

Conservation Biology of Indigenous Honeybee Species in India: *Apis cerana* and *Apis dorsata*

Dr Prahalad Kumar Meena

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

ABSTRACT

India's indigenous honeybee species — particularly *Apis cerana indica* and *Apis dorsata* — represent millions of years of evolutionary adaptation to the subcontinent's extraordinarily diverse climates, forests, and flowering plant communities. Yet both species now face a convergence of threats that conservation biology is only beginning to fully characterize: habitat loss, pesticide contamination, displacement by introduced species, emerging pathogens, and the gradual erosion of traditional beekeeping knowledge that once sustained wild populations across generations. This article examines the conservation status of these two species through the lens of population genetics, ecological dependency, threat assessment, and management strategy. It reviews documented population declines, explores the genetic diversity that makes these species resilient — or vulnerable — depending on landscape context, and evaluates the effectiveness of current conservation frameworks in India. The article argues that conserving *Apis cerana* and *Apis dorsata* requires moving beyond apiculture-focused thinking and treating these bees as wild species embedded in complex ecological networks that deserve the same institutional attention given to large, charismatic fauna.

Keywords: *Apis dorsata*, population genetics, , India, *Apis cerana indica*, conservation biology, indigenous pollinators

I. Introduction

India has a complicated relationship with its native bees. The country has practiced beekeeping for centuries, and traditional communities across the Himalayas, the Western Ghats, and the northeastern states have deep knowledge of wild honeybee behavior. But when the modern era of commercial apiculture arrived, it brought with it the European honeybee, *Apis mellifera*, and a management philosophy that largely sidelined indigenous species. The native bees were seen as less productive, harder to manage, and — in the case of *Apis dorsata* — too aggressive to domesticate. What followed was a slow, steady marginalization of species that had been shaping India's ecosystems long before humans arrived.

Today, that marginalization is beginning to look like a serious ecological mistake.

Apis cerana indica and *Apis dorsata* are not simply alternative sources of honey. They are deeply integrated into the ecological fabric of the Indian subcontinent. They pollinate wild plant species that anchor forest ecosystems, sustain soil stability, and support the food chains upon which wildlife — including many threatened vertebrate species — depend. Losing these bees would mean losing something far larger than the bees themselves.

Conservation biology, as a discipline, asks hard questions: How many individuals remain? How genetically diverse are local populations? What is driving decline, and at what rate? Are current protected area systems sufficient? Can traditional management practices be revived or adapted? For large mammals and birds, India has developed at least partial answers to these questions. For *Apis cerana* and *Apis dorsata*, the answers remain dangerously incomplete.

This article attempts to pull together what is known, identify the most critical gaps, and make the case that India's indigenous honeybees need a conservation framework that matches the ecological significance of what would be lost without them.

II. Biology and Ecological Roles of *Apis cerana* and *Apis dorsata*

2.1 *Apis cerana indica*: The Adaptable Hive Bee

Apis cerana indica which belongs to the Asiatic hive bee family represents the better known species for management purposes. The species constructs its nesting sites through the creation of closed multi-comb structures which it establishes inside tree hollows and rock crevices and human building walls to achieve harmony with human environments. The colonies operate at smaller sizes when compared to European honeybees which results in 6000 to 10000 workers per colony but this

leads to decreased honey production and increased ability to live in different environments (Ruttner, 2000).

The conservation research value of *A. cerana* exists because of its advanced capacity to display complex behaviors. The species exhibits strong hygienic behavior — workers detect and remove diseased or mite-infested brood before infections spread through the colony. The species exhibits a natural defense system which protects it from *Varroa destructor* through which *Apis mellifera* died out across the world (Peng et al., 2016). The resistance factor presents scientific interest because it shows biological characteristics which scientists find valuable for practical applications in India where managed *mellifera* colonies face increasing *Varroa* pressure.

