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Insect diversity in the Hill Regions of Rajasthan: A review

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Abstract
Insects form the most diverse class of organisms on Earth, playing indispensable roles in ecosystem functioning. The hill regions of Rajasthan, though often overshadowed by the state's dominant desert biome, represent ecologically significant pockets that support unique insect biodiversity. These areas, primarily located along the Aravalli hill range, include habitats such as Mount Abu, Kumbhalgarh and Sariska, which display remarkable microclimatic and floral variation. This review explores existing literature and field findings on insect diversity in Rajasthan's hill ecosystems, categorizing observed species by order and ecological function. The paper also highlights pressing conservation concerns, identifies research gaps, and proposes strategies for sustainable biodiversity management in these regions.

Keywords: Conservation, hills, insect diversity, management, Rajasthan, sustainable

Introduction
Rajasthan is India's largest state by area and is generally known for its arid and semi-arid landscapes, particularly the Thar Desert. However, interspersed within this seemingly inhospitable terrain are the Aravalli hills, an ancient mountain range that supports varied ecosystems. These habitats create microclimates with increased humidity and vegetation density, favourable to diverse insect communities. Recent biodiversity surveys indicate that these hilly zones are under-documented but biologically rich (Prajapat *et al*., 2025 [16]; Kumar & Sharma, 2025) [13].

Ecological and Geographical Context
The Aravalli Range and Hill Systems
The Aravalli range, stretching from Delhi to Mount Abu, comprises varied ecological habitats, from dry deciduous forests to moist plateaus. Kumar & Sharma (2025) [13] surveyed the Todgarh-Raoli Wildlife Sanctuary, a mid-altitude hill system, and found it to support over 41 butterfly species, demonstrating its conservation value. Similarly, surveys in Ajmer district highlighted how different microhabitats like hilltops, scrublands, and urban campuses contribute to diverse Lepidoptera communities (Sharma *et al*., 2023) [17]. A phytosociological study (Katewa and Sharma, 2016) [11, 18] revealed that overgrazing in Aravalli grasslands altered plant community structure by favouring hardier, low-palate grasses—a shift that indirectly affects insect niches and resource availability. The 2014 ZSI monograph remains a seminal source, comprehensively cataloguing Odonata and Lepidoptera in the Aravalli foothills, setting a taxonomic baseline that informed subsequent biodiversity assessments. The Forest Survey of India report (2006) highlighted the critical forest patches in the Aravalli hills, noting that undisturbed mixed deciduous forests support the richest insect faunas, which are often missing from degraded landscapes. A land use assessment by Meena *et al*. (2007) [15] documented habitat fragmentation around Jaipur and Udaipur, correlating forest loss with decline in butterfly and beetle diversity.

Climatic Variation and Its Impact
The elevation-induced climatic variation in these regions (higher humidity, moderated temperature) directly supports species like cavity-nesting bees and ants, which thrive in shaded forest patches or urban treescapes (Koli *et al*., 2025) [12]. Such microclimatic buffers also protect insect life from the harsher surrounding desert biome.

Diversity of Insect Orders in Hill Regions
Lepidoptera
Lepidoptera are perhaps the most studied insect group in Rajasthan's hill regions. Early work by Sharma (2001) documented 40 butterfly species in the Aravalli hills near Jaipur, describing habitat preferences and larval host plants, laying groundwork for later ecological studies. Recent work in Todgarh-Raoli Wild Life Sanctuary has catalogued several rare and endemic butterfly species, with the family Lycaenidae showing the highest species richness (Kumar & Sharma, 2025) [].. Ajmer's central Aravalli hills have shown a similarly diverse composition, with Nymphalidae and Pieridae dominating, influenced by microhabitat variation and vegetation density (Sharma *et al*., 2023). Swami and Lekha (2020) [23] studied an agro-ecosystem near Udaipur using light traps across vegetable, pulse, and oilseed fields, finding that Lepidoptera comprised 23-33% of captures, followed by Hemiptera and Coleoptera, with Shannon diversity indices between 1.595 and 1.731. A 2016 study in the Aravalli Range documented 38 species of Lepidoptera associated with vegetable crops, supported by five Hymenoptera, four Odonata, three Hemiptera, and single-family representation from Coleoptera and Neuroptera—highlighting multi-order roles in agro-ecosystems and complementing earlier forest-focused surveys (Sharma, 2016). Singh *et al*. (2010) [22] documented butterfly fauna in the Aravalli hills near Jaipur, recording 47 species with detailed notes on seasonal abundance and habitat preference, contributing foundational baseline data.

