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Distribution and Impact of Beetles in Agriculture and Integrated Pest Management (IPM)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Review Article

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ABSTRACT

The Indian subcontinent, with its diverse landscapes and climate variables, harbors a rich and varied beetle fauna. This effort aims to provide an overview of the distribution patterns of beetles across the region, considering factors such as geographical location, altitude, temperature, and rainfall. By analyzing existing literature and conducting field surveys, we had identified key beetle hotspots and assess the impact of human activities on their distribution. Understanding the distribution of beetles in the Indian subcontinent is crucial for conservation efforts and ecological research. The species which are studied: Blister Beetle, Aquatic Beetle, Ladybird Beetle, Dung Beetle, Ground Beetle. This review article focusses on the major beetles found in the Mohali region of Punjab. This article also focuses on the IPM which is the holistic approach to pest management that combines various strategies to minimize pesticide use while maintaining crop productivity and profitability. Beetles play a significant role in IPM strategies, both as targets of control measures and as beneficial agents that can be harnessed for natural pest suppression.

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Keywords: beetles, IPM strategies, morphology; geographical distribution.

1. INTRODUCTION

Beetles, belonging to the order Coleoptera, are the most diverse group of insects on Earth, and their distribution across the subcontinent is influenced by various factors, including geography, climate, vegetation, and human activities. Beetles are having over 400,000 described species. They are characterized by a hardened exoskeleton and a pair of forewings modified into protective covers called elytra. This amazing diversity is reflected in their wide range of sizes, shapes, colors, and habitats. Beetles can be found in virtually every terrestrial and freshwater ecosystem, playing crucial roles as predators, herbivores, decomposers, and pollinators. Beetles play complex and multifaceted roles in agricultural systems. While many species are significant pests that cause economic losses, others are beneficial organisms that contribute to natural pest control and ecosystem services. IPM strategies aim to manage beetle pests while harnessing the benefits of beneficial beetles. A comprehensive understanding of beetle biology, behavior, and interactions within the agroecosystem is essential for developing effective and sustainable IPM programs.

2. BLISTER BEETLE

Blister beetles are beetles of the family Meloidae, so called for their defensive secretion of a blistering agent, cantharidin. About 7,500 species are known worldwide. Many are conspicuous and some are aposematically colored, announcing their toxicity to would-be predators (Wikipedia).

A few adults are nocturnal, but most are diurnal or show no distinct diel cycle. Since adults are gregarious and often colorful, they tend to be conspicuous. However, larval blister beetles are seldom seen, except for first instar larvae (triungulins) frequenting flowers or clinging to adult bees. All blister beetle larvae are specialized predators (Zhang & Zheng, 2016).

