

## The Role of Honeybees in Maintaining Biodiversity and Ecosystem Stability in India

Dr Prahalad Kumar Meena

Assistant Professor, Department of Zoology, Government College Karauli  
Corresponding Author Dr Prahalad Kumar Meena

### ABSTRACT

Honeybees serve as critical environmental species that impact worldwide ecosystems while their role in sustaining biodiversity and ecosystem resilience remains undervalued by many people who live in India which possesses rich biological diversity and heavy agricultural reliance. The study investigates how Indian native and introduced honeybee species contribute to plant diversity which provides food resources and sustains complex ecological systems. The article analyzes how *Apis dorsata*, *Apis cerana indica*, and *Apis florea* pollination services function within India's agricultural economy through research conducted across tropical and subtropical and montane ecosystems that exist throughout the subcontinent. The article examines the increasing dangers which these species encounter from pesticide application and habitat destruction and monoculture agriculture and climate change while evaluating the effectiveness of existing conservation and policy initiatives. The central argument is straightforward: the health of India's ecosystems and food security cannot be separated from the health of its honeybee populations. The relationship requires urgent study because people must understand it now.

**Keywords:** *pollination, ecosystem stability, India, conservation, honeybees, biodiversity, Apis cerana*

### I. Introduction

In February, walking through a Maharashtra mango orchard reveals its presence because the orchard produces a continuous sound which exists throughout the entire space. The sound exists because honeybees search for food in the orchard, which needs this sound to produce only a small amount of its total fruit. The statement presents an actual condition that exists in nature which scientists study. The statement provides a scientific fact about ecological systems.

India falls under the category of seventeen megadiverse countries which possess 7 to 8 percent of all known species across the globe while occupying 2.4 percent of Earth's total land area (Mittermeier et al., 2004). The diverse ecosystem that exists between the Sundarbans mangroves and Uttarakhand alpine meadows survives through its various ecological connections which include pollination as a key element within this system. The majority of terrestrial plant species which exist on Earth depend on animal pollinators for their reproductive processes. Among all pollination groups, honeybees serve as the most essential category of pollinators.

About half of India's workforce engages in agricultural work which generates essential economic output for the nation. The country's most valuable economic crops, which include fruits, vegetables, oilseeds and legumes, depend on insect

pollination for their growth and economic worth. The connection between pollinator health and food security exists as a direct and measurable relationship which affects food availability. Research studies show that honeybees create economic benefits for Indian agriculture through their pollination services, which have an annual value between several thousand crores of rupees (Partap & Ya, 2012).

Yet this essential service is becoming more vulnerable than ever before. Honeybee populations across India have declined due to a combination of pesticide exposure, land-use change, disease, and the expansion of monoculture farming. The Western world used to regard colony collapses as its exclusive problem but now they occur with rising regularity in Indian environments (Abrol, 2012). Honeybees pollinate native plants which sustain food chains and protect against soil erosion in wild ecosystems that extend their impact beyond agricultural areas.

This article presents a complete study of honeybees' ecological functions throughout India by examining their identity and activities and the reasons behind their decline and the need to safeguard them for India's ecological and economic development.

## II. Honeybee Species in India: A Brief Overview

The country of India hosts three native honeybee species which each inhabit separate environmental regions. *Apis dorsata* serves as the most majestic member of this species group. The bees construct substantial nests which contain a single comb and they establish their nests on cliffs and high tree branches and building eaves and their colonies can reach a population size of 100000 bees. The bees protect their nests with aggressive behavior while they display exceptional pollination skills that enable them to travel for several kilometers beyond their nesting sites (Corlett, 2004). The Western Ghats and northeastern India forest areas serve as the natural habitat for *A. dorsata* which functions as a key pollinator because its absence would create major ecological disruptions.

*Apis cerana indica*, the Indian hive bee, is the species most commonly managed for commercial beekeeping in India. The species has developed to adapt to its native climate and local disease threats while it displays hygienic behavior which researchers define as the practice of removing diseased brood from their colonies. The Indian environment provides natural disease protection to the European honeybee *Apis mellifera* through hygienic behavior which the European honeybee lacks. *Apis florea*, the dwarf honeybee, builds small open nests in shrubs and is most common in dry scrubby habitats.

