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Multiple Honey Harvesting Strategy - migratory Beekeeping in Tamil Nadu and Puducherry, India

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Authors' contributions

This work was carried out in collaboration between both authors. Author KN designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author RK managed the analyses of the study. Both authors read and approved the final manuscript.

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ABSTRACT

Commercial beekeeping in Tamil Nadu and Puducherry depends on Indian bee, *Apis cerana* indica. The State had occupied first position in honey production in the country until 1990's. In commercial beekeeping, migration has assumed really important dimensions. Our results demonstrated that total brood area reached the highest area of 1286.86 cm2 at January II at Puducherry site and lowest brood area at May II (527.38 cm2) at Chidambaram sites. Similarly, a significant difference was noticed in the mean total brood area, pollen area and queen prolificacy between the different migratory sites. Pollen area (cm2) was 155.22±7.88 to 272.56±9.61 cm2. The largest fortnightly mean pollen area was in February I (272.56±9.61 cm2) at Puducherry site, while the lowest was in June II (165.46±7.30 cm2) Chidambaram site. Egg laying area peaked in January II (297.81±4.75 cm2) at Puducherry site and rapidly declining through February, March, and April to reach its lowest point in May II (122.05±4.26 cm2) at Chidambaram site. In contrast, a non-significant difference

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was observed in nectar area and honey yield at different migratory sites (P>0.05). Current findings add to our understanding the honey yield was high in all the migratory sites without any differences by the way multiple honey harvest was possible in migratory beekeeping practices.

Keywords: Migratory beekeeping; Apis cerana indica; multi season; honey; flora; foraging.

1. INTRODUCTION

Beekeeping is the activity of keeping and overseeing honey bees for the production of honey and other goods as well as for the pollination of crops [1]. Tamil Nadu, India's second-largest producer of honey, has a long history of beekeeping. Tamil Nadu's natural and cultivated vegetation both provide enormous possibilities for the growth of beekeeping businesses [2]. The Indian state of Tamil Nadu borders the union territory of Puducherry. One of the rare Tropical Dry Evergreen Forest (TDEF) eco-regions in the world may be found in the Puducherry bio-region [3]. According to evidence, honey bees in tropical regions may feed almost all year long [4]. But human land use has an impact on the variety, availability and composition of floral resources [5]. As a result, honey bees migrate long distances in search of areas with a greater diversity of floral resources [6]. Recognising this natural occurrence, beekeepers migrate their colonies from locations with scarce floral resources to those with abundant floral resources in order to support colony development and reproduction. According to reports, the plan is more cost-effective for producing honey than stationary beekeeping [7,8]. Multiple season honey yields that are a result of seasonal colony management and the availability of floral resources determine the profitability migratory beekeeping [9]. Migratory beekeeping is practiced to overcome these deficits in the availability of bee flora and to find out where the bees can resort to flows at different times of the year. This helps not only to prevent colony losses but even to increase colony number and get additional honey production [10]. A migratory system of beekeeping is more economical than a stationary beekeeping system, with 4-5 harvests per year, and boosts the beekeeper's income [11]. Pollination activity is even more important in migratory beekeeping, since crops and wild plants from different regions and different flowering seasons benefit from honey bee foraging behaviour [12].

In India, there are different vegetation zones with shorter or longer gaps between plant flowering times. As a result, different numbers and lengths of floral dearth periods occur throughout the year. Therefore, migratory beekeeping management is a significant alternative to increase honey output while lowering the colony's supplemental feeding expenses during times of scarcity. This will help make migratory beekeeping more lucrative and sustainable. Despite the potential of the nation's apicultural resources, comprehensive information on the management of migratory beekeeping is inadequate. The current study was conducted in order to learn more about all of these elements.

2. MATERIALS AND METHODS

Five colonies were subjected to migratory beekeeping studies for a period of one year (mid-August 2021 to mid-August 2022) at three different migratory sites, Karaikal (KKL), Puducherry (PY) and Chidambaram (CDM).

Table 1. Migratory beekeeping location

S. No.	Location	Latitude	Longitude	Vegetation	Duration
1.	KKL	10.921° N	79.755°E	Teak	Mid-August to mid-September, 2021
		10.976° N	79.824°E	Eucalyptus	Mid-September to October, 2021
		10.921° N	79.755°E	Coconut	November to December, 2021
2.	PY	11.944° N	79.756°E	Common floral vegetation	January to mid-February, 2022
		11.945° N	79.756°E	Cashew	Mid-February to March, 2022
3.	CDM	11.350° N	79.729°E	Sesame	April to mid-May, 2022
		11.359° N	79.726°E	Moringa	Mid-May to mid-August, 2022

2.1 Brood Rearing Behaviour

The total area under brood which comprised of eggs, larvae and pupae was measured at different migratory sites with the help of OHP sheet (1 cm x 1 cm square grid) placed over the brood frames and the comb area occupied by uncapped (eggs and larvae) and capped (pupae) brood was counted after brushing off the bees [13]. Observations were made at a fortnightly interval from mid-August 2021 to mid-August 2022. The total brood area of the colony was calculated using the following formula:

Total brood area (colony/cm^2) = 'n' x 2 x number of frames

Where;
'n' = 1 cm^2 square of comb covered by brood
1 cm^2 = 4.86 cells on the comb in *A. cerana indica.*

The cells with brood scattered in different places in a comb was counted separately and converted into square centimetres.