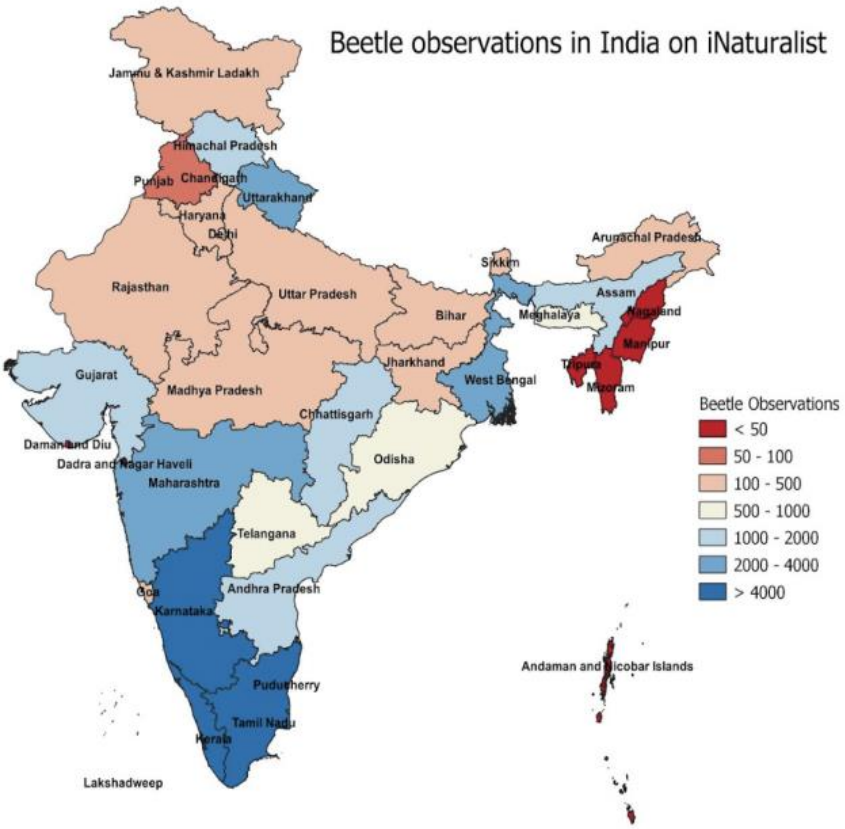

Fig. 1. Distribution of Beetles in India

Fig. 2. Few species of Beetles in Indian Subcontinent

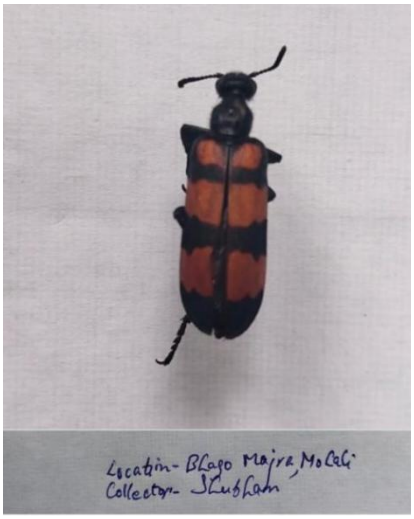

Fig. 3. Blister Beetle

Cantharidin (as a haemolymph exudation) serves as a feeding deterrent to most predators, thereby protecting blister beetles and their eggs from consumption. However, some insects are attracted to cantharidin, and this compound is involved in the chemical communication among blister beetles (Young et al., 1984; Klahn et al., 1987).

2.1 Diagnostic Character

They typically have elongated, cylindrical bodies.Blister beetles vary in color, but they often have black or striped patterns.Their heads are small and often hidden under the pronotum (the first segment of the thorax). Antennae are thread-like or clubbed.Legs are usually long and slender.They have hardened forewings (elytra) that cover the hindwings.The most distinctive feature is their ability to secrete cantharidin when disturbed or crushed.(Pinjara et al., 2018).

2.2 Distribution

Mylabrispustulata, is prevalent in several parts of India. It has been reported for its incidence on tomato crops in Lakhamandal village of Dehradun, Uttarakhand (Patel et al., 2023).

Paederusmelampus,the Manipal bug, is found in the Indian state of Karnataka. This beetle is known to cause Paederus dermatitis upon contact with human skin.

2.3 Role in the Agricultural Pest Control

Blister beetles are used for their predatory behavior for the regulation of pest populations in

agricultural ecosystems. For example, blister beetles prey on the larvae of destructive pests such as the cotton bollworm (*Helicoverpa armigera*) and other insect larvae that damage crops. However, their harmful effects on non-target species and their occasional overpopulation in certain areas can be a concern (Singh et al., 2009; Soni et al., 2014).

Fig. 4. Dung Beetle

3. DUNG BEETLES

Dung beetles belonging to the family. Scarabaeidae, are fascinating insects that play a crucial role in ecosystems by decomposing animal dung. Their unique adaptations and behaviors make them easily recognizable (Hanski et al., 2014).

