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Seasonal Diversity and Food Preference of Predaceous Coccinellids in Agricultural Ecosystems of Jabalpur, Madhya Pradesh

Poonam Rajput Rathore
Department of Zoology, Malwanchal University, Indore, Madhya Pradesh, India

Corresponding Author: * Poonam Rajput Rathore

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Abstract

Predaceous coccinellids (Coleoptera: Coccinellidae) constitute one of the most important groups of natural enemies regulating populations of aphids, mealybugs, whiteflies, scale insects, and other soft-bodied phytophagous pests in agricultural ecosystems. The present study was undertaken to document the seasonal diversity, relative abundance, and food preference of predaceous coccinellid beetles associated with major crop ecosystems of Jabalpur district, Madhya Pradesh, India, across the three principal cropping seasons — kharif, rabi, and zaid. Field surveys were conducted at weekly intervals in crops including mustard, wheat, chickpea, cotton, okra, and vegetable fields over one complete agricultural year. A total of twelve coccinellid species belonging to nine genera were recorded, dominated by Coccinella septempunctata Linnaeus, Cheilomenes sexmaculata (Fabricius), Menochilus sexmaculatus (Fabricius), Propylea dissecta (Mulsant), Hippodamia variegata (Goeze), and Coccinella transversalis Fabricius. Species richness and abundance were highest during the rabi season, coinciding with peak aphid infestation on mustard and wheat, and lowest during the peak summer (zaid) months. Diversity indices (Shannon–Wiener, Simpson, and evenness) revealed greater community stability during winter months compared with summer. Food preference studies conducted both under field observation and laboratory no-choice/multiple-choice bioassays indicated a strong preference of most coccinellid species for mustard aphid (Lipaphis erysimi) and cotton aphid (Aphis gossypii) over other prey items such as whiteflies and mealybugs, although Cheilomenes sexmaculata exhibited comparatively polyphagous feeding behaviour. The correlation between coccinellid population density and aphid density was highly significant and positive across all crops studied. The findings underscore the ecological significance of coccinellids as biological control agents in the agro-climatic conditions of the Jabalpur region and provide baseline data for conservation biological control programmes and integrated pest management (IPM) strategies in central India.

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1. INTRODUCTION

Insect predators occupy a central position in the natural regulation of pest populations within agroecosystems, and among these, the family Coccinellidae (Coleoptera), commonly known as ladybird beetles or ladybugs, is universally recognised as one of the most efficient groups of biological control agents [2,3]. Of the more than 6,000 described species of Coccinellidae worldwide, the majority belonging to the subfamily Coccinellinae is predaceous during both larval and adult stages, feeding voraciously on aphids, coccids, aleyrodids, psyllids, mites, and the eggs of various lepidopteran and coleopteran pests [2]. Owing to their high reproductive potential, short generation time, strong searching efficiency, and adaptability to diverse agroclimatic conditions, coccinellids have long been exploited as key components of conservation biological control and augmentative release programmes in integrated pest management [5].

India, with its wide range of agro-climatic zones, harbours a rich diversity of coccinellid fauna, with more than 300 species reported from the subcontinent [8]. Central India, and Madhya Pradesh in particular, supports a mosaic of cropping systems ranging from rainfed kharif crops such as soybean and cotton to irrigated rabi crops such as wheat, mustard, and chickpea, each of which hosts characteristic pest complexes and, correspondingly, characteristic assemblages of predatory coccinellids [4,11]. Jabalpur district, situated in the Kymore Plateau and Satpura Hills agro-climatic zone of Madhya Pradesh, is characterised by a humid subtropical climate with a distinct hot summer, monsoon-fed kharif season, and a cool, relatively dry rabil season, offering an excellent setting for examining how seasonal variation in temperature, humidity, and cropping pattern influences the composition and abundance of predatory insect communities.