Apis cerana pollinates a wide range of crops and wild plants, including several that *Apis mellifera* tends to overlook due to differences in body size and tongue length. The foraging behavior of this bee species ranges between 1 and 2 kilometers while its smaller body size limits its foraging distance to shorter lengths which results in the highest bee activity occurring within the area that surrounds its nesting location.

2.2 *Apis dorsata*: The Untameable Giant

Apis dorsata operates on a completely different scale. The giant rock bee builds massive single-comb nests which exceed one meter in diameter and contain between 60000 and 100000 worker bees. The colonies of this species establish their nests on cliff faces and on tall trees and on building overhangs which their aggressive workers defend by chasing away any unapproved visitors who attempt to enter their territory.

Research scientists believe this species cannot be domesticated because it has never been tamed by humans. The species performs an essential ecological function which no other species can fulfill. *A. dorsata* forages across distances which exceed 5 kilometers and thus connects different habitat areas by transferring pollen between forest patches that smaller bees cannot reach (Corlett 2004). The critical significance of long-distance gene flow for plant species in this area exists because forest habitats continue to be divided into smaller sections. Research done in the Western Ghats shows that various tree species which exist only in this region depend on *A. dorsata* to achieve proper seed production (Bawa et al. 2003).

Various parts of India host migratory populations of *Apis dorsata*. The colonies move to different areas which contain flowering plants at different altitude and latitude positions so their conservation needs multiple protected areas. The

conservation of invertebrates requires Indian policies to develop methods for evaluating landscape networks which have not yet received proper attention.

III. Genetic Diversity and Population Structure

3.1 Why Genetics Matters for Bee Conservation

The genetic assessment of species status which conservation biologists use requires them to understand how genetic variation exists between different population groups and whether existing genetic variation continues to exist. The genetic diversity of a species functions as the fundamental element which enables its evolution through natural selection and evolutionary development. A population with high genetic diversity can successfully overcome new environmental challenges because some members possess advantageous traits which facilitate better survival. The local extinction risk of a genetically depauperate population increases because it has fewer genetic options to survive different environmental conditions.

Honeybee colonies demonstrate that their overall fitness depends on the presence of genetic diversity among their members. Colonies which contain genetically diverse workers see their production levels increase while showing better resistance to diseases and improved adaptability compared to colonies with fewer genetic variations (Seeley & Tarry, 2007). A queen honeybee mates with 10-20 males which results in wild populations using this polyandry system to sustain their within-colony genetic diversity. The mating diversity of colonies decreases when drones become less accessible because habitat loss and fragmentation occur which results in poorer colony performance.

As illustrated in Figure 1, *Apis cerana indica* populations across India show significant geographic differentiation, documented through both morphometric analysis and mitochondrial COI gene sequencing. Baskaran (2016), in the first comprehensive morphometric study of *A. cerana indica* spanning 12 districts of Tamil Nadu, found wide morphometric variation across the state, with a close relationship between colony morphology and ecological zone of origin, reflecting the strong influence of local biogeographic conditions on population-level traits. This finding is consistent with broader patterns identified by Ruttner (2000), who documented significant morphometric differentiation between northern and southern Indian populations, with body size and wing morphology correlating with latitude and elevation across the subcontinent. At the subspecies level, Chalapathy et al. (2014) confirmed through COI gene analysis that

two distinct subspecies exist within the Indian range: *Apisceranacerana* (the black or Hill morph, characteristic of northern and montane populations including the Himalayan foothills and the Northeast) and *Apiscerana indica* (the yellow or Plain morph, prevalent across peninsular and southern India), with both found in sympatry in some Karnataka localities. Together, these studies establish that Indian *A. cerana* populations are not genetically

homogeneous: they represent multiple regionally distinct groups shaped by different ecological pressures. The conservation implication is direct — the loss of any regional population would eliminate locally adapted traits that have no equivalent elsewhere in the country. Table 1 below summarises the morphometric and subspecies variation data from these published studies across sampled Indian regions.

