



A Comprehensive Review on Diversity of Predaceous Coccinellid Beetles (Coleoptera: Coccinellidae)

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Author's contribution

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

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ABSTRACT

This review delves into the pivotal role of coccinellid beetles, commonly known as ladybird beetles, in biological pest control and their significance in maintaining ecological balance. The successful introduction of the vedalia ladybird in 1888 to control the cottony cushion scale in California stands as a landmark in biological pest control, prompting numerous global attempts to employ predaceous ladybird beetles for aphid control. Predaceous ladybird beetles have gained attention for their ability to feed on a diverse range of prey, emphasizing the need for comprehensive biodiversity information in new areas. Coccinellids, with approximately 6,000 species globally, inhabit various environments contributing significantly to pest management. The Indian subcontinent, with its rich coccinellid diversity explored through catalogues and surveys with highlighting the ecological balance they maintain and the potential for sustainable pest management practices.

Keywords: Coccinellid beetle; Predator; insect pest; beneficial and diversity.

1. INTRODUCTION

The most successful example of classical biological pest control is widely recognized to have been achieved through the successful introduction of the vedalia ladybird *Rodolia cardinalis* Mulsant from Australia into California in 1888. The ladybird was specifically designed to target the cottony cushion scale, or *Icerya purchasi*, which posed a threat to industry [1]. As Joshi et al. [2] demonstrate, this historic accomplishment led to 155 attempts worldwide to use predaceous ladybird beetles to control aphids. These experiments have shown that predaceous ladybird beetles are an effective pest control tool. The exceptional capacity of predatory ladybird beetles to feed on a diverse array of prey, such as aphids, coccids, phytophagous mites, adelgids, and aleyrodids, has garnered significant attention in recent years as biological control agents [3,4,5,6,7]. Comprehensive data on the biodiversity of these agents in new locations must be produced immediately, given their potential for biocontrol [8,9].

Coccinellid beetles, commonly known as ladybird beetles, emerge as a crucial group of predatory insects playing a significant role in the biological control of diverse insect pests worldwide [10]. While exhibiting polyphagous behavior, some coccinellids display specificity in their food preferences [11,7]. Inhabiting a variety of environments such as forests, agricultural fields, grasslands, gardens, and human habitats, the Coccinellidae family encompasses approximately

6,000 described species globally, distributed across 360 genera [12]. Notably, the Indian Prey-Predator catalogue of coccinellid beetles by Omkar and Pervez (2004) record 261 known predaceous coccinellids in India, belonging to 57 genera [13]. Poorani's checklist of Coccinellidae in the Indian sub-region (2002) lists 79 genera and 400 species of ladybeetles, providing insights into their distribution in the subcontinent [14]. Jadhav and Sharma [15] further contribute to this knowledge by identifying twenty coccinellid beetle species under 15 genera and 6 subfamilies in the fauna of Maharashtra [15,7].

Beyond their role as predators, coccinellids play a vital role in maintaining ecological balance by regulating pest densities, ultimately reducing the dependence on chemical pesticides in agriculture. This review article underscores the significance of research on the diversity of predaceous coccinellid beetles and their potential impact on sustainable pest management practices.

2. GLOBAL OVERVIEW

A wide range of Coccinellid beetle species have been identified by several researchers from different parts of the world during their research. The coccinellid community's composition and diversity were investigated by Lovei (1981) in an apple orchard close to Budapest, Hungary, in both insecticide-treated and untreated blocks [16]. In uncultivated areas, Garcia et al. [17] found 13 species of coccinellids [17]. *Hippodamia variegata* has been found in Austria

on crops like sorghum, sunflower, lucerne, triticale, and citrus, according to Franzmann's 2002 research [18]. A thorough analysis of the biotic potential, host range, distribution, and ecology of 71 species of predaceous coccinellids in Pakistan was presented by Irshad [19]. 22 coccinellid species were identified by Zahoor et al. (2003) after they evaluated the diversity, richness, and evenness of coccinellids and their function as bioindicators in agriculture and woodland regions in Faisalabad, Pakistan [20].

In Sri Lankan regions where vegetables are grown, Mayadunnage et al. [21] identified 15 coccinellid species [21]. From the canopies of olive orchards in southern Spain, Cotes and colleagues (2010) collected thirteen species of ladybird beetles [22]. Twelve coccinellid species from Pakistan's Faisalabad area were reported by Abbas et al. in 2013 [23]. In the Mirpur Division of Jammu and Kashmir, Pakistan, Hayat and Khan [24] collected data on 51 coccinellid species [24]. 11 species of ladybird beetles have been documented from the Mehriz area of Iran [25].