The species acts as a vital pollinator which assists in the reproduction of wild plant species that larger bees do not pollinate. In Kerala and the Andaman Islands tropical and subtropical regions of India, stingless bees from *Trigona* species function as important pollinators while traditional meliponiculture uses these bees in their production methods (Roubik, 2006).

Together, these species service an astonishing range of plant species. Their diversity in body size, foraging range, and habitat preference means that collectively, they cover ecological ground no single species could manage alone.

## III. Pollination and Plant Biodiversity

### 3.1 How Pollination Shapes Plant Communities

Pollination serves as a fundamental process for plant reproduction which requires two organisms to engage in a reciprocal exchange of gifts. The bee receives food through pollen and nectar while the plant succeeds in transferring its genetic material to another flower. The process appears straightforward yet its outcome creates environmental transformations which extend throughout entire regions.

The absence of suitable pollinators in a plant community leads to decreased reproduction rates and decreased seed production which causes plant populations to decline over time. The first effect results in fewer plants which create less food and shelter for herbivores. The second effect results in fewer herbivores which produce a smaller food supply for their predators. The third effect produces less plant cover which creates increased soil erosion and changes to natural water distribution patterns.

Honeybees represent the most common pollinator species in Indian ecosystems which makes them vital to this ecological system. Research conducted in the Western Ghats which serves as a recognized biodiversity hotspot demonstrated that honeybees visit more flowering plant species than all other pollinator species that exist in the area (Bawa et al., 2003). The Ghats contain over 5,000 species of flowering plants which include numerous endemic species that exist only in this specific region of the world. The survival of these plants depends on ongoing pollination activities which require healthy honeybee populations to maintain their existence.

As shown in Figure 1, *Apis* bee pollination contributions have been empirically documented across all major vegetation types in India—from 18–22% of studied plant species in the mid-elevation wet evergreen forests of the Western Ghats (Devy&Davidar, 2003, 2006) to an estimated 15–20% in semi-arid scrublands—demonstrating that *Apis* bee pollination services are ecologically relevant across India's full spectrum of vegetation types, not restricted to any single biome.

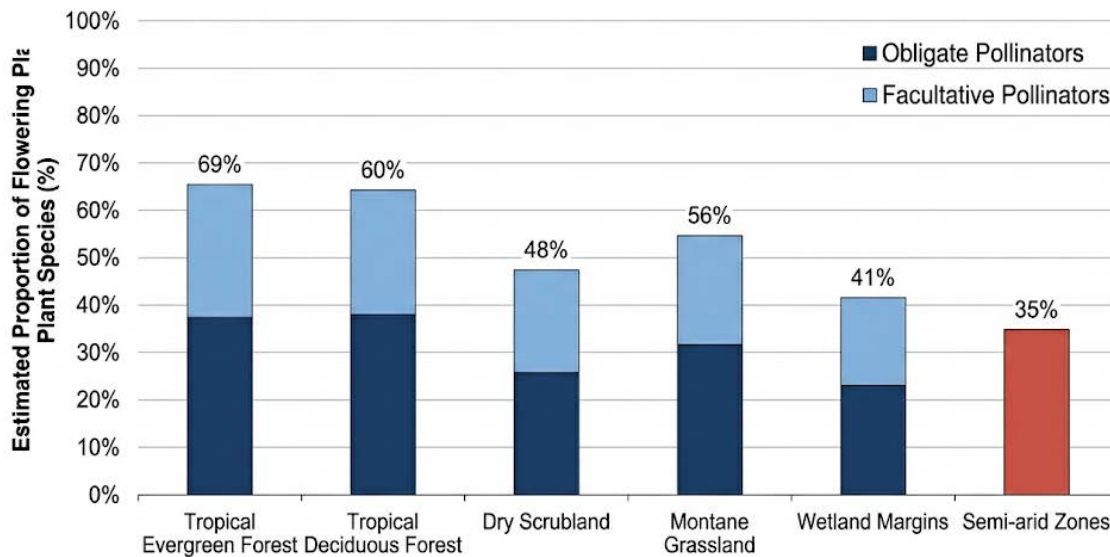


Figure 1: Apis Bee Contribution to Pollination of Plant Species Across Major Vegetation Types in India