State/Region	Study Area	Sites/Districts Sampled	Method	Key Finding	Biogeographic Zone	Source
Tamil Nadu	12 districts across the state	12 districts; n=60 colonies	35 morphometric characters measured; 24 compared with rest of India	Wide morphometric variation across districts; close relationship between morphology and ecological zone of origin confirmed	Multiple: coastal plains, dry zones, hill zones, rainforest margins	Baskaran (2016)
Karnataka	Multiple localities across the state	12 localities; COI gene sequenced	Mitochondrial COI gene sequencing; taxonomic status assessment	Two distinct subspecies confirmed: <i>A. ceranacerana</i> (black/Hill morph) and <i>A. cerana indica</i> (yellow/Plain morph); found in sympatry	Western Ghats, Deccan Plateau, coastal Karnataka	Chalapaty et al. (2014)
Pan-India (comparative)	Northern to Southern India range	Multiple states; morphometric data compiled	Morphometric comparison across Indian biogeographic zones	Significant morphometric differentiation between northern and southern Indian populations; body size and wing morphology correlated with latitude and elevation	Himalayan foothills to peninsular tip	Baskaran (2016); Ruttner (2000)
Himachal Pradesh / Himalayan region	Himalayan foothills and montane zones	Himalayan subspecies range per Ruttner (2000)	Subspecies-level biogeographic classification	<i>A. ceranacerana</i> (larger body size, cold-adapted) identified as northern mountain subspecies; distinct from <i>A. cerana indica</i> of southern plains	Montane/sub-alpine Himalayan zone	Ruttner (2000)

Northeast India (Assam / NE states)	Northeast biogeographic zone	Subspecies range documentation	Biogeographic range mapping and subspecies identification	Populations share morphological affinities with mainland Asia group; genetically closer to northern subspecies than to southern <i>A. cerana indica</i> populations	Subtropical broadleaf forest	Ruttner (2000); Chalapathy et al. (2014)
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Table 1: Morphometric and Subspecies-Level Population Differentiation of *Apis cerana indica* Across India — Evidence from Published Studies (Baskaran, 2016; Chalapathy et al., 2014; Ruttner, 2000)

