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"Pollination Efficiency of Native vs. Non-native Bee Species in Western India"

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Abstract

Pollination is a critical ecological service that sustains biodiversity and agricultural productivity. In India, particularly in the Western Ghats, a biodiversity hotspot, both native and non-native bee species contribute to pollination. However, their relative efficiency remains underexplored. This study investigates the pollination efficiency of native versus non-native bee species in Karanjali, Taluka Peth, District Nashik, Maharashtra. The region's rich floral diversity and subtropical climate make it an ideal site for comparative pollination studies.

Native bees such as *Xylocopa*, *Tetragonula*, and *Apis cerana indica* are adapted to local flora and exhibit specialized behaviors like buzz pollination. Non-native species, notably *Apis mellifera*, are widely introduced for commercial pollination but may lack ecological compatibility. Field observations, pollen deposition analysis, and fruit set measurements were conducted to assess efficiency. Preliminary findings suggest that native bees outperform non-native counterparts in terms of single-visit efficiency and flower fidelity, especially for indigenous crops. This research underscores the importance of conserving native pollinators and integrating them into sustainable agricultural practices. The study contributes to ecological understanding and offers practical insights for biodiversity conservation and agroecosystem management in Western India.

Keywords

Pollination Efficiency, Native Bee Species, Non-native Bees, Western Ghats Biodiversity, *Apis cerana* vs. *Apis mellifera*

Introduction

Pollination is a cornerstone of terrestrial ecosystems, facilitating the reproduction of over 80% of flowering plants and contributing to the yield of more than 75% of global crops (Klein et al.). Bees, as primary pollinators, play a pivotal role in maintaining ecological balance and food security. In India, the Western Ghats—a UNESCO World Heritage Site—harbour an extraordinary diversity of bee species, both native and non-native, that interact with a wide array of flora (Myers et al.).

The Western Ghats stretch across six states, including Maharashtra, and are characterized by tropical rainforests, montane grasslands, and rich river systems. This region supports over 4500 species of flowering plants and is home to numerous endemic and rare species (Gadagkar; Daniels). The ecological complexity of the Ghats makes them an ideal setting for studying pollinator dynamics.

Native Bee Species in the Western Ghats

Native bees in the Western Ghats include solitary and eusocial species such as *Xylocopa* (carpenter bees), *Tetragonula* (stingless bees), *Apis cerana indica* (Indian honeybee), and *Megachile* (leafcutter bees) (Kumar et al.; Batra). These species have co-evolved with local flora, exhibiting specialized behaviors that enhance pollination efficiency (Raju; Rehel et al.).

- *Xylocopa spp.* are known for buzz pollination, a technique vital for crops like tomatoes and brinjals (Buchmann).
- *Tetragonula spp.*, particularly *T. iridipennis*, are stingless bees that thrive in humid forests and contribute to pollination of small, tubular flowers (Kumar et al.).
- *Apis cerana indica* shows high flower fidelity and adapts well to seasonal floral changes (Verma and Dulta).

These native bees are resilient to local climatic conditions and often forage across diverse plant species, contributing to genetic diversity and ecosystem stability (Ghazoul; Somanathan et al.).

Non-native Bee Species

The most prominent non-native bee species in India is *Apis mellifera*, the European honeybee. Introduced for commercial honey production and crop pollination, *A. mellifera* has become widespread across agricultural landscapes (Crane; Singh et al.). While it is efficient in mass pollination, its ecological compatibility with native flora is limited (Oldroyd).

Studies have shown that *A. mellifera* may outcompete native bees for floral resources, potentially disrupting local pollination networks (Paini et al.; Goulson). Moreover, its foraging behavior is less specialized, and it may not effectively pollinate certain indigenous crops that require buzz pollination or deep floral access (Roubik).

Ecological Importance of Native Bees

Native bees contribute significantly to the pollination of wild plants, medicinal herbs, and minor crops that are often overlooked in commercial agriculture (Kevan and Baker). Their role in maintaining biodiversity is crucial, especially in regions like the Western Ghats where endemic plant species rely on specific pollinators (Daniels; Thomas et al.).

Research conducted in the Nilgiri Biosphere Reserve highlights the decline of *Apis dorsata* (giant honeybee) populations due to habitat loss and competition from non-native species (Rehel et al.). Similarly, stingless bees from the genus *Tetragonula* are under-documented despite their ecological importance (Kumar et al.).

Study Rationale

The study area, Karanjali (Lat 20.249698, Long 73.586143), located in Taluka Peth, Nashik District, lies within the northern reaches of the Western Ghats. The region features mixed deciduous forests, agricultural fields, and sacred groves—ideal habitats for diverse bee populations (Joshi and Gadgil).

This research aims to compare the pollination efficiency of native and non-native bee species in this region. Efficiency will be measured through parameters such as pollen deposition, fruit set, and flower visitation rates. The findings will inform conservation strategies and promote the integration of native pollinators into sustainable farming practices (Klein et al.; Ollerton et al.).

Materials and Methods

Methodology

3.1 Field Observations

Bee activity was monitored during daylight hours (7 AM to 5 PM). Observers recorded species, visitation frequency, and foraging behavior. Each flower species was observed for 10-minute intervals across multiple plots.

3.2 Pollen Deposition

Flowers visited by bees were collected immediately after visitation. Pollen grains were stained and counted under a microscope to determine deposition rates. Native bees were found to deposit more pollen per visit, especially on tubular flowers.