2.2 Pollen and Honey Hoarding Behaviour (Storage)

The comb portion containing cells filled with stored pollen and ripe and unripe (sealed and unsealed) honey was measured by the grid method at fortnightly interval during the period of experimentation and expressed in sq. cm. The total area under stored pollen was calculated in the same way as the total brood rearing area for each colony [13].

2.3 Queen Prolificacy (Egg Laying Efficiency)

Queen prolificacy was measured in terms of egg laying rate by the queen. In order to determine the number of eggs laid by the queen per day [14]. The queen prolificacy was calculated as:

Queen Prolificacy = Total brood area (cm^2) x 4.86 /21.

The cells with brood scattered in different places in a comb was counted separately and converted into square centimetres.

2.4 Honey Yield

Honey yield = comb weight (before extraction) - comb weight (after extraction)
Expressed in Kg/colony.

2.5 Statistical Analysis

In the data analysis, the data were calculated and presented as means followed by standard errors. The Kruskal–Wallis test was applied to compare the different locations. Statistical significance was indicated at $p < 0.05$, $p < 0.01$, and $p < 0.001$. The figures were prepared by GraphPad Prism software.

3. RESULTS

3.1 Brood Rearing Behaviour

Area of egg (cm^2) was ranged from 134.42±6.05 to 425.82±5.45 cm^2 and reached the maximum egg area of 425.82±5.45 cm^2 at September II. Area of Larva (cm^2) was ranged from 96.87±6.36 to 384.47±5.46 cm^2 and attained the peak at January II (384.47±5.46 cm^2) and minimum level in May II (96.87±6.36 cm^2). Pupal area of bees (cm^2) was ranged from 246.74±5.29 to 633.75±6.60 cm^2. The mean pupal area showed the peak at January II (633.75±6.60 cm^2) and a minimum level in June I (254.42±5.98 cm^2). Total brood area (cm^2) was ranged from 1286.86 to 527.38 cm^2. The fortnight mean total brood area reached the highest area of 1286.86 cm^2 at January II at PY site and lowest brood area at May II (527.38 cm^2) at CDM migratory sites during 2021-2022 (Fig. 1).

3.2 Pollen and Honey Hoarding Behaviour (Storage)

The range of pollen area (cm^2) was 155.22±7.88 to 272.56±9.61 cm^2. The largest fortnightly mean pollen area was in February I (272.56±9.61 cm^2), while the lowest was in June II (165.46±7.30 cm^2). The range of honey area (cm^2) was 632.88±7.15 to 1217.44±15.64 cm^2. At, January II, the fortnightly mean honey reached its high. (1217.44±15.64 cm^2) and November I (632.88±7.15 cm^2) (Fig. 2).

Pollen area (cm^2) during 2022–2022 varied from 135.02±52.35 to 280.16±29.90 cm^2. The fortnightly mean pollen area peaked in February I before progressively declining in March, April and May to reach its lowest point in June II. Between 506.24±5.72 and 1460.88±18.77 cm^2 of honey were produced. The fortnightly mean honey area peaked in January II and fall in November I (Fig. 2).

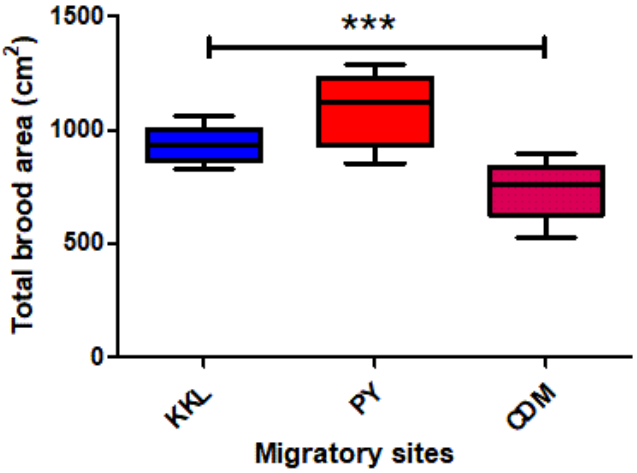

Fig 1. Fortnight values (mean) of the total brood area (cm^2) of *A. cerana indica* at different migratory sites. The asterisks indicate significant differences between the migratory sites (* $p < 0.001$)**