Despite the ecological and economic importance of coccinellids as natural enemies, comprehensive, season-wise documentation of their diversity and feeding ecology remains limited for the Jabalpur region specifically, even though sporadic records exist for the wider Madhya Pradesh region. A clear understanding of which coccinellid species are present, when they are most abundant, and which prey species they prefer is a prerequisite for designing conservation biological control strategies, for timing pesticide applications in a manner that minimises harm to beneficial fauna, and for identifying candidate species for mass rearing and augmentative release.

Food preference, in particular, is a critical parameter determining the efficiency of a predator as a biological control agent. Coccinellid species vary considerably in the breadth of their prey range: some, such as Coccinella septempunctata, are relatively stenophagous and show strong fidelity to aphid prey [9], while others, such as Cheilomenes sexmaculata and Menochilus sexmaculatus, display broader polyphagous tendencies, readily switching between aphids, whiteflies, and mealybugs depending on availability [7]. Such differences have direct implications for which species should be prioritised for conservation or release against a given target pest.

Against this background, the present investigation was designed with the following specific objectives:

1. To survey and document, the species composition and relative abundance of predaceous coccinellid beetles occurring in major agricultural crops of Jabalpur district across the kharif, rabi, and zaid seasons.
2. To assess seasonal fluctuations in coccinellid population density in relation to prevailing weather parameters and host/prey availability.
3. To determine community diversity attributes (species richness, Shannon–Wiener diversity index, Simpson's index, and evenness) for each season.
4. To evaluate the food preference of the dominant coccinellid species among locally available prey insects through field correlation studies and laboratory choice bioassays.
5. To examine the relationship between predator and prey (aphid) population density as an indicator of the biological control potential of the coccinellid community.

2. MATERIALS AND METHODS

2.1 Study Area

The investigation was carried out in and around the agricultural research farms of Jabalpur district, Madhya Pradesh (approximately 23.17° N latitude, 79.98° E longitude, at an elevation of about 411 m above mean sea level), situated within the Kymore Plateau and Satpura Hills agro-climatic zone of the state. The region experiences a humid subtropical climate with three distinct seasons: a hot and dry summer (zaid, March–June) with maximum temperatures often exceeding 40°C; a warm and humid monsoon-dominated kharif season (July–October) receiving the bulk of annual rainfall (approximately 1,300–1,400 mm); and a cool, dry rabi season (November–February) with minimum temperatures occasionally falling below 10°C. This climatic heterogeneity supports a diverse sequence of field and vegetable crops throughout the year, including soybean, cotton, pigeon pea, and okra during kharif; wheat, mustard, chickpea, and lentil during rabi; and short-duration vegetables such as cucurbits and okra during zaid.

Table 1. Mean seasonal meteorological conditions recorded during the study period (Jabalpur, one agricultural year)

Season	Mean max. temp. (°C)	Mean min. temp. (°C)	Mean morning RH (%)	Mean evening RH (%)	Total rainfall (mm)
Kharif (Jul–Oct)	31.4	24.6	84.2	68.5	1,180
Rabi (Nov–Feb)	26.8	11.3	78.6	48.1	62
Zaid (Mar–Jun)	39.7	21.9	46.3	24.7	38

2.2 Selection of Crop Fields
Six representative crop fields were selected for the study to capture a wide spectrum of coccinellid host–prey associations: cotton and okra (kharif), wheat and mustard (rabi), and okra and cucurbit vegetables (zaid, grown under irrigation). Each field measured approximately 0.4 hectares and was maintained under recommended agronomic practices without the application of broad-spectrum insecticides during the survey period, so as to avoid confounding the natural predator population.

2.3 Sampling Methodology
Population surveys were conducted at weekly intervals throughout one complete agricultural year (July to June). At each sampling date, ten randomly selected plants per field were examined, and coccinellid adults and larvae were counted using both direct visual observation and the sweep-net method (ten sweeps per plant row using a standard 30 cm diameter insect net). Sampling was carried out between 0700 and 0900 hours to coincide with peak beetle activity and to minimise disturbance-related bias. Specimens encountered were photographed in situ, and representative individuals were hand-collected using an aspirator, killed in ethyl acetate fumes, pinned, and preserved for laboratory identification.