Coleoptera
Coleopteran diversity in the Jaipur Aravalli reserves (Jhalana and Galta) is particularly notable. A 2025 study

recorded 56 beetle species, with the Scarabaeidae and Carabidae families showing strong seasonal variation. The Shannon Index for diversity peaked during the monsoon months, reflecting the close tie between moisture and beetle abundance (Prajapat *et al*., 2025) [16]. Additional studies have revealed how Scarabaeidae composition in the Jaipur region shifts with rainfall, vegetation type, and human activity (Yadav *et al*., 2024) [25]. A flower visitor survey near Bikaner on ridged gourd (*Luffa acutangula*) reported 66 insect species from 7 orders and 33 families, with peak floral visitor diversity in May (Bhati *et al*., 2020) [4]. A field survey in Sariska Tiger Reserve reported 52 species of beetles, emphasizing the ecological roles of dung beetles and predatory coccinellids in pest regulation (Kumar and Singh, 2012) [14]. Chauhan and Singh (2002) [5] reported one of the earliest detailed surveys of predatory beetles in the Sariska Tiger Reserve, emphasizing their role in natural pest control within forest ecosystems.

Hymenoptera

A study in Sariska Tiger Reserve by Bhardwaj *et al*. (2020) [3] documented patterns of ***Apis dorsata*** colonization, indicating strong seasonal and spatial clustering of wild bee colonies in hill forests. Bee populations are crucial pollinators in Rajasthan's hill flora. A study conducted in Abu Road on *Caesalpinia bonduc* observed 16 species of bees, including *Apis dorsata* and *A. florea*, which were among the most frequent floral visitors (Devanda & Charan, 2024) [6]. Stingless bees and solitary species like *Xylocopa* also play a key role, especially in semi-evergreen forest belts. Gupta and Sharma (2011) [8] assessed pollinator diversity on cumin and coriander crops in Rajasthan, recording 18 pollinator species including *Apis mellifera* and native solitary bees, highlighting pesticide impacts on population dynamics. In 2018, Joshi (MPUAT) conducted a detailed assessment of insect pollinators on coriander, cumin, and fennel, finding 12-13 pollinator species from Hymenoptera, Diptera, Coleoptera, Hemiptera, and Lepidoptera—the work underscored ***Apis florea*** dominance and compared pesticide-treated versus untreated plots. Bhatnagar *et al*. (2018) [2] documented insect pollinators on *Murraya koenigii* flowers in Rajasthan, recording three Lepidoptera and five Hymenoptera species—demonstrating pollinator breadth in traditional plant systems. In 2004, Joshi *et al*. studied wild bee diversity across agroforestry plots in southern Rajasthan, reporting 15 species with high activity during flowering seasons of key crops.

Odonata

Freshwater bodies in hill regions like Mount Abu and Sariska support a range of dragonflies and damselflies. Although recent specific surveys are sparse, ongoing monitoring projects are increasingly incorporating audio-based detection and machine learning to track insect activity across seasons (Shetty & Kumar, 2025) [20, 21].

Orthoptera and Hemiptera

Though often considered agricultural pests, grasshoppers and bugs are an integral part of the hill ecosystem's food web. In the central Aravallis, surveys report seasonal fluctuations and species turnover influenced by vegetation dynamics and grazing pressure (Sharma *et al*., 2023).

Ecological Roles of Insects

Pollination

Pollination is arguably the most crucial ecosystem service provided by insects. In the Aravalli and Vindhya-Malwa transition zones, native plants such as *C. bonduc* and *Wrightia tinctoria* depend on bees and butterflies for successful reproduction (Devanda & Charan, 2024 [6]; Arpita *et al*., 2025) [1].