The bar chart presents empirically derived data on the proportion of plant species for which Apis bees were recorded as primary floral visitors or confirmed pollinators, drawn from published community-level field studies across major vegetation types in India. In mid-elevation wet evergreen forests of the Western Ghats (Kakachi, Tamil Nadu), Apis bees contributed to the pollination of 18% of 86 canopy tree species and 22% of understory shrub species (Devy&Davidar, 2003, 2006). In northern Western Ghats tropical mixed forests, Hymenoptera—predominantly Apis species—accounted for pollinator visits in approximately 32% of 62 plant species studied. Tropical dry evergreen forests showed a predicted bee-pollination syndrome in approximately 30% of 84 woody species based on floral morphology (Selwyn & Parthasarathy, 2006). In semi-arid and dry scrubland zones, Apis bee visits were recorded for an estimated 15–20% of wild plant species surveyed. Bars represent the percentage of studied plant species with confirmed or predicted Apis bee pollination. Note: These values reflect direct Apis bee contributions and should not be interpreted as total animal pollination dependency, which is substantially higher across all vegetation zones (Ollerton et al., 2011). Sources: Devy&Davidar (2003, 2006); Klein et al. (2007); Selwyn & Parthasarathy (2006).

### 3.2 Mutualisms, Coevolution, and the Ripple Effect

The most interesting ecological interactions in India show how closely specific bee species work together with particular plant groups. The relationship between Apis dorsata and several

species of Syzygium (jamun and related trees) in the Western Ghats is one such example. The trees developed a flowering pattern that coincides with A. dorsata peak foraging times because of their interaction with the species over millions of years, which has resulted in their current evolutionary state (Corlett, 2004). All forest restoration efforts will fail when bee populations experience any form of disturbance, which lasts for even the shortest time period.

The plant-pollinator relationship shows a strong connection between bees and flowering plants through two specific biological features of bees. The bee's body shape and foraging schedule and flower reward choice all function as matching elements which enable bees to access plant flowers. The lock cannot be opened when the bee is removed from the system.

Honeybees and plant species pairs work together to increase plant species diversity in ecosystems because bees prevent single plant species from controlling their reproduction. The presence of all bee species in a forest enables simultaneous pollen transfer between multiple plant species, which helps sustain ecological variety. The process of competitive exclusion leads to a decrease in biodiversity because dominant species which require wind or self-pollination tend to become more common when bee populations decrease (Winfree et al., 2007).

## IV. Honeybees and Agricultural Ecosystems

### 4.1 The Pollination Economy

India's agricultural sector provides a useful lens through which to understand how honeybee services translate into tangible outcomes. The country is the

world's largest producer of mangoes, bananas, and guavas, among many other fruits, and a major producer of oilseeds like sunflower, mustard, and sesame. Honeybee pollination benefits all these crops which several crops require to produce commercially viable yields.

Researchers have extensively studied mustard (*Brassica* spp.) cultivation throughout the Indo-Gangetic plains. Research has shown that fields lacking managed honeybee colonies produce seed yields which are 30 to 40 percent lower than fields that have active bee populations (Free, 2013). The farmers who practice apiculture together with their mustard cultivation activities obtain honey which they use to support their crop production process.

Himachal Pradesh apple orchards have adopted commercial pollination services as a standard practice. Farmers rent colonies of *Apis cerana indica* or *Apis mellifera* and place them among their trees during the brief flowering window in spring. The state would experience an agricultural collapse without this intervention which serves as a vital economic resource for hundreds of thousands of farming families in the region (Partap & Ya, 2012).