Dung beetles primarily feed on animal dung. Many species create dung balls, which they roll to a suitable location for breeding or feeding. Dung balls are often used to construct underground nests, where eggs are laid and larvae develop. Dung beetles play a vital role in nutrient cycling by burying dung, which promotes decomposition and returns nutrients to the soil. Some dung beetle species are also known to pollinate flowers while searching for food (Nichols et al., 2008).

3.1 Diagnostic Character and Distribution

Dung beetles are well-adapted for digging and rolling dung balls. Their legs are equipped with spines and claws for digging and manipulating dung. The head capsule is often enlarged and flattened, allowing them to push dung. Antennae are usually clubbed, aiding in sensing odors and locating dung. Dung beetles particularly3 species in the genus *Onthophagus*, are known for their behavior of rolling dung balls. These balls are used for breeding and feeding, providing a habitat and food source for their larvae (Halffter et.al., 1982).

3.2 Distribution

1. A 2015 publication in the Indian Journal of Entomology lists 420 species from 38 genera in the country. (Monogobay)
2. *Mylabris thunbergia* is a species of blister beetle found in India and Sri Lanka (Wikipedia).

3.3 *Proagoderus lansberge*

Proagoderus lansberge is a genus of dung beetles belonging to the Scarabaeidae family. These insects are known for their distinctive morphology and behavior, which sets them apart from other dung beetles.

Diagnostic character and distribution: *Proagoderus* species are generally medium-sized to large dung beetles. Males often possess prominent horns on their heads, which are used for competition with other males for access to females and resources. Like other dung beetles, *Proagoderus* species create dung balls, which they use for feeding and nesting.

Distribution: Members of this genus are typically found in tropical and subtropical regions like in Punjab, Delhi (Daniel et al., 2024)

3.4 *Onthophagus ramosus*

Onthophagus ramosus is a species of dung beetle belonging to the Scarabaeidae family. It's characterized by its distinctive horned head, which is particularly prominent in males.

Diagnostic character and distribution: Males have a prominent, forked horn on their head, which they use for competition with other males for access to females and resources (Emlen et al., 2000).

Like other dung beetles, *Onthophagus ramosus* creates dung balls, which they roll to suitable locations for breeding and feeding. This species is widely distributed across various regions, including parts of Asia and Europe.

Role in the agricultural pest control: These are abundant in regions where livestock farming is prevalent, like in rural parts of Rajasthan, Punjab, Uttar Pradesh, and Tamil Nadu. Dung beetle like *Onthophagus*are frequently found in areas with high dung deposition from cattle, horses, and other herbivores. Their role in pest control is significant as they reduce the presence of dung-breeding flies and promote the breakdown of animal waste. Dung beetles can significantly diminish the populations of fly larvae in dung, thus reducing the impact of fly-borne diseases in both livestock and humans (Gupta et al., 2014).

4. LADYBIRD BEETLES

Ladybird beetles or ladybugs or coccinellids, are a group of beetles belonging to the family Coccinellidae. These beetles are well-known for their distinctive appearance. Mainly characterized by a rounded or oval body, often brightly colored with red, orange, or yellow hues, and marked with black spots.

The ecological role of ladybird beetles in India is significant, as they contribute to pest regulation, and their diversity in the region is an important indicator of environmental health (Rao et al., 2015).

4.1 *Harmonia octomaculata*

Harmonia octomaculata, commonly known as the spotted ladybird beetle, is a member of the Coccinellidae family. *Harmonia octomaculata* is recognized for its role as a natural predator of various agricultural pests, including aphids and whiteflies, thereby contributing to pest management in diverse ecosystems.

Diagnostic character and distribution: Adult beetles typically measure between 4.60 to 7.50 mm in length and 3.50 to 5.50 mm in width. They exhibit a yellowish-orange to reddish-brown coloration on their elytra (wing covers), each adorned with five distinct black spots. The pronotum (the area behind the head) features one to two black markings, often forming an 'M' shape (Poorani et al., 2023).