Nutrient Cycling and Decomposition

Dung beetles and saprophagous flies form essential guilds for nutrient cycling in hilly forests. Recent studies in Jaipur highlight the abundance and activity of Scarabaeidae during monsoon seasons, which aligns with increased biomass and detritus availability (Yadav *et al*., 2024) [25].

Biological Control

Ants and parasitoid wasps help regulate aphid populations on native shrubs and trees. Urban studies from Udaipur suggest that cavity availability in green spaces fosters populations of solitary wasps and predatory ants that can serve as natural pest control agents (Koli *et al*., 2025) [12].

Trophic Linkages

Insects form a crucial prey base for birds, reptiles, and bats in the hill ecosystems. Several butterfly and beetle species recorded in Mount Abu and Kumbhalgarh form part of the diet of insectivorous avian fauna (Sharma *et al*., 2023 [17]; Kumar & Sharma, 2025).

Threats to Insect Diversity

Habitat Destruction and Fragmentation

Infrastructure development, especially in Mount Abu and Sariska, has led to habitat fragmentation. Butterfly species with specific host plant requirements are most vulnerable to such disruptions (Kumar & Sharma, 2025) [20]. An environmental assessment linked rapid urbanization around Jaipur to fragmentation of forest patches, leading to documented declines in insect species richness, particularly among pollinators and butterflies (Verma and Meena, 2015) [24].

Climate Change

Recent field studies report shifts in the seasonal activity of Scarabaeidae and Lepidoptera, likely influenced by altered rainfall patterns and rising temperatures (Yadav *et al*., 2024 [25]; Prajapat *et al*., 2025) [16].

Pollution and Agrochemical Runoff

Hilly farmlands adjacent to reserves often use pesticides that affect local pollinator and aquatic insect populations. Moreover, urban light pollution has been shown to disrupt moth activity and beetle navigation (Koli *et al*., 2025) [12]. The Udaipur agro-ecosystem light trap study by Swami and Lekha (2020) [23] also highlighted the presence of Coleoptera and Diptera alongside Lepidoptera, suggesting that insect assemblages are sensitive to pesticide use and seasonal cropping cycles.

Invasive Species

Non-native species like *Paratrechina longicornis* (crazy ant) have been observed displacing native ant communities in semi-urban zones of southern Aravallis (Arpita *et al*., 2025) [1].

Deforestation and Overgrazing

The ZSI Flora & Fauna Survey of the Aravalli Range (2008) documented 878 insect species but also warned that increasing deforestation and overgrazing had started degrading key insect habitats.

Conservation Strategies

Biodiversity Inventories

Ongoing studies now emphasize DNA barcoding and acoustic monitoring to catalogue cryptic or nocturnal insect species (Shetty & Kumar, 2025) [20, 21]. This is essential for accurately documenting underreported groups like moths and parasitic wasps.

Protected Areas and Buffer Zones

Studies like those in Todgarh-Raoli (Kumar & Sharma, 2025) [20] and Abu Road (Devanda & Charan, 2024) [6] suggest the need to expand buffer zones around existing sanctuaries to preserve pollinator corridors.

Sustainable Tourism

Eco-tourism initiatives such as butterfly walks, insect safaris, and interpretation centers are being piloted in areas like Mount Abu, leveraging data from recent species checklists (Sharma *et al*., 2023) [17].

Community Engagement and Education

Using local ecological knowledge and incorporating farmer observations on seasonal insect patterns (Yadav *et al*., 2024) [25] can support conservation-friendly agricultural practices.

Future Research Directions

Advancement of Acoustic and AI-Based Species Recognition

Building on recent developments (Shetty & Kumar, 2025), future studies should expand the use of bioacoustic sensors and machine learning algorithms for accurate, non-invasive species identification, particularly in remote or densely vegetated habitats.

DNA Barcoding of Cryptic Taxa in Lepidoptera and Hymenoptera

To resolve taxonomic ambiguities, especially among morphologically similar species, further investment in molecular techniques such as DNA barcoding is needed, focusing on understudied insect orders like Lepidoptera and Hymenoptera.

Long-Term Monitoring of Pollinator-Plant Interactions

Consistent with the findings of Devanda & Charan (2024) [6], longitudinal studies are essential to assess the stability and dynamics of pollination networks under climate and land-use change scenarios.