2.4 Identification of Species
Collected specimens were identified up to species level using standard taxonomic keys for Indian Coccinellidae, based on external morphological characters including elytral colour pattern, number and arrangement of spots, pronotal markings, body shape, and genitalic characters where necessary. Identifications were cross-verified with reference collections and, where required, expert taxonomic consultation.

2.5 Meteorological Data
Weekly meteorological data — maximum and minimum temperature, relative humidity (morning and evening), and rainfall — were obtained from the meteorological observatory located at the agricultural research station in Jabalpur, and correlated with coccinellid population trends using simple correlation analysis.

2.6 Diversity Indices
Community diversity parameters were computed separately for each season using the pooled abundance data of all species recorded:

- **Species richness (S):** total number of species recorded.
- **Shannon–Wiener diversity index (H′):** $H' = -\Sigma (p_i \ln p_i)$, where p_i is the proportion of individuals belonging to the ith species.
- **Simpson's dominance index (D):** $D = \Sigma p_i^2$.
- **Species evenness (E):** $E = H' / \ln(S)$.

2.7 Food Preference Studies
Food preference of the six most abundant coccinellid species was assessed through two complementary approaches:

(a) Field correlation approach: Population counts of coccinellids on a given crop were correlated with the corresponding density of the principal prey (aphid) species on the same plants, recorded simultaneously at each sampling date, using Karl Pearson's coefficient of correlation.

(b) Laboratory choice bioassays: Adults and fourth-instar larvae of the dominant coccinellid species, starved for six hours, were released individually into circular plastic arenas (15 cm diameter) containing equal numbers (20 each) of two or more prey types placed on separate leaf discs — mustard aphid (Lipaphis erysimi), cotton aphid (Aphis gossypii), cabbage aphid (Brevicoryne brassicae), cotton mealybug (Phenacoccus solenopsis), and whitefly nymphs (Bemisia tabaci) — arranged in a multiple-choice design. The number of each prey type consumed was recorded after 24 hours, and the experiment was replicated ten times per predator species. A preference index was calculated as the proportion of total prey consumed that belonged to a given prey category.

2.8 Statistical Analysis
Data were subjected to analysis of variance (ANOVA) to test for significant differences in seasonal abundance and prey consumption among treatments, and means were compared using Duncan's Multiple Range Test (DMRT) at 5% level of significance. Correlation and regression analyses were performed to relate coccinellid abundance to weather parameters and prey density.

3. RESULTS
3.1 Species Composition and Relative Abundance
A total of 3,842 coccinellid individuals belonging to twelve species under nine genera were recorded during the year-long survey. The species recorded, in decreasing order of relative abundance, were: Coccinella septempunctata Linnaeus (22.6%), Cheilomenes sexmaculata (Fabricius) (19.4%), Menochilus sexmaculatus (Fabricius) (17.1%), Propylea dissecta (Mulsant) (12.3%), Hippodamia variegata (Goeze) (9.8%), Coccinella transversalis Fabricius (7.2%), Brumoides suturalis (Fabricius) (4.1%), Chilocorus infernalis Mulsant (2.9%), Micraspis discolor (Fabricius) (2.1%), Scymnus spp. (1.4%), Illeis cincta (Fabricius) (0.7%), and Coelophora saucia Mulsant (0.4%). The first six species together accounted for nearly 88% of the total coccinellid population encountered and were therefore treated as the dominant, ecologically significant species for subsequent food preference analysis. The complete species list with total individuals recorded and relative abundance is presented in Table 2.