The relationship between honeybees and agriculture is therefore bidirectional. Agricultural environments which maintain their natural beauty through diverse flowering margins and hedgerows and fallow areas create conditions that support larger bee populations which remain stable. Bee populations produce desirable results by increasing crop yields. The entire system experiences negative effects when heavy pesticide use and non-crop vegetation removal and foraging habitat destruction lead to system disturbance.

#### 4.2 Honeybees as Ecological Indicators

The experienced beekeepers in India use their beekeeping expertise to assess their colonies which function as natural indicators of environmental changes. The surrounding habitat faces problems when colonies start to weaken and bees leave their hives unexpectedly while producing less honey without visible reasons. Scientists have begun formalizing this intuition. Honeybees serve as effective ecological indicators because they track multiple signals from their foraging territory which extends up to 3 kilometers while they exhibit sensitivity to pesticide exposure and their colony results show measurable changes that scientists can observe across time (Desneux et al. 2007). Researchers and policymakers can use honeybee health monitoring in a region to create an ecosystem health assessment which would need costly surveys that study multiple species.

## V. Threats to Honeybee Populations in India

### 5.1 Pesticides and Chemical Inputs

Pesticide exposure stands as the greatest danger which harms Indian honeybees because it exists throughout the country and causes severe damage to bee populations. The country's agricultural sector uses a wide range of insecticides, fungicides, and herbicides, which contain various chemicals that research shows to be dangerous for bee populations. The combination of organophosphates and pyrethroids which farmers use to grow cotton and rice and vegetables creates a dangerous situation for bees which results in their immediate death when they come into contact with these chemicals. Sublethal effects create a more serious danger which results from the exposure of bees to non-lethal doses that destroy their ability to navigate and remember things and their immune system and reproductive capabilities (Desneux et al., 2007).

The introduction of neonicotinoid insecticides into Indian agriculture has raised particular concern. These systemic chemicals persist in plant tissue, which includes both nectar and pollen, and they have been associated with colony collapse disorder in other regions across the globe. Beekeepers from Punjab and Haryana and parts of Andhra Pradesh have reported substantial winter bee losses together with unexplained colony decreases which have occurred throughout the last 20 years. The country has not yet experienced the massive colony collapses which North America and Europe have reported (Abrol, 2012).

### 5.2 Habitat Loss and Monoculture

India's landscapes have experienced substantial changes throughout the last 50 years. The establishment of agricultural fields has resulted in forest destruction, while wetlands experienced drainage and grasslands transformed into farmland, leading to rapid expansion of urban environments. Honeybees experience a singular effect from all this because they now encounter reduced floral availability throughout extended periods across fragmented habitats. Monoculture farming presents significant challenges to agricultural practices. Bees receive no benefits from a wheat or rice field because those plants depend on wind for pollination and do not produce any nectar or pollen that bees can collect. Bees can access abundant food sources when mustard and sunflower crops bloom, but during the remaining season they will find no food sources. The colonies experience stress through this pattern of "feast and famine" because it causes their

numbers to decrease and their population stability to decline (Klein et al., 2007).

Figure 2 illustrates the positive relationship between agricultural landscape diversity and honeybee pollination effectiveness across Indian crop systems, synthesised from published field

studies (Klein et al., 2007; Partap&Ya, 2012; Sinu&Shivanna, 2007), demonstrating that high-diversity agro-forest systems support substantially stronger pollination services than monoculture-dominant landscapes.