Urban Biodiversity Planning Based on Cavity Availability

Urban ecology research should prioritize the role of cavity-bearing trees and structures, as highlighted by Koli *et al*. (2025) [12], to inform biodiversity-sensitive urban planning and green infrastructure design.

Melanoplus bivittatus

Heteronychus arator

Silpha spp.

Tarucus balkanicus

Poekilocerus pictus

Scopula inductata

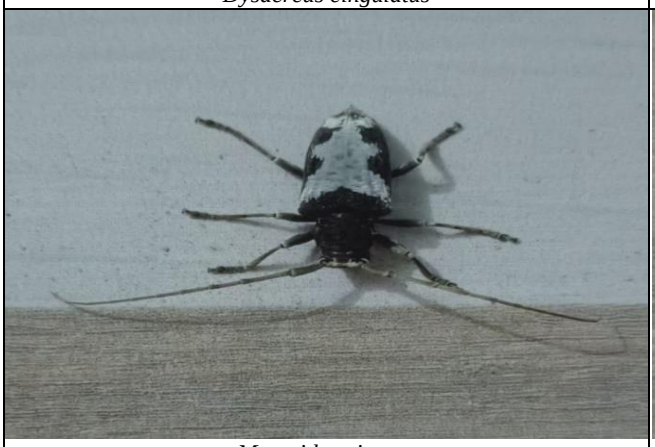
Fig1: Some Insect Species Found in the Hilly Regions of Rajasthan

Lymantria dispar

Chinavia hilaris

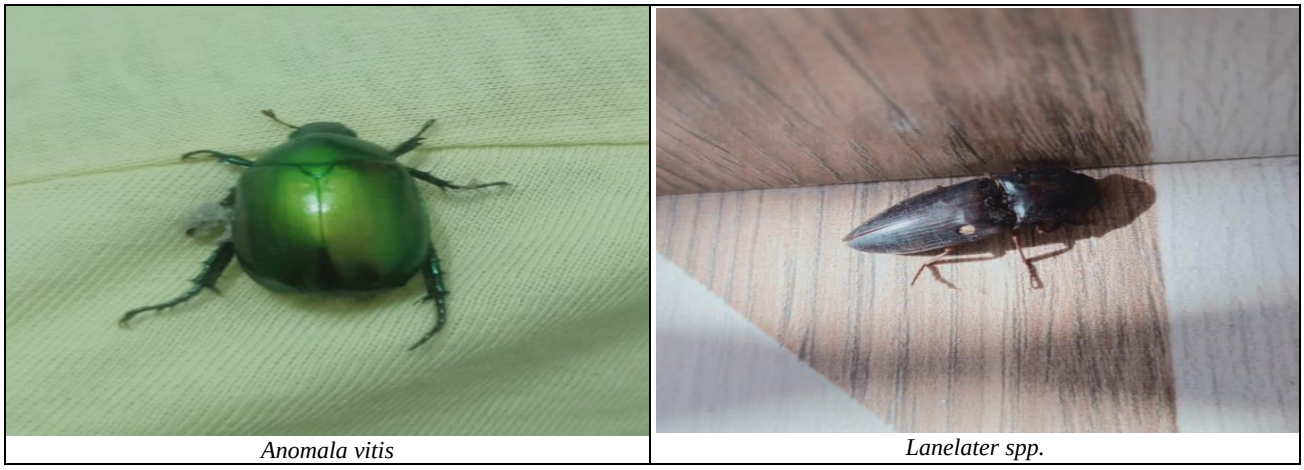
Dysdercus cingulatus

Coptocephala gebleri



Metopides nivosus

Tarachodes spp.



Anomala vitis | *Lanelater spp.*

Fig 2: Insect Species Found in the Hilly Regions of Rajasthan

Conclusion

Rajasthan's hill regions serve as critical insect biodiversity hubs in an otherwise arid landscape. Recent studies emphasize the richness of beetles, butterflies, bees, and aquatic insects across varying elevations and microhabitats. However, increased human activity, climate variability, and lack of coordinated conservation strategies pose threats. By integrating recent scientific tools, ecological surveys, and local participation, these ecosystems can be better understood and preserved.

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