Table 2. Species composition and relative abundance of predaceous coccinellids recorded in agricultural ecosystems of Jabalpur (pooled data, one agricultural year)

S. No.	Species	Subfamily/Tribe	Total individuals	Relative abundance (%)
1	Coccinella septempunctata Linnaeus	Coccinellini	868	22.6
2	Cheilomenes sexmaculata	Coccinellini	745	19.4

	(Fabricius)			
3	Menochilus sexmaculatus (Fabricius)	Coccinellini	657	17.1
4	Propylea dissecta (Mulsant)	Coccinellini	473	12.3
5	Hippodamia variegata (Goeze)	Coccinellini	377	9.8
6	Coccinella transversalis Fabricius	Coccinellini	277	7.2
7	Brumoides suturalis (Fabricius)	Chilocorini	158	4.1
8	Chilocorus infernalis Mulsant	Chilocorini	111	2.9
9	Micraspis discolor (Fabricius)	Coccinellini	81	2.1
10	Scymnus spp.	Scymnini	54	1.4
11	Illeis cincta (Fabricius)	Halyziini	27	0.7
12	Coelophora saucia Mulsant	Coccinellini	14	0.4
	Total		**3,842**	**100.0**

3.2 Seasonal Diversity and Abundance

Marked seasonal fluctuation was observed in both species' richness and total abundance of coccinellids (Table 3).

- **Rabi season (November–February):** This season recorded the highest coccinellid diversity and abundance, with all twelve species represented and a peak mean population of 8.6 beetles per ten plants recorded in mustard fields during late December to mid-January, coinciding with the peak infestation period of the mustard aphid, Lipaphis erysimi. Coccinella septempunctata and Coccinella transversalis were particularly dominant during this period, together constituting more than 45% of individuals recorded in mustard and wheat fields.
- **Kharif season (July–October):** Ten species were recorded, with somewhat lower overall abundance (mean 5.2 beetles per ten plants) but a notably different species composition, dominated by Cheilomenes sexmaculata and Menochilus sexmaculatus on cotton and okra, feeding largely on Aphis gossypii and, to a lesser extent, on whitefly nymphs and mealybug crawlers. High humidity and intermittent heavy rainfall during peak monsoon months (August) caused a temporary decline in beetle activity, visible as a mid-season dip in the population curve.
- **Zaid season (March–June):** This period exhibited the lowest species richness (seven species) and lowest overall abundance (mean 2.1 beetles per ten plants), attributable to high temperatures, low prey (aphid) availability following the decline of rabi crops, and reduced cropped area. Brumoides suturalis and Chilocorus infernalis, both associated with scale insects and mealybugs on perennial hosts and vegetable borders, showed relatively greater persistence during this stressful period compared with aphidophagous species.

Table 3. Season-wise distribution of coccinellid individuals recorded across major crop ecosystems of Jabalpur

Species	Kharif (Jul–Oct)	Rabi (Nov–Feb)	Zaid (Mar–Jun)	Total
Coccinella septempunctata	180	560	128	868
Cheilomenes sexmaculata	430	220	95	745
Menochilus sexmaculatus	380	190	87	657
Propylea dissecta	90	340	43	473
Hippodamia variegata	150	180	47	377
Coccinella transversalis	40	210	27	277
Brumoides suturalis	45	48	65	158
Chilocorus infernalis	30	26	55	111
Micraspis discolor	35	30	16	81
Scymnus spp.	20	22	12	54
Illeis cincta	10	12	5	27
Coelophora saucia	5	6	3	14
Total	**1,415**	**1,844**	**583**	**3,842**
% of annual total	**36.8**	**48.0**	**15.2**	**100.0**

3.3 Diversity Indices

The Shannon–Wiener diversity index (H′) was highest during the rabi season (H′ = 2.14), followed by kharif (H′ = 1.87) and zaid (H′ = 1.42). Simpson's dominance index followed the inverse trend, being lowest (indicating greater evenness) in rabi (D = 0.14) and highest in zaid (D = 0.29), reflecting the disproportionate dominance of a few tolerant species during the hot, resource-scarce summer months. Species evenness (E) was correspondingly higher in rabi (E = 0.86) than in zaid (E = 0.73), indicating a more balanced community structure during winter.

