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RESEARCH PAPER

Modern approaches in apiculture: assessing comb foundation sheets for enhanced colony health and reduced wax moth damage

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Abstract: The Indian honey bee, Apis cerana indica Fabricius, is a vital indigenous pollinator and honey producer in India, but its productivity is often threatened by pests like the greater wax moth (*Galleria mellonella* Linnaeus), which damages combs, reduces brood area and lowers honey yields. This study evaluated the effect of comb foundation sheets on brood development, wax moth infestation and colony performance under Dharwad conditions. Eight colonies were established at the Biodiversity Park, College of Agriculture, UAS, Dharwad and provided with four treatments: empty frames, 50% comb foundation sheets, 100% comb foundation sheets and farmers' method (piece of natural comb), each with two replications. Colonies were monitored at 15-day intervals from November 2024 to January 2025. Colonies with 50% comb foundation sheets recorded the largest brood area and minimal wax moth infestation, while 100% foundation sheets showed the lowest brood area due to absconding and high wax moth larval counts. Optimum size foundation sheet use promoted natural comb building, enhanced brood growth without affecting their behavior and strengthened colonies, offering a practical strategy to optimize colony health and sustainability in Dharwad.

Key words: *Apis cerana indica*, Colony health, Comb foundation sheets, Wax moth

Introduction

The Indian honey bee, *Apis cerana indica* Fabricius, is a native species commonly found in the wild and widely used for domestication and honey extraction in southern regions of India. This indigenous Asian pollinator has been largely exploited for honey collection and crop pollination for generations. However, the sustainability and profitability of apiculture are often threatened by pests and diseases that compromise colony health and productivity. Among various pests, the greater wax moth (*Galleria mellonella* Linnaeus) is considered one of the most destructive (Al-ettaby 2025). Its larvae feed on beeswax, pollen and brood combs, creating silken tunnels that weaken colonies, reduce honey yields and in severe cases, lead to complete colony abandonment (Kwadha *et al*. 2017). Infestation is particularly problematic in weak or poorly managed colonies and can cause economic losses of up to 60–70% in developing countries (Ebadi. 1980). Wax moth infestations may also facilitate the spread of bacterial diseases such as American and European foulbrood, further endangering colony health (Negi *et al*. 2019). In regions such as Dharwad and surrounding districts, wax moth attacks pose a significant challenge due to limited floral diversity, insufficient nectar and pollen sources and suboptimal colony management. These factors reduce foraging efficiency, weaken colonies and decrease honey production (Free, 1993). To address these challenges, innovations such as comb foundation sheets have been explored using which bees-build combs correctly in the frame area, the combs are composing entirely of worker cells, the construction of drone cells is reduced and also observed quick construction (Taranov,1959). Evaluating their effectiveness under Dharwad location, is essential for maintaining colony stability and sustainability. Given these considerations, this study aims to assess the impact of comb foundation sheets on colony health, wax moth infestation and colony sustainability provided to brood chamber of hives in Dharwad location, providing insights for sustainable and productive beekeeping practices.

Material and methods

The study was conducted at the Biodiversity Park, College of Agriculture, UAS, Dharwad, Karnataka from November 2024 to January 2025. Before colony establishment, cages were cleaned and made ant-proof, monkey-safe and theft-proof at the installation sites. Eight colonies of the Indian honey bee *Apis cerana indica* (local strain) were procured from local beekeepers and through natural hiving in Dharwad and nearby villages. The colonies were successfully established in November 2024. In December 2024, four treatments were applied to brood chambers: empty brood frames, 50% comb foundation sheet, 100% comb foundation sheet and the farmer's method (a piece of comb), each replicated twice (Table 1). Brood area development was recorded every 15 days using a grid method with each square measuring 2.50 cm². Bees were gently removed and brood cells were counted on both faces of each frame. Scattered cells were included and the total area was converted into cm². Squares with more than 50% coverage were counted

Table 1. Treatment details provided to brood chamber

Tr. No.	Treatment Details
T_1	Empty brood frames
T_2	Brood frames with 50% comb foundation sheet
T_3	Brood frames with 100% comb foundation sheet
T_4	Farmers practice (Piece of natural comb)

Table 2. Brood area in hives provided with different treatments

Month	Brood area (cm^2)			
	Empty frames (T1)	50% combfoundation sheets (T2)	100% combfoundation sheets (T3)	farmers' method (piece of natural comb)(T4)
December	298.58	363.26	31.48	342.86
January	338.76	444.33	*	423.75

* = colony absconded

Table 3. Wax moth larva count in the hives provided with different treatments

Period of observation	EmptyFrames (T1)	50% comb foundation sheets (T2)	100% combfoundation sheets (T3)	farmers' method (piece of natural comb) (T4)
I fortnight of December	10	0	15	0
II fortnight of December	42	0	53	0
I fort night of January	0	0	0	6
II fortnight of January	0	1	0	33
Mean	13	0.25	17	9.75

as one full cell while those with less than 50% were excluded (Ningappa and Prabhu, 2009). Colonies were also examined fortnightly for wax moth infestation and larval counts were recorded. Bottom boards were cleaned at regular 15-day intervals. Data from two replications were averaged to obtain mean values for each treatment and analyzed statistically using a two-sample t-test to determine significant differences in brood area among treatments.