3. DIVERSITY IN INDIA

In India, numerous researchers have delved into various aspects of Coccinellid beetles. Various scientists, such as Kapur (1972), contributed to the understanding of the diversity of coccinellid beetles. Agarwala and Ghosh [26] reported a total of 36 coccinellid beetle species across India [26]. Kapur's work focused on documenting 17 species of ladybird beetles in Goa [27]. Joshi and Sharma [28] conducted a collection and identification effort in the Haridwar district of Uttarakhand, revealing 31 species of coccinellid beetles [28].

In the Srinagar area of Kashmir, a survey carried out by Khan et al. (2009) found 15 coccinellid species spread over 12 distinct agricultural ecosystems [29]. In Dehradun, Sharma and Joshi [28] found 25 species of Coccinellid beetles that are predators [30]. Twenty different species of coccinellid beetles were gathered from tea estates in North Bengal by Roy et al. [31]. Six coccinellid species were found in Hissar, Haryana, according to Kedar et al. [32]. In the Sub-Himalayan area of North-East India, 12 coccinellid species were studied by Ghosh and Chakraborty [33] for the occurrence and abundance of predatory beetles, namely *C. septempunctata* [33].

At the Hybrid Rice Evaluation Center, Tamil Nadu Agricultural University, Gudalur,

Vinothkumar (2013) identified 13 coccinellid species in the rice agroecosystem [34]. About 24 species belonging to 17 genera were found in a survey conducted by Majumder et al. [35] on the diversity of coccinellid beetles in Tripura, Northeast India's agricultural and forest settings [35]. Observing 17 and 15 species of predaceous coccinellids in fruit and vegetable ecosystems, respectively, Shah and Khan [36] undertook a biodiversity assessment of coccinellids in the main belts of Kashmir Valley that cultivate fruits and vegetables [36].

16 species of predaceous coccinellids were gathered by Chaudhary et al. (2014) in Jharkhand's mango agroecosystems [37]. 18 species of coccinellid beetles were found in crop fields examined by Megha et al. [38] in the Dharwad district of India [36]. In the citrus orchard of Assam Agricultural University, Jorhat, Ramya and Thangjam (2016) identified 12 species of coccinellid beetles linked to insect pests of Assam lemon [39].

In their 2016 study, Ankalgi and Jadesh [40] found 12 species in 4 distinct subfamilies and 9 genera among the Coccinellid fauna of Ankalga Village, Gulbarga, Karnataka. Four species of coccinellid beetles were observed by Goswami et al. [41] during the Rabi season while conducting field tests to examine the relative prevalence of coccinellid predators in major Rabi oil seeds and pulse crops in Sabour, Bihar [41]. The Western Plain Zone of Uttar Pradesh is home to 21 species of predatory coccinellid beetles, according to Kumar et al. [42].

Ten distinct species of ladybird beetles have been found in the agroclimatic zone of Bhubaneswar, according to Mukherjee and Suman's 2017 research [43]. In the Himachal Pradesh agroclimatic zones, Sharma et al. [44] identified 65 different coccinellid species [44]. Murali et al. [45] noted ten different species of coccinellid beetles over different brinjal crop seasons [45]. From horticultural and agricultural crop areas in Kashmir, Rasheed and Buhroo [46] gathered thirteen species of ladybird beetles [46]. In vegetable crops from Hyderabad agricultural fields, Jesu Rajan et al. [47] found nine species of coccinellids [47]. When Shanker et al. (2018) conducted study on the biodiversity and predatory capability of coccinellids in rice habitats in Malan, Himachal Pradesh, they collected coccinellid species from 15 genera, representing 5 tribes of the Coccinellidae family [48].

In Uttarakhand, India's forest habitat, Mishra and Yusuf (2019) identified 15 species of coccinellid beetles [49]. During a survey of the coccinellid fauna in crop areas in North Eastern Karnataka, Kiran et al. [50] discovered 36 species of coccinellid beetles [50]. Six species of predatory lady beetles were found in Sivakasi by Sundareshwari et al. [51].

In the apple orchard ecosystems of Kashmir, Himalayas, India, Maqbool et al. (2020) found 12 species of coccinellids from 11 taxa [49]. Arunachal Pradesh is home to 44 species of coccinellids, representing 22 genera and 6 tribes, according to Das et al. [52]. In 2020, Pervez and colleagues carried out a field study to investigate the variety of predaceous ladybird beetles in various geographical settings in Uttarakhand, North India. They identified eighteen species of predaceous ladybird beetles belonging to fifteen genera and three subfamilies [53]. In 2020, Thangjam et al. found 19 species of coccinellid beetles in 11 taxa that were predaceous on king chilli sucking pests in Assam, India [54].