3.3 Fruit Set Analysis

Marked flowers were tracked for fruit development. Fruit set was calculated as the ratio of successfully developed fruits to total flowers visited. Native bees showed higher fruit set in brinjal and tomato crops.

3.4 Statistical Modeling

Efficiency metrics were analyzed using:

- **ANOVA** to compare mean differences
- **Linear regression** to correlate visitation rate with fruit set
- **Chi-square tests** for categorical data (e.g., presence/absence of fruit)

3.5 Ethical Considerations

No bees were harmed during the study. Observations were non-invasive, and floral samples were collected responsibly. Permissions were obtained from local authorities and farmers.

Discussion

The results clearly demonstrate that native bee species outperform non-native bees in pollination efficiency across multiple parameters. This aligns with global studies emphasizing the ecological importance of native pollinators (Goulson; Klein et al.).

1. Behavioural Adaptations

Native bees like *Xylocopa spp.* exhibit buzz pollination, a technique essential for crops such as tomato and brinjal. This behavior is absent in *Apis mellifera*, which relies on generalist foraging strategies. Buzz pollination increases pollen release and enhances fertilization, explaining the higher fruit set observed in native bee-pollinated crops (Buchmann).

Tetragonula spp. and *Apis cerana indica* showed strong flower fidelity, revisiting the same species repeatedly. This behavior ensures targeted pollen transfer, reducing wastage and increasing reproductive success (Verma and Dulta).

2. Ecological Compatibility

Native bees are better adapted to the local climate and floral architecture. Their smaller size, foraging range, and nesting preferences align with the microhabitats found in the Western Ghats (Somanathan et al.). In contrast, *Apis mellifera* often struggles with deep or complex floral structures and may abandon flowers prematurely.

Moreover, native bees contribute to the pollination of wild and medicinal plants, which are often neglected in commercial agriculture. This supports biodiversity and ecosystem resilience (Daniels; Ghazoul).

3. Competition and Displacement

The presence of *Apis mellifera* can lead to competitive exclusion of native species. Studies have shown that non-native bees monopolize floral resources, reducing the foraging success of native bees (Paini et al.). In Karanjali, *A. mellifera* was observed displacing *A. cerana* from mustard fields during peak bloom.

This competition may lead to long-term declines in native bee populations, threatening ecological balance and crop diversity. Conservation strategies must prioritize native bee habitats and regulate the introduction of non-native species (Oldroyd; Rehel et al.).

4. Agricultural Implications

Farmers in Nashik and surrounding regions often rely on *Apis mellifera* for pollination due to its commercial availability. However, this study suggests that integrating native bees into farming systems can enhance yield, reduce dependency on managed hives, and promote sustainable agriculture.

Practices such as maintaining hedgerows, planting native flowering species, and preserving nesting sites can support native bee populations. Agroecological models that include native pollinators are more resilient to climate change and pest outbreaks (Kevan and Baker).

Conclusion

This study highlights the superior pollination efficiency of native bee species over non-native *Apis mellifera* in the Western Ghats region of Maharashtra. Native bees demonstrated higher pollen deposition, stronger flower fidelity, and significantly greater fruit set across multiple crops and wild plants.

The ecological compatibility of native bees with local flora and their specialized behaviours—such as buzz pollination—make them indispensable to both natural ecosystems and agricultural landscapes. In contrast, non-native bees, while useful in commercial settings, may lack the precision and adaptability required for optimal pollination in biodiverse regions.

The findings underscore the urgent need to conserve native bee habitats and integrate them into farming practices. This includes:

- Protecting forest patches and sacred groves
- Reducing pesticide use
- Promoting floral diversity in agroecosystems
- Educating farmers about the benefits of native pollinators

Future research should explore long-term population dynamics, the impact of climate change on bee behavior, and the role of native bees in pollinating underutilized crops and medicinal plants.

By valuing and preserving native pollinators, we not only safeguard biodiversity but also ensure food security and ecological resilience for generations to come.

Results

Field observations across five flowering plant species revealed distinct differences in pollination behavior and efficiency between native and non-native bee species.

1. Visitation Rate

- *Apis cerana indica* and *Xylocopa spp.* showed higher visitation rates during early morning and late afternoon hours.
- *Apis mellifera* dominated mid-day foraging but exhibited lower flower fidelity.
- *Tetragonula spp.* were consistent throughout the day, especially on small tubular flowers.

Bee Species	Avg. Visits/Hour	Flower Fidelity (%)	Dominant Time
Apis cerana indica	45	82%	Morning
Xylocopa spp.	30	88%	Morning/Evening
Tetragonula spp.	25	90%	All Day
Apis mellifera	50	65%	Midday

2. Pollen Deposition

Microscopic analysis of pollen grains deposited per visit showed:

- *Xylocopa spp.* had the highest pollen load per visit, especially on brinjal and tomato.
- *Apis mellifera* deposited fewer pollen grains per visit, often requiring multiple visits for successful fertilization.

3. Fruit Set

- Native bees led to higher fruit set percentages across all crops.
- Tomato and brinjal showed a 20–30% increase in fruit set when pollinated by native bees compared to *A. mellifera*.

Crop Species	Fruit Set (%) – Native Bees	Fruit Set (%) – Non-native Bees
Tomato	78%	52%
Brinjal	72%	48%
Mustard	65%	60%
Wild Turmeric	80%	55%
Forest Jasmine	75%	50%

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