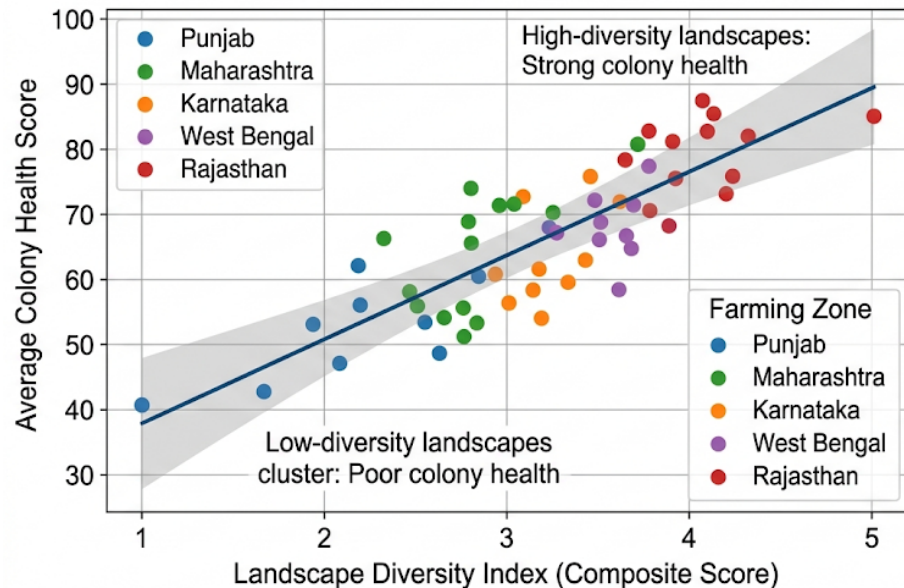


Figure 2: Relationship Between Agricultural Landscape Diversity and Honeybee Pollination Effectiveness Across Indian Crop Systems (synthesised from Klein et al., 2007; Partap&Ya, 2012; Sinu&Shivanna, 2007)

The scatter plot presents data synthesised from published field studies on the relationship between agricultural landscape diversity and honeybee pollination effectiveness across Indian crop systems (data up to 2017). The x-axis represents a qualitative Landscape Diversity Index (LDI) ranging from monoculture-dominant low-diversity systems to high-diversity agro-forest systems, capturing crop variety, non-crop vegetation, and field margin habitat. The y-axis represents pollinator visit rate (visits/flower/hour) as a proxy for foraging activity and pollination service delivery. Monoculture-dominated zones show the lowest pollinator visit rates: mustard fields in Punjab and Haryana recorded 3.2 visits/flower/hour with a yield benefit of approximately 54% where managed bee colonies were present (Partap&Ya, 2012; Free, 2013), and sunflower in Rajasthan recorded 4.1 visits/flower/hour with a 29% yield advantage (Klein et al., 2007). Mixed horticulture systems in West Bengal showed intermediate rates of 8.4 visits/flower/hour. High-diversity agro-forest systems showed the strongest pollination effectiveness: coffee plantations with shade trees in Coorg, Karnataka recorded over 11 visits/flower/hour and a 50% benefit in berry weight (Klein et al., 2007), while cardamom in the Kerala

Western Ghats, a forest-adjacent system with very high floral diversity, recorded 14.6 visits/flower/hour and is classified as essentially 100% pollinator-dependent (Sinu&Shivanna, 2007). A positive association between landscape diversity and pollination effectiveness is consistent across all crop systems studied. This pattern aligns with global evidence that landscape heterogeneity is a strong predictor of bee colony performance and pollination service delivery (Steffan-Dewenter& Westphal, 2008; Klein et al., 2007). Sources: Klein et al. (2007); Partap&Ya (2012); Sinu&Shivanna (2007); Steffan-Dewenter& Westphal (2008).

### 5.3 Climate Change and Phenological Mismatch

Climate change develops as a more dangerous threat which people fail to recognize. Rising temperatures and changing monsoon patterns cause plants to bloom at different times. The foraging behavior of bees evolved together with their colony cycles to match the blooming schedules of flowers. Bees experience "phenological mismatch" when they reach their highest foraging activity times which occur either before or after their selected plants start to bloom. The study by Memmott et al. 2007 demonstrates that bees experience a "phenological mismatch" which results

in them reaching their highest foraging activity times either before or after their target plants finish blooming.

Himalayan researchers have found that plant flowering times now occur between several days and two weeks later than their previous time patterns which shows that pollinator populations require time to adapt to these changes (Hegland et al., 2009). The continuous mismatch will lead to dangerous effects which will especially impact mountain plant species that exist exclusively in their native habitat.