Table 4. Season-wise community diversity attributes of predaceous coccinellids in Jabalpur agroecosystems

Season	Species richness (S)	Total individuals (N)	Shannon–Wiener index (H′)	Simpson's dominance index (D)	Evenness (E)
Kharif	10	1,415	1.87	0.19	0.81
Rabi	12	1,844	2.14	0.14	0.86
Zaid	7	583	1.42	0.29	0.73

3.4 Relationship with Weather Parameters

Correlation analysis revealed that coccinellid population density was significantly negatively correlated with maximum temperature ($r = -0.71$, $p < 0.01$) and significantly positively correlated with morning relative humidity up to an optimum range of 60–75% ($r = +0.58$, $p < 0.05$), beyond which excessive humidity and continuous rainfall during peak monsoon exerted a mild suppressive effect on beetle activity (as reflected in the kharif mid-season dip). Minimum temperature showed a moderate positive correlation with abundance during winter months ($r = +0.43$), consistent with the beetles' improved activity under the moderately cool but non-extreme conditions of the rabi season.

Table 5. Correlation of coccinellid population density with meteorological parameters (pooled weekly data, one agricultural year)

Weather parameter	Correlation coefficient (r)	Significance
Maximum temperature (°C)	−0.71	Significant at 1% ($p < 0.01$)
Minimum temperature (°C)	+0.43	Significant at 5% ($p < 0.05$)
Morning relative humidity (%)	+0.58	Significant at 5% ($p < 0.05$)
Evening relative humidity (%)	+0.39	Significant at 5% ($p < 0.05$)
Rainfall (mm)	−0.22	Non-significant ($p > 0.05$)

3.5 Relationship with Prey (Aphid) Density

A strong, highly significant positive correlation was observed between coccinellid population and aphid density across all crops (mustard: $r = +0.89$, $p < 0.01$; wheat: $r = +0.81$, $p < 0.01$; cotton: $r = +0.76$, $p < 0.01$; okra: $r = +0.69$, $p < 0.01$), confirming that aphid abundance was the principal driver of coccinellid aggregation and reproduction in the study area, with coccinellid population peaks consistently lagging aphid population peaks by approximately one to two weeks — a pattern typical of predator–prey numerical response.

Table 6. Correlation between coccinellid population density and principal aphid prey density across crops

Crop	Principal aphid prey	Correlation coefficient (r)	Significance	Predator peak lag (weeks)
Mustard	*Lipaphis erysimi*	+0.89	Significant at 1% ($p < 0.01$)	1–2
Wheat	*Rhopalosiphum padi / L. erysimi*	+0.81	Significant at 1% ($p < 0.01$)	1–2
Cotton	*Aphis gossypii*	+0.76	Significant at 1% ($p < 0.01$)	1–2
Okra	*Aphis gossypii*	+0.69	Significant at 1% ($p < 0.01$)	1–2

3.6 Food Preference

Field correlation approach: Among the six dominant species, *Coccinella septempunctata* and *Coccinella transversalis* showed the strongest association with mustard aphid and wheat aphid populations, whereas *Cheilomenes sexmaculata* and *Menochilus sexmaculatus* showed comparably strong associations with both cotton aphid and, to a lesser degree, whitefly and mealybug infestations, indicating broader dietary flexibility. *Propylea dissecta* was most closely associated with mustard aphid, while *Hippodamia variegata* showed intermediate preference across aphid species on both rabi and kharif crops.

Laboratory multiple-choice bioassay: The preference index results (mean percentage of total prey consumed) are summarised qualitatively as follows:

- Coccinella septempunctata: strong preference for Lipaphis erysimi (46.3%) and Brevicoryne brassicae (28.1%), with comparatively low consumption of mealybug (9.2%) and whitefly (7.4%) — indicating a narrow, aphid-specialist feeding pattern.
- Coccinella transversalis: similarly, aphid-biased, preferring L. erysimi (41.7%) and Aphis gossypii (30.5%).
- Cheilomenes sexmaculata: the most polyphagous of the species tested, consuming A. gossypii (33.8%), L. erysimi (24.6%), mealybug crawlers (21.3%), and whitefly nymphs (20.3%) in relatively even proportions, confirming its suitability as a generalist predator for multi-pest situations.
- Menochilus sexmaculatus: intermediate polyphagy, favouring A. gossypii (38.2%) over mealybug (26.4%) and L. erysimi (20.9%), with lowest preference for whitefly (14.5%).
- Propylea dissecta: strong preference for L. erysimi (44.5%), with limited feeding on other prey types.
- Hippodamia variegata: moderate preference for L. erysimi (35.6%) and A. gossypii (32.1%), with low consumption of mealybug and whitefly.

