Review Article

A comprehensive review on diversity of predaceous coccinellid beetles (Coleoptera: Coccinellidae)

Abstract

This review delves into the pivotal role of coccinellid beetles, commonly known as ladybird beetles, in biological insect 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 known species globally, inhabit various environments, and contributing significantly to pest management. The Indian subcontinent, with its rich coccinellid diversity, is can be explored through catalogues and surveys, with highlighting the ecological balance they maintain and the potential for sustainable pest management practices.

Keyword: Coccinellid beetle, Predator, insect pest, beneficial insect and diversity.

Introduction

The successful introduction of the vedalia ladybird beetle, *Rodolia cardinalis* Mulsant, from Australia into California in 1888 is widely acknowledged as the most effective instance of classical biological pest control, specifically targeting the cottony cushion scale, *Icerya purchasi*, which posed a threat to the citrus industry [1]. This historic success prompted 155 worldwide attempts to control aphids by introducing predaceous ladybird beetles, as documented by Joshi *et al.*,2003[2]. The outcomes of these attempts underscore the efficacy of predaceous ladybird beetles in pest management. Predaceous ladybird beetles have gained substantial attention in recent years as biological control agents due to their remarkable ability to feed on a wide range of prey, including aphids, coccids, phytophagous mites, adelgids, and aleyrodids [3,4,5,56,57].Recognizing their potential for biocontrol, there is a pressing need to generate comprehensive information on the biodiversity of these agents in new areas [6,7].

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 [8]. While exhibiting polyphagous behavior, some coccinellids display specificity in their food preferences [9,57]. 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 [10]. Notably, the Indian Prey-Predator catalogue of coccinellid beetles by Omkar and Pervez (2004) records ed 261 known predaceous coccinellids in India, belonging to 57 genera [11]. 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 [12]. Jadhav and Sharma (2012) further contribute to this knowledge by identifying twenty coccinellid beetle species under 15 genera and 6 subfamilies in the fauna of Maharashtra [13,57].

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.

Global Overview

Numerous researchers from diversified regions around the globe have documented various species of Coccinellid beetles during their investigations. Lovei (1981) examined the composition and diversity of the coccinellid community in both insecticide-treated and untreated blocks within an apple orchard near Budapest, Hungary [14]. Garcia *et al.*, (1997) identified 13 coccinellid species in uncultivated habitats [15]. Franzmann (2002) documented the presence of Hippodamia variegate on crops such as sorghum, sunflower, Lucerne, triticale, and citrus in Austria [16]. Irshad (2001) provided a comprehensive review detailing the distribution, host range, ecology, and biotic potential of 71 species of predaceous coccinellids in Pakistan [17]. Zahoor *et al.*, (2003) assessed the diversity, richness, and evenness of Coccinellids and their role as bioindicators in crop and forest areas in Faisalabad, Pakistan, identifyingied 22 coccinellid species [18].

Mayadunnage *et al.*, (2007) recorded 15 coccinellid species in vegetable-growing areas of Sri Lanka [19]. Cotes and co -workers et al. (2010) collected 13 ladybird beetle species from the canopies of olive orchards in southern Spain [20]. Abbas *et al.*, (2013) reported 12 coccinellid species from the Faisalabad district, Pakistan [21]. Hayat and Khan (2013) gathered data on 51 coccinellid species in the Mirpur Division of Jammu and Kashmir, Pakistan [22]. In Mehriz region of Iran, 11 species of ladybird beetles were reported [23].

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 (1988) reported a total of 36 coccinellid beetle species across India [25]. Kapur's work focused on documenting 17 species of ladybird beetles in Goa [24]. Joshi and Sharma (2008) conducted a collection and identification effort in the Haridwar district of Uttarakhand, revealing 31 species of coccinellid beetles [26].

A survey conducted by Khan *et al.,* (2009) in the Srinagar district of Kashmir documented 15 coccinellid species across 12 different crop ecosystems [27]. Sharma and Joshi (2010) identified 25 species of predatory Coccinellid beetles in Dehradun [28]. Roy *et al.,* (2010) collected 20 species of coccinellid beetles from tea plantations in North Bengal [29]. Kedar *et al.,* (2011) observed six coccinellid species in Hissar, Haryana [30]. Ghosh and Chakraborty (2012) conducted a study on the incidence and abundance of predatory beetles, particularly *C. septempunctata*, in the Sub-Himalayan region of North-East India and documented ~~documenting~~ 12 coccinellid species [31].

Vinothkumar (2013) recorded ~~observed~~ 13 coccinellid species in ~~the~~ rice agroecosystem at Hybrid Rice Evaluation Centre, Tamil Nadu Agricultural University, Gudalur [32]. Majumder *et al.,* (2013) surveyed the diversity of coccinellid beetles in agricultural and forest habitats of Tripura, Northeast India, reporting approximately 24 species under 17 genera [33]. Shah and Khan (2014) conducted a biodiversity survey of coccinellids in the major fruit and vegetable growing belts of Kashmir Valley~~,~~ observing ~~-~~ed 17 and 15 species of predaceous coccinellids in fruit and vegetable ecosystems, respectively [34].