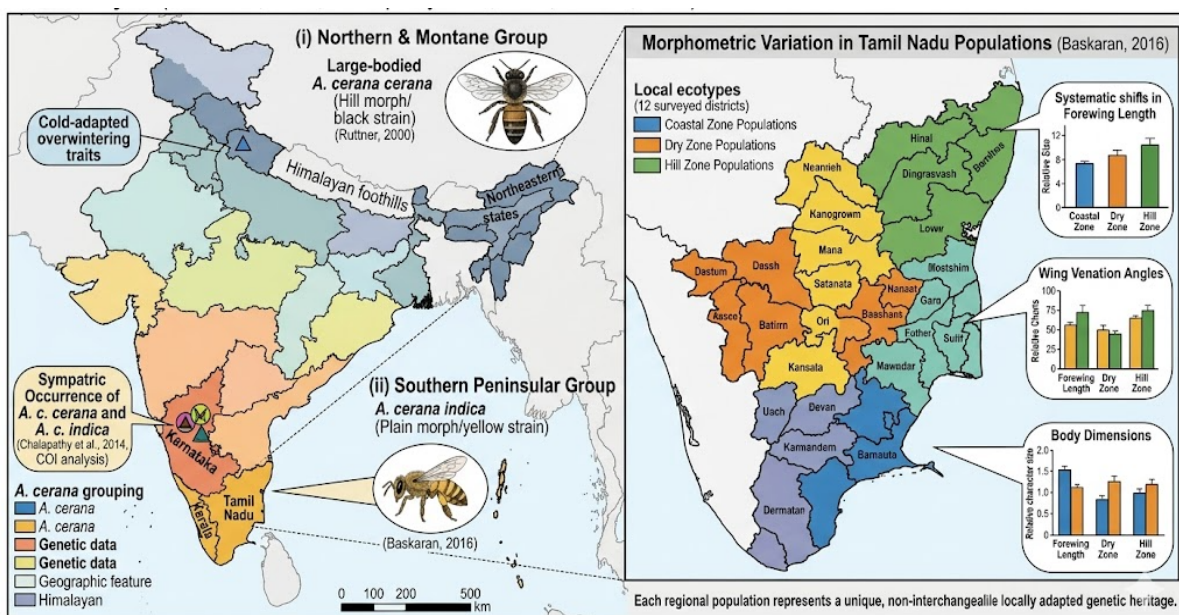


Figure 1: Geographic Differentiation of *Apis cerana indica* Populations Across India, Based on Morphometric and COI Gene Analysis (Baskaran, 2016; Chalapathy et al., 2014; Ruttner, 2000).

The figure presents a map of India indicating sampled regions across which population-level morphometric and subspecies differentiation of *A. cerana indica* has been documented. Two major population groupings are evident from the published literature: (i) a northern and montane grouping, encompassing Himalayan foothills and northeastern states, characterised by the larger-bodied *A. cerana cerana* (Hill morph/black strain) and cold-adapted overwintering traits (Ruttner, 2000); and (ii) a southern peninsular grouping, encompassing Tamil Nadu, Kerala, Karnataka, and adjacent states, characterised by the smaller-bodied *A. cerana indica* (Plain morph/yellow strain) with morphometric variation correlating strongly with local ecological zones (Baskaran, 2016). Chalapathy et al. (2014)

confirmed through COI mitochondrial gene analysis that both subspecies occur in sympatry across parts of Karnataka. Within southern populations, morphometric characters including forewing length, wing venation angles, and body dimensions show systematic variation across Tamil Nadu's 12 surveyed districts, reflecting adaptation to coastal, dry zone, and hill ecotypes (Baskaran, 2016). The figure underscores that Indian *A. cerana* populations are not morphologically or genetically uniform, and that each regional population represents locally adapted genetic heritage that is not interchangeable with populations from other zones.

3.2 Threats to Genetic Integrity

The genetic contamination of wild *Apis cerana* populations through the escape of managed colonies needs more research attention than it currently has. In states where commercial beekeeping has expanded rapidly — Bihar, Uttar Pradesh, and parts of Maharashtra — managed colonies sometimes abscond into the wild which brings genetic material from honey production populations that were specially chosen instead of local ecological adaptation (Peng et al., 2016).

Local adaptation matters enormously for wild bees. The cold valleys of Himachal Pradesh have created unique overwintering strategies which southern populations do not possess. The bees of Meghalaya's humid forests possess immune gene variants which are adapted to the pathogen communities found in tropical rainforests. The introduction of external genetic material from outside their region into these locally adapted populations will result in the erosion of their developed adaptations which took thousands of years to create. The issue exists as a less apparent problem than pesticide poisoning or habitat loss, yet it requires recognition in conservation programs.

IV. Threats to Indigenous Honeybee Populations

4.1 Pesticides and the Silent Toll

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4.2 Habitat Fragmentation and Floral Resource Loss

The migratory behavior of *Apis dorsata* makes it highly vulnerable to changes in its native

environment. The species requires its seasonal flowering resources which exist in forests and scrubland areas that suffer from both deforestation and land degradation. Colonies may attempt to establish in suboptimal sites, fail to build adequate food stores before winter or the dry season, and die. *A. dorsata* colonies do not build food reserves which enclosed-nesting species use for survival because these colonies depend entirely on their ability to move through connected territories.

The Deccan Plateau together with peninsular India's regions has experienced dry deciduous forest and scrubland loss which transformed the area into farming operations that disrupted the continuous foraging patterns of *A. dorsata* colonies. Researchers tracking colony movements in Karnataka have documented cases where colonies apparently searching for new nest sites travel through landscapes with no suitable foraging habitat and fail to establish successfully (Dyer & Seeley, 2014).

4.3 Competition from *Apis mellifera*

The introduction of *Apis mellifera* into Indian apiculture — promoted heavily from the 1960s onward as a higher-yield alternative — has had consequences for native bee populations that were not anticipated at the time. European honeybees exhibit larger body sizes and higher aggression levels during foraging activities which enable them to surpass wild *A. cerana* bees when they compete for floral resources in agricultural areas that have restricted flower diversity (Paini, 2004).