Distribution: Within India, it is particularly common in the peninsular and northeastern areas, encompassing states such as Andhra Pradesh, Arunachal Pradesh, Assam, Bihar, Karnataka, Kerala, Manipur, Meghalaya, Mizoram, Punjab, Tamil Nadu, Tripura, Uttarakhand, and Uttar Pradesh (Poorani et al., 2023).

4.2. *Harmonia axyridis*

Harmonia axyridis commonly known as the harlequin ladybird or Asian lady beetle, is an invasive species that has spread globally and is a significant pest in agriculture and residential settings.

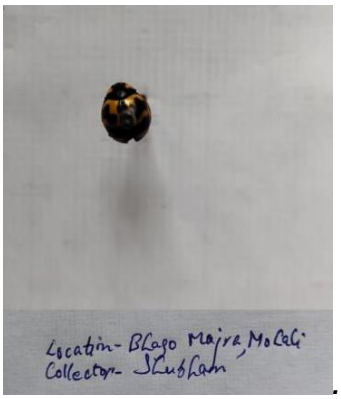

Fig. 5. *Harmonia axyridis*

Diagnostic character: It has distinctive markings, orange to red with black spots on its elytra, some may appear black with red or orange spots. One significant diagnostic feature is the characteristic M or W-shaped marking on its pronotum (area behind the head) (Koch et al.,2003).

Distribution: The harlequin ladybird was first detected in India in the early 2000s, with reports confirming its presence in states like Himachal Pradesh, Punjab, Haryana, and Uttar Pradesh (Koul et al., 2010).

Role in the agricultural pest control: Ladybird beetles, are well-known for their voracious appetite for aphids, which are major pests in crops like cotton, vegetables, and cereals. In various parts of India, such as Punjab, Haryana, and Tamil Nadu, reports demonstrated the effectiveness of ladybirds in controlling aphid populations, thus improving crop yields and reducing the reliance on chemical pesticides (Chauhan et al., 2010)

5. AQUATIC BEETLES

Aquatic beetles, belonging to various families within the order Coleoptera, exhibit a diverse range of diagnostic characteristics and distributions across India.

Table 1. (Narwade et al.,2025)

Enemy Type	Host Range	Activity Period	Reproduction Rate	Pest Control Efficiency
Lady Beetles	Wide	Year-round	High	75%

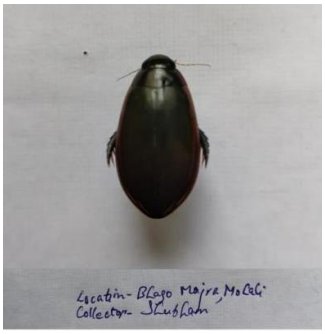

Fig. 6. *Cybister chinensis*

5.1 Diagnostic Character

Aquatic beetles, belonging to several families such as Dytiscidae, Hydrophilidae, and Gyrinidae, are usually found in freshwater habitatsacross India. These beetles are identified easily due to their features for aquatic life, streamlined bodies, specialized legs for swimming, and ability to trap air beneath their elytra for respiration while submerged. Dytiscidae, famous due to their large size, oval bodies, and strong swimming legs. Hydrophilidae, water scavenger beetles, are identified by their broad, flattened bodies and long antennae. Gyrinidae, are distinguished by their unique habit of swimming in rapid circles on the surface of the water. These beetles are important contributors to the aquatic food web, preying on small invertebrates and decomposing organic material (Kumar et al., 2006).

