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# Sustainable Bee Hotels: Strategies, Evidence, and Best Practices for Solitary Bee Conservation

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Solitary bees are essential pollinators for both wild plants and crops, yet are increasingly threatened by habitat loss, pesticides, and urbanization. Artificial "bee hotels" are promoted worldwide as conservation tools to supplement diminishing natural nesting sites, but their success depends on design, placement, and maintenance. This article synthesizes the latest literature and the results of a structured field experiment in South India, critically evaluating occupancy, material preferences, and species outcomes. Data confirm that bamboo and untreated wood attract greater bee diversity and occupancy relative to plastic or clay, with mixed-material hotels further boosting visitation across taxa. Community science, ongoing monitoring, and evidence-based management are imperative to maximize conservation value and avoid common pitfalls, such as disease buildup or dominance by invasive species.

**Keywords:** Solitary bees, bee hotel, biodiversity, bamboo, pollinator conservation, artificial nesting, urban ecology, species occupancy

## Introduction

Solitary bees, comprising a vast number of species worldwide, underpin global biodiversity and agricultural productivity through pollination (Klein *et al.*, 2007; Ollerton et al., 2011). Unlike social honey bees, each solitary bee female provisions her own nest, often using plant stems or wood tunnels, with no division of labor. The widespread loss of suitable natural nesting sites, driven by agriculture and urbanization, has led to the global promotion of "bee hotels"—artificial trap-nest structures—for conservation and research (MacIvor, 2015; Prendergast *et al.*, 2023). However, despite their popularity, the effectiveness of bee hotels in supporting target native species—while minimizing risks from invasive species, parasites, or improper design—is still a matter for scientific scrutiny (Geslin *et al.*, 2020).

## Materials and Methods

### Study Site & Period

Field research was undertaken from May to August 2025 at the KRISAT campus, Srirengapuram, Madurai district, India. The climate was characterized by hot/humid conditions (26–34°C) and intermittent monsoon rainfall.

### Bee Hotel Design and Experimental Layout

Seven hotel designs were constructed (bamboo, reed stem, wood, paper straw, clay, plastic straw, and mixed-material: see Table 1 for details).
Each hotel:
50cm tall × 30cm wide × 15–20cm deep,
90 holes/tubes (3–12mm in diameter, 80–150mm length each),
Compartments for each material type,

Installed at 1m height, facing east-southeast, in randomized block design (RBD) across diverse floral zones (orchard, garden, apiary, shadenet, etc.).

Observations were conducted thrice weekly (mornings, afternoons, evenings), recording occupied holes, visitor species, nesting substrates, timing, and presence of parasitoids or wasps.

**Occupancy rate (%)** = (Number of occupied holes / Total number of holes) × 100

## Statistical Analysis

Mean values, standard deviation, and significance (CD) were calculated for all parameters. Visitation and occupancy data were tabulated by hotel material.

**Table 1**. Overview of Bee Hotel Designs and Field Placement

| Hotel code | Material | Main features/preparation | Nests/Holes | Placement |
|---|---|---|---|---|
| T1 | Bamboo | Bundled, Clay-Sealed tubes, 20 cm | 90 | Near apiary |
| T2 | Reed Stem | Bundled, thinner stems, 15-20 cm | 90 | Mini Orchard |
| T3 | Wood | Drilled Hardwood, Smooth holes | 90 | Orchard |
| T4 | Paper straw | Biodegradable, wax coated | 90 | Orchard |
| T5 | Clay | Sun-dried blocks, drilled holes | 90 | Near apiary |
| T6 | Plastic | Synthetic, Open tubes, Control | 90 | Shade net area |
| T7 | Mixed material | Bamboo, Reed, wood, Straw, Clay | 90 | Nursery |