There is also a disease transmission concern. *Apis mellifera* colonies can harbor pathogens — including certain *Varroa* biotypes and bacterial diseases — that native species may not have evolved defenses against. The transmission route from managed *mellifera* colonies to wild *cerana* or *dorsata* populations involves pathogen spillover which scientists have not studied sufficiently in India yet they acknowledge this as a theoretical danger (Fürst et al., 2014).

V. Conservation Strategies and Frameworks

5.1 In Situ Conservation: Protecting Wild Populations

The most ecologically meaningful form of honeybee conservation is in situ — keeping wild populations alive in functioning habitats. The *Apis dorsata* species requires forest protection because this environment provides its essential nesting and foraging resources. The actual situation shows that existing forest conservation priorities contain significant portions of their coverage yet fail to

achieve complete matching. Indian protected areas use flagship mammal species to define their boundaries, but the habitat elements that bees need for nesting and foraging and which bees need for their conservation efforts which include large emergent trees and diverse flowering plants and absence of pesticide drift do not match mammal-centric management approaches.

Pollinator ecologists increasingly support establishing dedicated management zones for pollinators within current protected areas together with buffer zones that restrict pesticide application near forest boundaries (Ricketts et al., 2008).

Karnataka and Kerala, through their forest divisions, have started testing this method which involves collaborating with communities near forests to create pesticide-free areas while protecting flowering understory plants.

Figure 2 summarizes the conservation strategy framework that integrates in situ habitat management, ex situ colony preservation, and community-based monitoring — the three pillars that most conservation biologists agree are necessary for a comprehensive native bee conservation program.