5.2 Distribution

Aquatic beetles are distributed in the plains, foothills, and coastal regions, where they inhabit ponds, lakes, rivers, and marshes. E.g. Dytiscidae species have been found in the northern states such as Jammu & Kashmir, Himachal Pradesh, and Uttarakhand, while Hydrophilidae and Gyrinidae are more commonly found in the southern and eastern parts of the country, such as Tamil Nadu, Kerala, West Bengal, and Odisha (Ghosh et al., 2014)

5.3 Role in Agricultural Pest Control

Aquatic beetles contribute to pest control in agricultural fields where irrigation or waterlogging is prevalent. Their presence in fields with standing water, such as rice paddies or vegetable farms, can help reduce pest populations naturally, reducing the need for chemical pesticides. These are beneficial in integrated pest management (IPM) strategies (Tiwari et al., 2024). In India, research has highlighted the role of aquatic beetles in rice fields, where their predation of insect larvae contributes to reducing the need for synthetic pesticides and promoting biodiversity (Ghosh et al., 2014).

6. GROUND BEETLE

Ground beetles, belonging to the family Carabidae, are an important and diverse group of beetles found across India. They are primarily predatory, feeding on a wide range of invertebrates, including pests like slugs, snails, and other insects.

6.1 Diagnostic Character

Ground beetles exhibit well-developed hind wings, allowing them to fly, but they are often more commonly found scurrying on the ground, under rocks, leaf litter, and in soil, where they hunt for prey. These often have shiny, smooth exoskeletons, black or brown in color, and their large, powerful mandibles are used for capturing prey. The shape and texture of their pronotum and elytra are having distinct grooves or patterns.

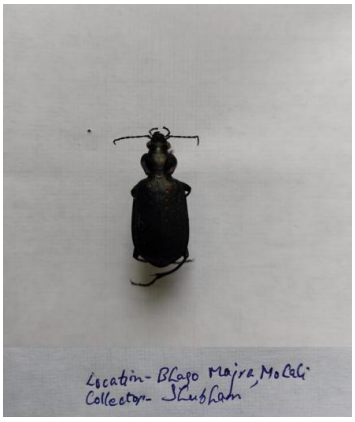

Fig. 7. *Syntomus truncatellus*

Table 2. (Narwade et.al.,2025)

Enemy Type	Host Range	Activity Period	Reproduction Rate	Pest Control Efficiency
Ground Beetles	Wide	Nocturnal	Low	65%

6.2 Distribution

Present in states like Uttarakhand, Himachal Pradesh, and the Western Ghats of southern India. These are having a diverse range of species, as these areas provide the dense vegetation and varied habitats preferred by ground beetles. Ground beetles also play a significant ecological role in pest control, particularly in agricultural areas, where they help maintain the balance of pest populations.

6.3 Role in Agricultural Pest Control

Ground beetles, with their powerful mandibles, prey on soil-dwelling pests such as root weevils, larvae, and caterpillars. In Western Ghats and the Indo-Gangetic plains, these beetles contribute significantly to pest regulation in rice, wheat, and vegetable crops (Ghosh et al.,2011)

6.4 Significance of the Study for Agricultural Science

Many beetle species are significant agricultural pests, causing damage to crops through various feeding habits. Wireworms, the larval stage of click beetles (Coleoptera: Elateridae), are generalist herbivores that are difficult to control and can significantly impact crop yields (Nikoukar et al., 2022). Beetle infestations can lead to significant economic losses in agriculture and forestry. The Colorado potato beetle, for instance, has caused increased control costs and yield losses due to insecticide resistance (Regmi et al., 2020). Beetles, despite the damaging effects can be used to mitigate other pest using the IPM strategies.

7. CONCLUSION

Beetles show remarkable global distribution, occupying terrestrial and freshwater habitats. Their sheer abundance and ecological diversity make them significant players in ecosystem. While many beetles are beneficial, acting as pollinators, predators of other pests, and crucial for decomposition, a considerable number pose threats to agriculture and forestry.

Pest management strategies carefully consider the intricate role of beetles within the ecosystem. Broad-spectrum insecticides can have unintended consequences, disrupting beneficial beetle populations and potentially exacerbating pest problems in the long run. Integrated pest management (IPM) approaches, which focusses on ecological principles and utilize a combination of techniques, offer more sustainable and effective solutions.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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