Chaudhary *et al.,* (2014) collected 16 species of predaceous coccinellids in Mango agroecosystems in Jharkhand [35]. Megha *et al.,* (2015) surveyed crop fields in the Dharwad region, India, reporting 18 species of coccinellid beetles [36]. Ramya and Thangjam (2016) recorded 12 species of coccinellid beetles associated with insect pests of Assam Lemon in the citrus orchard of Assam Agricultural University, Jorhat [37].

Ankalgi and Jadesh (2016) conducted a study on the Coccinellid fauna of Ankalga Village, Gulbarga, Karnataka, discovering 12 species belonging to 4 different subfamilies and 9 genera [38]. Goswami *et al.,* (2016) performed field experiments to investigate the relative abundance of coccinellid predators in major Rabi oil seeds and pulse crops at Sabour, Bihar, recording 4 species of coccinellid beetles during the Rabi season [39]. Kumar *et al.,* (2017) documented 21 species of predatory coccinellid beetles in the Western plain zone of Uttar Pradesh [40].

Mukherjee and Suman (2017) documented the presence of 10 different species of ladybird beetles in the agroclimatic zone of Bhubaneswar [41]. Sharma et al. (2017) recorded a total of 65 coccinellid species in the agroclimatic zones of Himachal Pradesh [42]. Murali *et al.,* (2017) observed 10 species of coccinellid beetles across various seasons of brinjal crops [43]. Rasheed and Buhroo (2018) collected 13 species of ladybird beetles from agricultural and horticultural crop fields in Kashmir [44]. Jesu Rajan *et al.,* (2018) documented 9 species of coccinellids in vegetable crops from agricultural fields in Hyderabad [45]. Shanker *et al.,* (2018) gathered coccinellid species from 15 genera, representing 5 tribes of the Coccinellidae family, during their research on biodiversity and predatory potential of coccinellids in rice ecosystems in Malan, Himachal Pradesh [46].

Mishra and Yusuf (2019) recorded 15 species of coccinellid beetles from the forest ecosystem of Uttarakhand, India [47]. Kiran *et al.,* (2019) identified 36 species of coccinellid beetles during a survey of the coccinellid fauna in crop fields of North eastern Karnataka [48]. Sundareshwari *et al.,* (2019) observed 6 species of predatory lady beetles in Sivakasi [49].

Table 1. ~~Information on the~~ ~~b~~ **Biodiversity and distribution of different subfamilies within the Coccinellidae family in India** [56].

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

			Meghalaya, Tamil Nadu, West Bengal

Maqbool *et al.*, (2020) reported 12 species of coccinellids belonging to 11 genera from apple orchard ecosystems in Kashmir Himalayas, India [47]. Das *et al.*, (2020) reported 44 species of coccinellids belonging to 22 genera and 6 tribes from Arunachal Pradesh [50]. Pervez *et al.*, (2020) conducted a field survey exploring the diversity of predaceous ladybird beetles in different geographical habitats of Uttarakhand, North India, identifying 18 species of predaceous ladybird beetles from 15 genera and 3 subfamilies [51]. Thangjam *et al., (*2020) observed 19 species of coccinellid beetles belonging to 11 genera, predaceous on sucking pests of king chilli in Assam, India [52].

Vasista *et al.*, (2020) documented 9 species of coccinellid beetles in groundnut crop ecosystems in the Rayalaseema Region of Andhra Pradesh [53]. Anitha *et al.*, (2020) recorded 6 species of coccinellids in kharif rice fields in Rajendranagar, Hyderabad [54]. Hirur *et al.*, (2020) conducted a study on the biodiversity and abundance of coccinellids in ~~rabi~~ tomato under sprayed and unsprayed conditions during the rabi season~~,~~ and they observed 3 species of coccinellids [55].

The works mentioned in this review article ~~above~~ collectively reveal that the coccinellid beetles inhabit various habitats, including forests, grasslands, and agro-ecosystems. These researchers conducted comprehensive studies on different aspects of coccinellid beetles by , collecting specimens for their analyses. Among the collected specimens, *Cheilomenes sexmaculata* emerged as the most dominant predatory coccinellid species across the diverse ecosystems. The diversity and abundance of coccinellid beetle species exhibit variations influenced by environmental conditions, agricultural crops~~,~~ and prey species. Despite the richness and diversity of the coccinellid fauna in the Indian region, a complete understanding is hindered by the limited exploration and collections spanning the entire geographic expanse of India.

Conclusion

~~In conclusion, t~~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. ~~The s~~ 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 our 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 balance, and the pressing need for continued research to unlock the full potential of these remarkable insects in sustainable agriculture.

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