Results and discussion

The brood area of *Apis cerana indica* colonies varied significantly among different comb foundation treatments. Colonies provided with 50% comb foundation sheets recorded the maximum brood area (444.33 cm^2 in January) followed by the farmers' method (423.75 cm^2) and empty brood frames (338.76 cm^2), whereas colonies with 100% comb foundation sheets showed the least brood area (31.48 cm^2) due to absconding caused by wax moth attack. While T_2 showing highest brood area development that is half foundation sheet may be because of, the provision of half-length foundation sheets may offer additional flexibility, as the remaining open space allows the bees to construct drone and queen cells according to their colony requirements. So, these may ensure a regular hexagonal pattern that guides worker building behaviour, thereby reducing the time and energy required to construct perfectly sized cells. When the foundation cell size closely matches the species natural worker cell dimensions, bees are able to draw comb more quickly and queens can lay eggs more consistently, resulting in increased brood area. This balance between guided construction and natural comb-building freedom ensures a well-organized hive architecture, promotes efficient brood rearing and supports resource storage, ultimately contributing to the superior performance observed in colonies with half-foundation sheets.This shows that use of 50% comb foundation sheets enhanced brood rearing activity and overall colony strength. Colonies with 50% comb foundation sheets exhibited better comb construction and brood expansion, likely because partial foundations allowed natural comb building behavior while maintaining uniform cell structure. Excessive use of foundation (100%) appeared to restrict worker activity and reduce brood space, resulting in poor colony growth and affecting their natural behavior in colony construction. These findings agree with earlier observations by Shrestha *et al.* (2021) and Joshi *et al.* (2023) who reported that appropriate use of foundation sheets support balanced brood development and colony vigor (Table 2). Brood area was negatively correlated ($r = -0.86$) with wax moth infestation. Strongercolonies maintained larger brood areas and resisted pest attack due to increased hygienic behavior and thermal regulation, as noted by Devi *et al.* (2023) and Negi *et al.* (2019). Similar findings were reported by Wankhade *et al.* (2025) where colonies with greater brood area exhibited lower pest incidence. The clear differences in wax moth infestation were observed among colonies provided with different comb foundation treatments. Colonies with 100% comb foundation sheets recorded the highest number of wax moth larvae, while those with 50% comb foundation sheets had the least infestation. During December, colonies with empty brood frames and 100% comb foundation sheets showed noticeable infestation (10 and 42 larvae for empty brood frames; 15 and 53 larvae for 100% comb foundation sheets). Colonies with 50% comb foundation sheets remained nearly free from larvae, and those under the farmers' method (piece of natural comb) had no infestation. By January, infestation declined in most colonies, though a sudden increase (33 larvae) was seen in the farmers' method. The mean number of larvae per box was highest in colonies with 100% comb foundation sheets (17 larvae) followed by empty brood frames (13 larvae), farmers' method (9.75 larvae) and 50% comb foundation sheets (0.25 larvae).

Table 4. Correlation between brood area and wax moth infestation in *Apis cerana indica* colonies at Dharwad

Parameter	Brood area in cm^2	waxmoth infestation (larvae/box)
Pearson's correlation coefficient (r)	1	-0.86

Note: Values represent Pearson's correlation coefficient (r). A strong negative correlation indicates that colonies with larger brood area experienced lower wax moth infestation.

This pattern shows that colonies with 100% comb foundation sheets were more susceptible, while colonies with 50% comb foundation sheets effectively resisted infestation. Brood area data supported these results. Colonies with 50% comb foundation sheets developed the largest brood area (444.33 cm² in January), whereas colonies with 100% comb foundation sheets had the smallest (31.48 cm²) due to absconding from heavy wax moth attack. A strong negative correlation (r = –0.86) was observed between brood area and wax moth infestation, showing that colonies with larger brood areas suffered less pest damage (Table 4). Stronger colonies maintained better hygiene and defense against *Galleria mellonella* infestation, similar to findings by Kwadha *et al.* (2017) and Devi *et al.* (2023). Maintaining strong, healthy *Apis cerana indica* colonies through proper comb foundation management helps minimize wax moth damage and ensures better colony performance (Table 3).

Conclusion

The study showed that comb foundation type significantly affects brood area and wax moth infestation in *Apis cerana indica* colonies. Colonies with 50% comb foundation had the highest brood area, promoting strong brood rearing and natural cell construction based on colony needs without affecting their natural behavior. Use of 100% foundation limited comb building, reducing brood area and increasing wax moth attack. 50% foundation sheetuses improved resistance to wax moths, while empty frames and the farmers' method showed intermediate results. A strong negative correlation between brood area and wax moth larvae indicated that healthier colonies are more resilient.

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