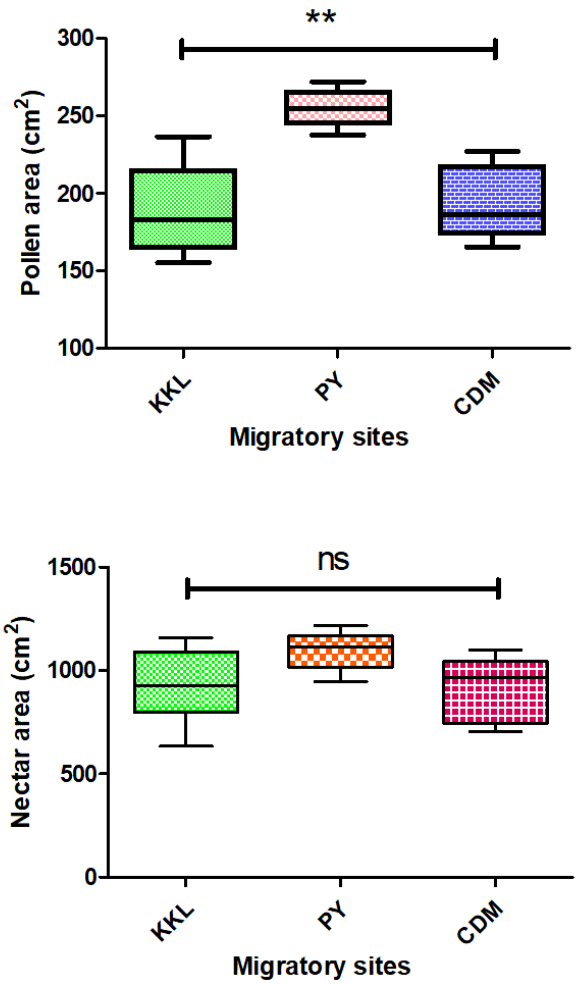

Fig 2. Fortnight values (mean) of pollen and honey area (cm^2) of *A. cerana indica* at different migratory sites. The asterisks indicate significant differences between the migratory sites ($p < 0.01$, ns – Non significant)**

3.3 Queen Prolificacy (Egg Laying Efficiency)

The range of egg laying / day (cm^2) was between 122.05±4.26 and 297.81±4.75 cm^2. The fortnightly mean egg laying area peaked in January II (297.81±4.75 cm^2) at PY site and rapidly declining through February, March, and April to reach its lowest point in May II (122.05±4.26 cm^2) at CDM site (Fig. 3).

3.4 Honey Yield

The range of honey yield in 2021–2022 at various migratory locations was 0.28±0.27 to 2.60±0.33 kg/colony, with January II recording the highest yield and October I the lowest (Fig. 4).

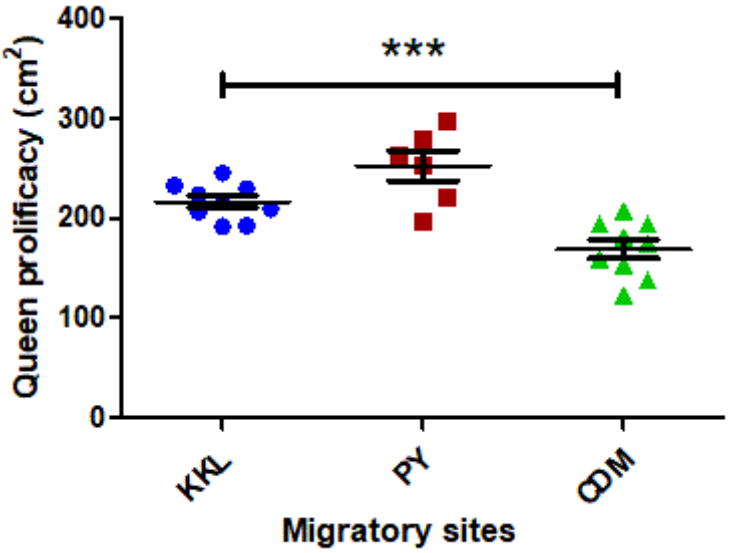

Fig. 3. Fortnight values (mean) of queen prolificacy (cm^2) of *A. cerana indica* at different migratory sites. The asterisks indicate significant differences between the migratory sites (* $p < 0.001$)**

