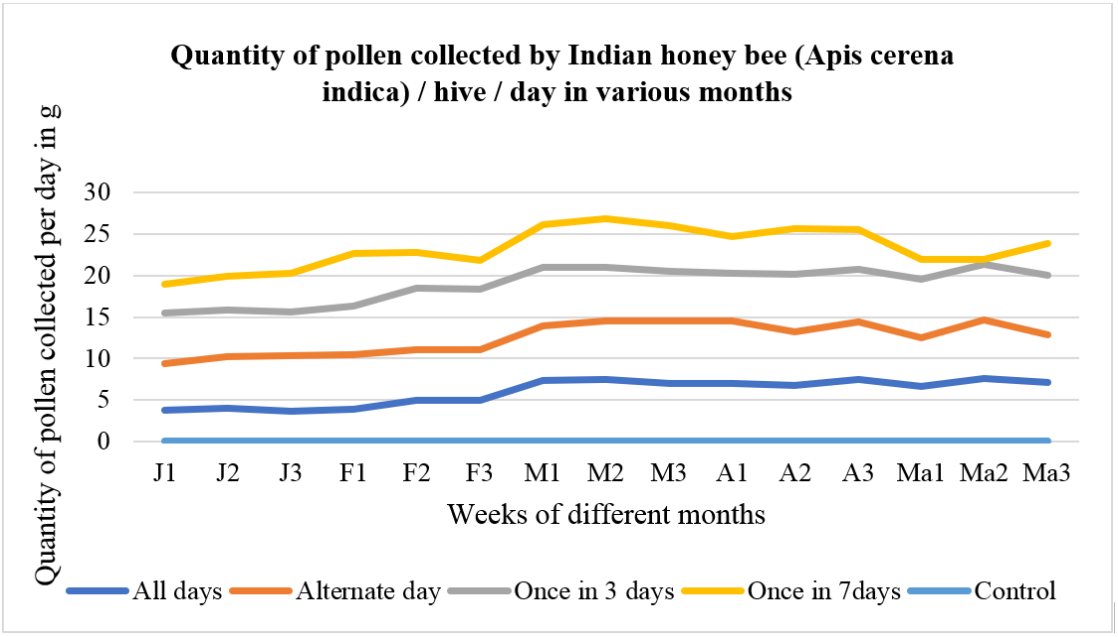

Fig. 2. Quantity of pollen collected by Indian honey bee (*Apis cerana indica*)/hive/day in various months.

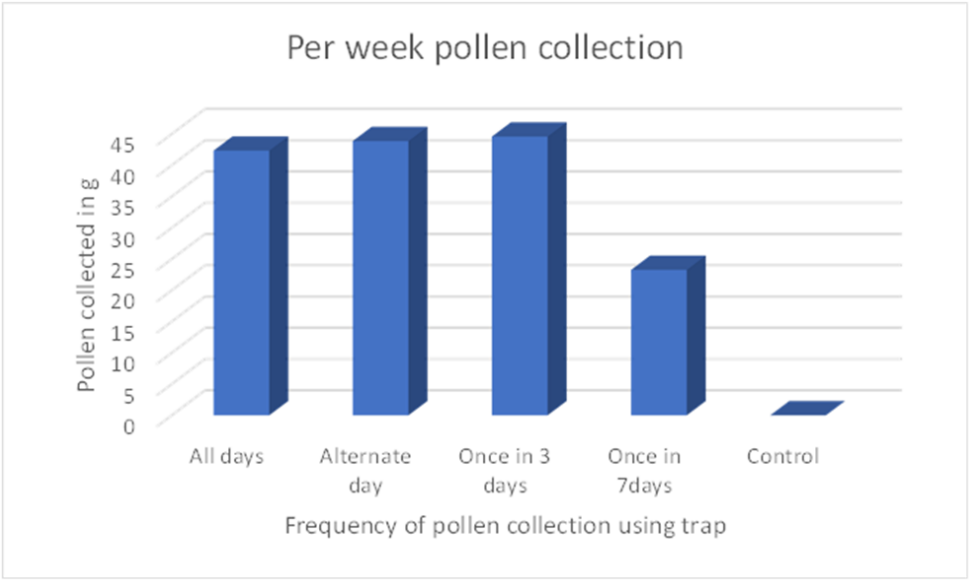

Fig. 3. Mean weekly pollen collection.

Similarly, El-Dakhakhni *et al.* (1986) noted the lowest pollen amounts during the winter season due to scarcity of pollen sources and decreased temperatures (with a recorded temperature of 18.70°C in January), significantly affecting the foraging behaviour of bees as studied by Nisa *et al.* (2023). These findings are further supported by research conducted by Shaheen (2012) and Abou El Naga *et al.* (2008), who also indicated that the highest pollen quantities were collected in the spring and summer seasons. Nonetheless, Elfeel (2008) had contrasting observations, noting that the summer months (June to September) accounted for the most substantial period of pollen collection by Italian bees (31.26%), followed by spring (29.0%), autumn (21.89%), and finally winter (17.85%). This variation could be attributed to diverse climatic conditions such as temperature and humidity, as well as the presence of different honey bee species. In the present study, the reason for increased pollen collection during the months of March-April compared to other months could be attributed to the conducive weather conditions for effective bee flight during these months, unlike the other months of the year, namely January, February, and May.

CONCLUSION

In conclusion, the study investigated the pollen collection potential of Indian honey bee colonies (*A. cerana indica*) through the installation of pollen traps over a five-month period in a coconut orchard. The results demonstrated that the highest pollen yield occurred in March with January exhibiting the lowest pollen count. This pattern suggests a correlation between pollen collection and the flowering seasons. Notably, a gradual increase in pollen collection was observed in the weeks following the installation of pollen traps, possibly due to the honey bees' acclimation to the new trap. It was concluded that placing pollen traps for a period of 2 h in a day between 7 and 9 am for 3 days in a week can be recommended in coconut ecosystem to get maximum pollen yield of 44.58 g / hive/ week and without adversely affecting the honey bees. The findings align with previous research on other bee species, such as Italian honey bees (*A. mellifera*), which have shown similar trends in pollen collection related to seasonal changes. These insights contribute to our understanding of pollen trap efficiency and its impact on honey bee colonies, shedding light on the potential benefits and challenges of implementing such techniques for studying and supporting bee health and pollination dynamics.

FUTURE SCOPE

Standardizing the method of pollen collection using pollen traps in *A. cerana indica* can help to increase revenue of bee keepers by selling the bee collected pollens.

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Conflict of Interest. None.

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