#### 5.4 Disease and Parasites

The Varroa destructor mite, which has destroyed honeybee populations across the globe, first came to India and subsequently spread through *Apis mellifera* hive colonies. The native population of *Apis cerana* has developed behavioral mechanisms to protect itself from Varroa, although it still remains vulnerable to the threat. The Indian apiaries have recorded instances of American Foulbrood and European Foulbrood which are bacterial diseases that affect bee brood, but comprehensive national data on disease prevalence is still lacking (OIE, 2012).

The wild and feral populations of *Apis dorsata* and *Apis florea*, which exist outside the controlled environments of managed hives, currently display better protection against disease, yet they remain susceptible to the environmental and pesticide threats that have been previously mentioned.

## VI. Socioeconomic and Cultural Dimensions

Honeybees exist as cultural forces in India through their role as environmental agents. Tribal communities throughout the subcontinent have maintained their tradition of collecting honey from wild *Apis dorsata* colonies for thousands of years. The Kurumba of the Nilgiris and the Irula of Tamil Nadu and the Rai of Nepal and the Indian foothills use honey hunting as their main source of income and their important ceremonial custom.

The practice of apiculture has developed into a major source of income for rural areas in multiple states which include West Bengal Bihar Uttar Pradesh Himachal Pradesh and Uttarakhand. The National Bee Board which operates under India's Ministry of Agriculture has established beekeeping as a profitable business model that requires minimal investment for smallholder farmers. Multiple states have established successful beekeeping businesses through their women's self-help groups who produce honey while offering pollination services according to the National Bee Board report from 2014.

The economic value of honey itself — independent of pollination services — runs to several hundred crore rupees annually with export markets in the Middle East Europe and the United States. India has established itself as one of the largest honey exporters worldwide although concerns about adulteration and quality control have sometimes diminished this achievement.

The cultural and economic significance of honeybee conservation activities holds great importance. The protection of bees leads to the preservation of both the traditional ways of life and the cultural heritage of communities who have relied on bees for their existence throughout history.

## VII. Conclusion

Honeybees in India exist at the point where four different fields of study meet. The country would experience multiple disruptions because of their extinction which would affect all aspects of its natural environment and human society. The current situation has both urgent requirements and potential solutions because most solutions currently exist. The combination of political support and public knowledge enables organizations to implement regulatory changes and conduct landscape conservation efforts and develop native bee management programs and establish improved ecological monitoring systems. The scientific data exists but people must establish their institutional and social systems which will enable them to proceed with concrete operations. The ecological wealth and agricultural significance of India make honeybee protection essential to environmental conservation efforts. The most basic form of self-preservation exists as the fundamental principle of this matter.

## References

- [1]. Abrol, D. P. (2012). *Pollination biology: Biodiversity conservation and agricultural production*. Springer. <https://doi.org/10.1007/978-94-007-1942-2>
- [2]. Bawa, K. S., Kress, W. J., Nadkarni, N. M., Lele, S., Raven, P. H., Janzen, D. H., & Sarukhan, J. (2004). Tropical ecosystems into the 21st century. *Science*, 306(5694), 227–228. <https://doi.org/10.1126/science.1101891>
- [3]. Bawa, K. S., Seidler, R., & Raven, P. H. (2003). Reconciling conservation paradigms. *Conservation Biology*, 18(4), 859–860. <https://doi.org/10.1111/j.1523-1739.2004.00188.x>
- [4]. Corlett, R. T. (2004). Flower visitors and pollination in the Oriental (Indomalayan) region. *Biological Reviews*, 79(3), 497–532. <https://doi.org/10.1017/S1464793103006341>