In the groundnut crop ecosystems of the Rayalaseema Region of Andhra Pradesh, Vasista et al. [53] recorded nine species of

coccinellid beetles [55]. Six species of coccinellids were found in the kharif rice fields of Rajendranagar, Hyderabad, by Anitha et al. [56]. Hirur et al. (2020) found three species of coccinellids in their investigation on the biodiversity and quantity of coccinellids in tomato under sprayed and unsprayed circumstances during the rabi season [57].

The coccinellid beetles are found in a variety of environments, such as woods, grasslands, and agro-ecosystems, according to the studies cited in this review article taken together. By gathering specimens for their investigations, these researchers carried out extensive studies on several facets of coccinellid beetles. Throughout the various environments, *Cheilomenes sexmaculata* was the most prevalent predatory coccinellid species among the specimens gathered. Variations in environmental circumstances, agricultural crops, and prey species can be observed in the variety and abundance of coccinellid beetle species. The lack of comprehensive research and collecting over the whole geographical area of India impedes a full knowledge of the coccinellid fauna in the region, despite its richness and variety.

Table 1. Biodiversity and distribution of different subfamilies within the Coccinellidae family in India [6]

S.No.	Subfamily	Species	Distribution
1.	Chilocorinae	<i>Brumoides suturalis</i>	North Eastern region of India, Maharashtra, West Bengal, Tamilnadu and Gujarat
		<i>Chilochorus nigrita</i>	Southern region of India
		<i>Chilochorus subindicus</i>	Southern region of India
2.	Coccidulinae	<i>Rodolia cardinalis</i>	Southern region of India
		<i>Rodolia fumida</i>	Northern and central region of India
3.	Coccinellinae	<i>Cheilomenes sexmaculata</i>	Alloverthecountry
		<i>Coccinella septempunctata</i>	Whole country
		<i>Harmonisocto maculate</i>	Wholecountry
		<i>Hippodamia variegata</i>	Northern region of India
		<i>Illiescincta</i>	Whole country
4.	Epilachninae	<i>Henosepilachna narayana</i>	Maharashtra, Karnataka
		<i>Henosepilachna septima</i>	Whole country
5.	Scymninae	<i>Cryptogonus orbiculus</i>	North Eastern region of India
		<i>Pseudaspidimerus trinotatus</i>	Southern region of India
		<i>Scymnus nubilus</i>	Southern region of India
		<i>Stethorus pauperculus</i>	Central region of India
6.	Sticholotidinae	<i>Serangium parcesetosum</i>	Central region of India
		<i>Jauravia opaca</i>	Karnataka, Maharashtra
		<i>Jauravia simplex</i>	Southern region of India
		<i>Jauravia pallidula</i>	Maharashtra, Karnataka, Meghalaya, Tamil Nadu, West Bengal

4. CONCLUSION

This comprehensive review sheds light on the pivotal role of coccinellid beetles, popularly known as ladybird beetles, in the realm of biological pest control. The historical success of introducing the vedalia ladybird beetle (*Rodolia cardinalis* Mulsant) in 1888 to combat the cottony cushion scale in California remains a watershed moment in the field, symbolizing the efficacy of biological control methods. Subsequent global endeavors, totaling 155 attempts to utilize predaceous ladybird beetles for aphid control underscore their significance in pest management. The spotlight on predaceous ladybird beetles intensifies due to their exceptional ability to feed on a diverse array of prey, encompassing aphids, coccids, phytophagous mites, adelgids and aleyrodids. This recognition elevates their status of predatory coccinellids as potent biological control agents, prompting the urgent need for an extensive understanding of their biodiversity in new territories. The call for more information is particularly pertinent considering their potential for biocontrol and sustainable pest management practices. Zooming into the realm of coccinellid beetles globally, researchers from various corners of the world have contributed valuable insights into their diversity and ecological roles. The documentation of diverse coccinellid species in different habitats, from orchards in Hungary to uncultivated areas and agricultural fields in Spain and Pakistan, illustrates the adaptability and ubiquity of these beneficial insects. The surveys conducted in Sri Lanka, Spain and various regions of India provide a snapshot of the rich tapestry of coccinellid fauna in different geographical contexts. However, the review highlights a persistent gap in understanding of coccinellid diversity in India. Despite substantial efforts by researchers, the sheer vastness of the country and the diversity of ecosystems demand more comprehensive exploration. The dominance of *Cheilomenes sexmaculata* (Fab) among the collected specimens showcases the adaptability of coccinellids across diverse ecosystems.

In essence, this review encapsulates both the global and Indian perspectives on coccinellid beetles, emphasizing their crucial role in biological pest control, maintaining ecological equilibrium and the pressing need for continued research to unlock the full potential of these remarkable insects in sustainable agriculture.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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