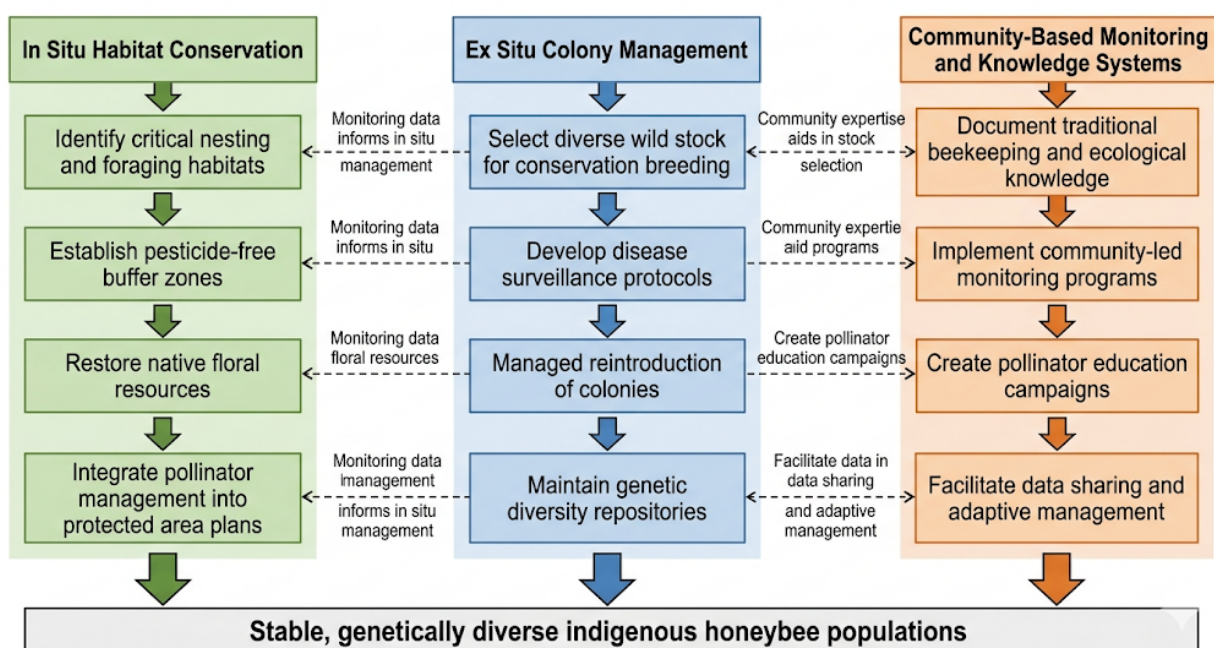


Figure 2: Integrated Conservation Framework for Indigenous Honeybee Species in India — A Three-Pillar Conceptual Model

The figure displays a flowchart-based conceptual diagram which connects three vertical pillars that extend from In Situ Habitat Conservation on the left to Ex Situ Colony Management in the middle and Community-Based Monitoring and Knowledge Systems on the right. The first pillar contains three to four action boxes which show their sequential steps through downward arrows that lead from "Identify critical nesting and foraging habitats" to "Establish pesticide-free buffer zones" and "Integrate pollinator management into protected area plans" in the left pillar. The pillars unite through horizontal arrows which show multiple connection points between the three methods that work together to create different conservation outcomes like the connection between community monitoring and adaptive management of in situ habitats. The three

pillars unite at the diagram base to create one output box which displays the result as "Stable, genetically diverse indigenous honeybee populations." The main point demonstrates that effective conservation needs all three pillars to work together because no single method can achieve success.

5.2 Ex Situ Conservation and Genebank Approaches

Ex situ conservation which refers to the practice of keeping live bee populations and their genetic material outside their natural environments shows limited effectiveness for protecting native bee species. The National Bee Research and Training Institute in Pune and several state apiculture departments maintain breeding stocks of *Apis cerana indica* but these programs focus on

improving beekeeping efficiency more than they aim to protect bee genetic heritage. An ex situ program which bases its operations on ecological knowledge should first collect genetic material from different *A. cerana* populations before those populations face disappearance through habitat destruction. Honeybee semen cryopreservation methods have reached a technical standard which multiple European nations now use for their native bee subspecies genebank programs (Pettis & Delaplane 2010). India has not yet developed a comparable program despite having far greater intraspecific diversity at stake.

5.3 Reviving Traditional Beekeeping Knowledge

India's most valuable conservation resource remains unused because it stores traditional knowledge which Indian communities accumulated through their long-term relationship with native bee populations. The Kurumba and Irula peoples of the Nilgiris and the Adi and Garo communities of the northeast together with many other ethnic groups possess detailed knowledge about *A. dorsata* nesting sites and seasonal movements and management techniques which stem from their extensive experience with these bees.

This knowledge is not simply cultural heritage to be documented and archived. It is practically useful. Traditional honey hunters can identify specific cliff faces which *A. dorsata* colonies have established as their nesting areas throughout generations dating back to their ancestral territories. Traditional timing of honey collection — based on reading colony development rather than calendar dates — represents a form of sustainable harvest management that modern conservation programs are only beginning to formalize (Crane, 2013).

VI. Conclusion

Apis cerana indica and *Apis dorsata* serve as essential elements that function within India's natural ecosystems. The two species function as essential designers who create the ecological connections that enable forests to grow again and agricultural fields to yield crops and ecosystems to maintain their various life forms. The conservation of these species represents an ecological problem which should receive national priority because people have treated it as a secondary matter for too extended a period.

Conservation biology has the tools to address this challenge. The field provides established research methods which include population genetics and habitat modeling and threat assessment as well as community engagement and policy advocacy. What has been lacking is institutional will and a coherent framework that

places these bees where they belong — at the center of India's biodiversity strategy rather than its margins.

The process of protecting them will need people to discuss uncomfortable topics which include pesticide regulations and land use planning and the impact of introduced species and the rights of traditional knowledge holders. Those conversations are worth having. The alternative — continuing to lose wild native bee populations while treating honey production as an adequate metric of success — is an ecological gamble India cannot afford.

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