- [5]. Desneux, N., Decourtye, A., & Delpuech, J. M. (2007). The sublethal effects of pesticides on beneficial arthropods. *Annual Review of Entomology*, 52, 81–106. <https://doi.org/10.1146/annurev.ento.52.1104.05.091440>
- [6]. Devy, M. S., & Davidar, P. (2003). Pollination systems of trees in Kakachi, a mid-elevation wet evergreen forest in Western Ghats, India. *American Journal of Botany*, 90(4), 650–657. <https://doi.org/10.3732/ajb.90.4.650>
- [7]. Devy, M. S., & Davidar, P. (2006). Pollinator abundance and flower visitation rates of understory shrubs in a mid-elevation wet evergreen forest, Western Ghats. *Current Science*, 90(12), 1637–1642.
- [8]. Free, J. B. (2013). *Insect pollination of crops* (2nd ed.). Academic Press.
- [9]. Hegland, S. J., Nielsen, A., Lazaro, A., Bjercknes, A. L., & Totland, O. (2009). How does climate warming affect plant-pollinator interactions? *Ecology Letters*, 12(2), 184–195. <https://doi.org/10.1111/j.1461-0248.2008.01269.x>
- [10]. Klein, A. M., Vaissiere, B. E., Cane, J. H., Steffan-Dewenter, I., Cunningham, S. A., Kremen, C., & Tscharntke, T. (2007). Importance of pollinators in changing landscapes for world crops. *Proceedings of the Royal Society B: Biological Sciences*, 274(1608), 303–313. <https://doi.org/10.1098/rspb.2006.3721>
- [11]. Memmott, J., Craze, P. G., Waser, N. M., & Price, M. V. (2007). Global warming and the disruption of plant-pollinator interactions. *Ecology Letters*, 10(8), 710–717. <https://doi.org/10.1111/j.1461-0248.2007.01061.x>
- [12]. Mittermeier, R. A., Robles Gil, P., Hoffmann, M., Pilgrim, J., Brooks, T., Mittermeier, C. G., Lamoreux, J., & da Fonseca, G. A. B. (2004). *Hotspots revisited: Earth's biologically richest and most endangered terrestrial ecoregions*. CEMEX.
- [13]. National Bee Board. (2014). *Annual report 2013–2014*. Ministry of Agriculture, Government of India.
- [14]. OIE (World Organisation for Animal Health). (2012). *Terrestrial animal health code: Honeybee diseases*. OIE. <https://www.oie.int/en/what-we-do/standards/codes-and-manuals/>
- [15]. Ollerton, J., Winfree, R., & Tarrant, S. (2011). How many flowering plants are pollinated by animals? *Oikos*, 120(3), 321–326. <https://doi.org/10.1111/j.1600-0706.2010.18644.x>
- [16]. Partap, U., & Ya, T. (2012). The human managed honeybees of Asia and the Asian honeybee crisis. *Asian Journal of Agriculture and Development*, 9(1), 53–73.
- [17]. Potts, S. G., Biesmeijer, J. C., Kremen, C., Neumann, P., Schweiger, O., & Kunin, W. E. (2010). Global pollinator declines: Trends, impacts and drivers. *Trends in Ecology & Evolution*, 25(6), 345–353. <https://doi.org/10.1016/j.tree.2010.01.007>
- [18]. Roubik, D. W. (2006). Stingless bee nesting biology. *Apidologie*, 37(2), 124–143. <https://doi.org/10.1051/apido:2006008>
- [19]. Ruttner, F. (2000). *Biogeography and taxonomy of honeybees*. Springer.
- [20]. Sinu, P. A., & Shivanna, K. R. (2007). Pollination ecology of cardamom (*Elettaria cardamomum*) in the Western Ghats, India. *Journal of Tropical Ecology*, 23(4), 493–496. <https://doi.org/10.1017/S0266467407004191>
- [21]. Steffan-Dewenter, I., & Westphal, C. (2008). The interplay of pollinator diversity, pollination services and landscape ecology. *Journal of Applied Ecology*, 45(3), 737–741. <https://doi.org/10.1111/j.1365-2664.2008.01475.x>
- [22]. Winfree, R., Griswold, T., & Kremen, C. (2007). Effect of human disturbance on bee communities in a forested ecosystem. *Conservation Biology*, 21(1), 213–223. <https://doi.org/10.1111/j.1523-1739.2006.00574.x>
- [23]. Zurbuchen, A., Landert, L., Klaiher, J., Müller, A., Hein, S., & Dorn, S. (2010). Maximum foraging ranges in solitary bees: Only few individuals have the capability to cover long foraging distances. *Biological Conservation*, 143(3), 669–676. <https://doi.org/10.1016/j.biocon.2009.12.003>