Statistical analysis (ANOVA) confirmed that differences in prey consumption among prey categories were significant ($p < 0.01$) for all species except *Cheilomenes sexmaculata*, whose more uniform consumption pattern across prey types was not statistically distinguishable, reaffirming its polyphagous status. Larvae generally showed a similar qualitative preference ranking to adults of the same species but consumed comparatively fewer prey items per unit time owing to their smaller size, except in the fourth instar, where consumption rates approached those of adults.

Table 7. Food preference index (mean % of total prey consumed) of dominant coccinellid species in laboratory multiple-choice bioassays (adults, n = 10 replicates per species).

Predator species	*Lipaphis erysimi* (%)	*Aphis gossypii* (%)	*Brevicoryne brassicae* (%)	Mealybug crawlers (%)	Whitefly nymphs (%)	Preferred prey category
Coccinella septempunctata	46.3	9.0	28.1	9.2	7.4	Aphid specialist
Coccinella transversalis	41.7	30.5	12.0	9.0	6.8	Aphid specialist
Cheilomenes sexmaculata	24.6	33.8	0.0	21.3	20.3	Polyphagous / generalist
Menochilus sexmaculatus	20.9	38.2	0.0	26.4	14.5	Moderately polyphagous
Propylea dissecta	44.5	20.0	15.0	12.0	8.5	Aphid specialist
Hippodamia variegata	35.6	32.1	16.0	10.0	6.3	Aphid-favouring, moderate range

Values are mean percentage of total prey consumed per 24-hour multiple-choice trial; row totals equal 100%. ANOVA: differences among prey categories significant at $p < 0.01$ for all species except Cheilomenes sexmaculata ($p > 0.05$).

4. DISCUSSION

The present study provides comprehensive baseline information on the seasonal diversity and feeding ecology of predaceous coccinellids in the agricultural ecosystems of Jabalpur, Madhya Pradesh, and the findings are broadly consistent with patterns reported from other agro-climatic zones of the Indian subcontinent, while also reflecting features specific to the central Indian plateau environment.

The dominance of Coccinella septempunctata, Cheilomenes sexmaculata, and Menochilus sexmaculatus in the coccinellid assemblage of Jabalpur mirrors their status as the most widely distributed and abundant aphidophagous coccinellids across northern and central India [8,11]. The pronounced peak in both species' richness and abundance during the rabi season can be directly attributed to the extensive cultivation of mustard, a crop highly susceptible to infestation by *Lipaphis erysimi*, which serves as an abundant and nutritionally favourable prey resource that supports rapid coccinellid population build-up [9,12]. This finding reinforces the well-established ecological principle that coccinellid population dynamics are strongly prey-driven, with predator numerical response typically lagging prey population peaks by a short interval sufficient for oviposition, larval development, and adult emergence [2,3].

The comparatively lower diversity and abundance recorded during the zaid season is consistent with the general physiological intolerance of most coccinellid species to extreme summer temperatures, coupled with a scarcity of preferred aphid prey following the harvest of rabi crops [2]. The relative persistence of coccid- and mealybug-feeding species such as Brumoides suturalis and Chilocorus infernalis during this period highlights the ecological importance of alternative, less temperature-sensitive prey sources — such as scale insects and mealybugs on perennial hosts and field bunds — in sustaining coccinellid populations through the unfavourable summer months, and underscores the value of maintaining diverse non-crop vegetation and field margins as refugia for natural enemy conservation[10].

The strong positive correlation between coccinellid and aphid population densities across all crops studied provides quantitative support for the biological control potential of the resident coccinellid community in the region [5,9] and suggests that conservation of these predators — through judicious, need-based use of selective rather than broad-spectrum insecticides — could substantially reduce reliance on chemical aphicides in mustard, wheat, and cotton production systems around Jabalpur.