**Table 2.** Occupancy & visitation by material type

| Material | Mean Occupied Holes | Occupancy Rate (%) | Bee visits (Mean) | Wasp Visits (Mean) | Parasitioids visits( mean) | Total Visits |
|---|---|---|---|---|---|---|
| Bamboo | 15.0 | 16 | 18.7 | 4.3 | 3.3 | 91 |
| Wood | 15.0 | 16 | 17.0 | 11.7 | 2.0 | 80 |
| Reed Stem | 14.0 | 15 | 15.2 | 8.0 | 2.6 | 88 |
| Paper Straw | 13.7 | 15.1 | 14.5 | 4.0 | 2.4 | 80 |
| Clay | 11.0 | 12 | 12.0 | 5.5 | 5.0 | 70 |
| Mixed material | 13.0 | 14 | 19.0 | 7.3 | 4.0 | 97 |
| Plastic straw | 11.0 | 12 | 6.0 | 2.0 | 1.0 | 36 |

**Table 3**.Nesting Site Preferences and substrate Use

| NESTING SITE | SPECIES | SUBSTRATE | SEALING BEHAVIOUR |
|---|---|---|---|
| Stone cracks | *Ceratina sp.* | Rock crevice | Seals mud + resin |
| Bamboo sticks | *Megachile sp.* | Bamboo | Leaf discs for lining/Sealing |
| Banana field soil | *Andrena sp.* | Soil tunnels | Soil capping |
| Flower pots | *Osmia sp.* | Potteries,hollow sticks | Mud partitions |
| Stacked bricks | *Ceratina sp.* | Brick gaps | Mud,resin capping |

## Discussion

**Material Matters**: Bamboo and wood show significantly higher bee occupancy—likely owing to superior moisture control, insulation, and resemblance to natural nesting preferences (MacIvor, 2015; Fortel *et al.*, 2016). Plastic and clay underperformed due to condensation, poor temperature buffering, and (for plastic) a lack of grip or natural scent cues (Geslin *et al.*, 2020; Goulson, 2025).

**Placement & Orientation**: East or southeast-facing hotels, sheltered from rain and wind and located near abundant floral resources, exhibited the highest activity, confirming global recommendations (Prendergast *et al*., 2023).

**Community and Ecosystem Impact:** Mixed hotels encouraged the greatest diversity but also increased presence of parasitoids and wasps, highlighting the need for regular monitoring and cleaning. Most bee occupancy occurred in spring and early summer, aligning with native bee phenology.

**Risks and Recommendations:** Annual cleaning is essential to reduce disease and mite accumulation (at odds with some public recommendations; see Goulson, 2025). Hotels should not be oversized (ideally <100 holes) to avoid unnaturally aggregating pests and parasites. A variety of diameters and natural materials maximizes benefit for native bee diversity.

## Conclusion

Bee hotels, when informed by ecological science, provide valuable supplemental nesting for solitary bees, especially in human-impacted landscapes. Optimal conservation outcomes are achieved with bamboo and hardwood substrates in moderate, carefully sited, and wellmaintained installations. The involvement of schools, gardeners, and researchers can further amplify pollinator benefits and community engagement, provided that monitoring and adaptive management are in place to address unintended risks.

## References

1. Geslin, B., et al. (2020). Bee hotels host a high abundance of exotic bees in an urban environment. *Acta Oecologica*, 104, 103544.
2. MacIvor, J.S. (2015). 'Bee hotels' as tools for native pollinator conservation: A premature verdict? *PLoS ONE*, 10(3), e0122126.
3. Prendergast, K.S., et al. (2023). Checking in at bee hotels: Trap-nesting occupancy and the influence of habitat type. *Urban Ecosystems*, 26, 701-717.
4. Fortel, L., et al. (2016). Urban bee diversity: how habitat and landscape structure shape species composition and functional traits. *Ecology and Evolution*, 6(11), 3702–3717.
5. Goulson, D. (2025). Improving Bee Hotel Design: The Big Bee Hotel Experiment. *The Buzz Club*.
6. Klein, A.-M., et al. (2007). Importance of pollinators in changing landscapes for world crops. *Proceedings of the Royal Society B*, 274, 303–313.
7. Ollerton, J., et al. (2011). How many flowering plants are pollinated by animals? *Oikos*, 120, 321–326.