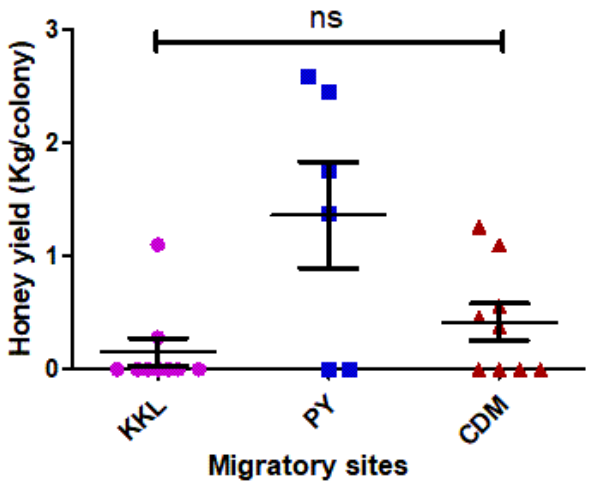

Fig 4. Fortnight values (mean) of honey yield (Kg/colony) of *A. cerana indica* at different migratory sites. The asterisks indicate significant differences between the migratory sites (ns-Non significant)

4. DISCUSSION

4.1 Brood Rearing Behaviour

The current discoveries are bolstered by [15] recorded maximum brood rearing activities during March and April and less activity during the rainy season, which is in agreement with our results. Identical observations were recorded under Assam and Orissa conditions [16,17]. Brood rearing activity was greatest in January to March, and a minimum in July, followed by a sharp increase in August [18]. In contrast, brood area was greatest in May (*A. cerana* 3226 cm^2) but, brood rearing was lowest in January [19]. First migratory site in Solan, HP, had a brood area of 381.4±170.45 cm^2 in the month of November. February, second migratory site in Hisar, Haryana, area 426.8±160.33 cm^2. Ambala (Haryana), was the third migration location, with an average brood area of 272.2±27.27 cm^2 [20]. *A. mellifera* colonies under migratory beekeeping on Eucalyptus blooming, brood area of 15850.9 cm^2 compared to stationary beekeeping (14513.0 cm^2) [21].

4.2 Pollen and Honey Hoarding Behaviour (Storage)

Pollen area and honey stores in December were 61.25 and 201.25 cm^2, respectively whereas, In the month of February, pollen and honey store were 189.37 and 876.25 cm^2, respectively [22]. The colonies' pollen storage was documented to have high in April and minimum in June. From November through April, the honey area grew steadily [23]. First migratory site in Solan, HP had a pollen area of 34 2±6.48 cm^2 and a nectar area of 290.4±186.18 cm^2 in the month of November. The second migratory location in Hisar, Haryana, measured the pollen area (217.8±109.59 cm2) and nectar area (1312.4±344.96 cm^2) in February. Ambala third site, Haryana, has a pollen area of 219±37.10 cm^2 and a nectar area measuring 1144.2±253.82 cm^2 in March [20]. Pollen area (2765.4 cm^2) in migratory beekeeping on blossoming eucalyptus than in stationary beekeeping (2685.7 cm^2) [1].

4.3 Queen Prolificacy (Egg Laying Efficiency)

The current outcomes are also more or less in accordance with brood rearing efficiency of *A. cerana* was studied in terms of egg laying rate of the queen. The maximum brood rearing efficiency was found at Srinagar in Jammu and Kashmir than Coimbatore in Tamil Nadu [24]. Rate of egg laying was 600-700 eggs per day during peak brood rearing season [25]. The maximum egg laying rate was related to a period of floral abundance.

4.4 Honey Yield

Ahmad [26] who reported that honey yield of honey bee migrated to Rawalpindi, Islamabad, Haripur and Swat was 16.08 kg per colony. Thus, migration in colony was most profitable for honey production in these areas. Migratory bee keeping resulted in higher honey yield (41.60 kg/colony) as compared to stationary beekeeping (15.66 kg/colony), the cost structure of the two was not statistically significant. The net returns were higher in former as compared to the latter [27]. Comparative honey yield potential of *A. cerana* F. under stationary and migratory condition and observed more honey was produced in migratory condition than in stationary condition [28]. First migratory site in Solan, HP, had a honey production of 4.58±0.45 kg in the month of September. December, second migratory site in Hisar, Haryana, honey production of 22.95±0.69 kg. Ambala (Haryana), was the third migration location, with an average honey production of 12.92±0.45 kg in March [20]. Honey harvested 19.4±3.6 kg per hive at the end of December and the colonies remained there till the end of February at migratory site, Alaba, Ethiopia [29]. Thus confirms the present findings.

5. CONCLUSION

Migratory beekeeping increases honey production and lowers the feed costs of stationary beekeeping during longer periods of shortage. The study implies that local strategies for migratory beekeeping should be developed through coordination and communication between beekeepers and landowners of potential migratory bee sites. The success of beekeeping depends on some basic factors such as suitable climatic conditions, bee feed, bee management and beekeeping. Similar studies should be carried out in other parts of India to improve honey production within different land use systems and attention should be given to the practice of migratory beekeeping for crop pollination.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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