The food preference results carry particular significance for the design of conservation and augmentative biological control strategies. The relatively narrow, aphid-specialist feeding behaviour exhibited by Coccinella septempunctata, Coccinella transversalis, and Propylea dissecta suggests that these species are best suited for targeted conservation or release in aphid-dominated systems such as mustard and wheat, where they can be expected to exert strong top-down pressure on aphid populations without significant diversion of predatory effort toward alternative prey [9,12]. In contrast, the markedly polyphagous feeding pattern of Cheilomenes sexmaculata, and to a lesser extent Menochilus sexmaculatus, indicates their greater ecological versatility and potential value in mixed-pest cropping systems such as cotton and okra, where aphids, whiteflies, and mealybugs frequently co-occur [6,7]. Such generalist predators may also provide a degree of population continuity during periods of prey scarcity by switching to alternative prey, thereby maintaining a resident predator base capable of rapid numerical response when the primary target pest resurges [1].

These findings are in general agreement with earlier reports from other parts of India that have similarly documented the aphid-specialist tendencies of Coccinella species in contrast with the broader polyphagy of Cheilomenes and Menochilus species [4,11,12], and they extend this understanding specifically to the agro-climatic conditions of the Kymore Plateau region, for which such detailed, season-wise data have previously been limited.

From an applied standpoint, the results suggest several practical implications for integrated pest management in the Jabalpur region. First, insecticide applications targeting aphids in mustard and wheat during the peak rabi period should, where possible, be timed and selected so as to minimise mortality of the naturally occurring coccinellid population, given the clear evidence of strong natural regulation during this season.

Second, the demonstrated persistence of alternative-prey-feeding species during the stressful summer season highlights the potential value of habitat management practices — such as maintaining flowering border plants, reduced tillage refugia, and diverse non-crop vegetation — to sustain coccinellid populations through periods of low pest density, thereby ensuring a ready predator base at the onset of the following cropping season. Third, the identification of Cheilomenes sexmaculata and Menochilus sexmaculatus as effective polyphagous predators makes them attractive candidates for laboratory mass rearing and augmentative release in vegetable and cotton ecosystems where multiple pest species co-occur.

Certain limitations of the present study should also be acknowledged. The survey, though conducted over a full agricultural year, represents a single annual cycle, and inter-annual variation in weather and cropping pattern could influence the precise timing and magnitude of population peaks in subsequent years. Additionally, while the laboratory choice bioassays provide valuable comparative information on innate prey preference, actual field consumption rates may be modified by factors such as prey accessibility, plant architecture, presence of ants tending mealybugs, and intraguild interactions with other predators [1], which warrant further investigation.

5. CONCLUSION

The present investigation demonstrates that the agricultural ecosystems of Jabalpur, Madhya Pradesh, support a rich and ecologically significant assemblage of predaceous coccinellid beetles, with twelve species recorded across the kharif, rabi, and zaid cropping seasons. Coccinellid diversity and abundance were maximal during the rabi season, closely tracking the availability of mustard aphid, and minimal during the hot, prey-scarce zaid season. Food preference studies confirmed a general pattern of aphid specialisation among the dominant *Coccinella* and *Propylea* species, contrasted with a broader, more polyphagous feeding strategy in *Cheilomenes sexmaculata* and *Menochilus sexmaculatus*. The strong positive relationship between coccinellid and aphid densities affirms the substantial natural biological control service provided by this predator community. These findings provide a valuable scientific foundation for the development of conservation biological control and integrated pest management strategies tailored to the specific cropping calendar and agro-climatic conditions of the Jabalpur region, and highlight the importance of season-specific, prey-informed approaches to harnessing coccinellid predators for sustainable pest management in central India.

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About the Author

Poonam Rajput Rathore is a researcher in the Department of Zoology at Malwanchal University, Indore, Madhya Pradesh, India. Her academic work focuses on advancing zoological studies, contributing to research and teaching within the department. She is dedicated to fostering scientific inquiry and mentoring students in the field of zoology.