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continued on the back inside cover

Cover: Little Andaman is part of the island chain with incredible biodiversity, but these amazing species are threatened by development projects, and need our support. Pen and ink artwork by Priyanka Iyer.

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COMMUNICATION

Spider (Araneae) fauna in paddy ecosystem of Kangra Valley, Himachal Pradesh, India

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Abstract: Spiders are considered biological indicators of ecosystem health. The present study documents the diversity and abundance of predatory spiders in the paddy ecosystem of Kangra District, Himachal Pradesh, India, during the cropping period from July 2023 to October 2023. A total of 543 specimens were collected, representing 15 species across six families and nine genera. Oxyopidae was the most abundant family accounting for 44% of specimens, followed by Tetragnathidae (24%), Salticidae (10%), and Araneidae (10%); Lycosidae and Pisauridae were sparsely represented. The most abundant species was *Oxyopes javanus*, while *Peucetia viridana* was the least recorded. The abundance of spider populations exhibited temporal fluctuations throughout the study period, with the highest numbers recorded during the second fortnight of August. Among the three study localities, Shahpur exhibited the highest diversity, with a Shannon-Wiener Index (H) of 1.95 and a Simpson Index (D) of 0.84, indicating a well-balanced spider community, while Nagrota Bagwan had the highest evenness (J' = 0.93), suggesting a more uniform species distribution.

Keywords: Agroecosystem, biodiversity, biological control, community, conservation, insect-pest suppression, predatory spiders.

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Author contributions: MBS did extensive spider collections from the study locations, photography, data analysis, and manuscript preparation and writing. MSK conceptualization, methodology, and spider identification. AKS supervision and guidance.

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INTRODUCTION

Spiders are abundant invertebrate predators in many terrestrial, natural, and agricultural ecosystems (Reshma & Manju 2020). The updated checklist by Caleb & Sankaran (2025) documents 1,976 spider species in India from 511 genera comprising 63 families, representing approximately 3.7% of global spider diversity. Spiders play a pivotal role in agricultural pest control by regulating insect populations (Sudhikumar et al. 2005; Reshma & Manju 2020); and they are highly sensitive to habitat loss, climate change, and environmental disturbances (Thirukonda et al. 2022). Paddy *Oryza sativa* L. is a significant staple and cash crop in India, and spiders in paddy fields can play an important role in controlling populations of planthoppers, and leafhoppers (Samal & Misra 1975). Spider diversity documentation is a necessary aspect of conservation strategies involving integrated pest management, especially where paddy is an important crop as in Kangra Valley of Himachal Pradesh. A preliminary investigation of spider fauna by Chhavi et al. (2021) reported nine spider families, of which four: Araneidae, Oxyopidae, Salticidae, and Tetragnathidae were also recorded in the present study. Detailed information on species diversity and community composition remains limited, and the present investigation was undertaken to comprehensively assess spider communities in the paddy ecosystem of Kangra Valley.

MATERIAL AND METHODS

Study Area

The study was conducted across three localities in the Kangra District of Himachal Pradesh: Nagrota Bagwan, Palampur, and Shahpur. In Nagrota Bagwan, the surveyed locations were Jalbimbi (32.105° N, 76.369 °E), Tharu (32.105° N, 76.369° E), and Tarandi (32.103° N, 76.368° E). In Palampur locality, the locations included Banuri (32.082° N, 76.534° E), Holta (32.105° N, 76.545 °E), and Rajpura (32.105° N, 76.544° E). Whereas, in Shahpur, spider collections were carried from Chandaran (32.211° N, 76.118° E), Jhaghi (32.2086° N, 76.1803° E), and Manjhiar (32.202 °N, 76.189 °E) (Figure 1).

Field data were recorded during the cropping period from July to October 2023. Thirty days after transplantation fortnightly sampling was undertaken using quadrates. Spiders were collected from three quadrates (1 × 1 m) placed at each selected location using direct hand collection method. In addition to that, five sweeps were performed at the same location. Observations and collections were carried out during the morning (0700–0800 h) and evening (1700–1800 h). Each of the three quadrates were observed for a one-hour duration. The collected spider specimens were preserved in 70% ethyl alcohol. The adult spider specimens were identified based on taxonomic literature (Tikader 1970; Tikader & Malhotra 1980; Tikader & Biswas 1981; Gajbe 2008; Yoshida 2009; Jäger 2011; Caleb 2020; Sankaran & Caleb 2023; World Spider Catalog 2025).

Specimens have been deposited in the National Insect Museum (NIM) of Indian Council of Agricultural Research–National Bureau of Agricultural Insect Resources, Bengaluru for further studies. The diversity indices of spider communities were calculated using the following indices:

Margalef's Index of Richness (MI): Measures species richness using the formula:

$$MI = (S - 1) / \ln (N)$$

Where S is the number of species, and N is the total number of individuals. A higher MI value indicates greater richness.

Shannon-Wiener Diversity Index (H): Calculates species diversity based on abundance and evenness:

$$H = \Sigma \{Pi \times \ln (Pi)\}$$

Where Pi is the proportion of individuals of a species. Higher H values represent more diverse and evenly distributed communities.

Simpson's Index (D): Measures dominance of species:

$$D = \Sigma (Pi^2)$$

The complement (1-D) indicates diversity, values closer to 1 signifying greater diversity.

Pielou's Evenness Index (J): Analyse the evenness of species distribution: $J = H / H_{max}$

Where $H_{max} = \ln (S)$. The index ranges from 0–1, 1 indicating maximum evenness.

Statistical calculations were performed in Microsoft Excel program.

RESULTS

A total of 15 species belonging to nine genera under six families were recorded from the paddy ecosystem of Kangra Valley of Himachal Pradesh (Table 1). Oxyopidae was the dominant family, constituting six species under two genera, followed by Araneidae (3 species), Tetragnathidae, Pisauridae, Lycosidae, and Salticidae, recording one species each (Table 1, Figures 2 & 4). Analysis of spider population data from the three study sites—Nagrota Bagwan, Palampur, and Shahpur—

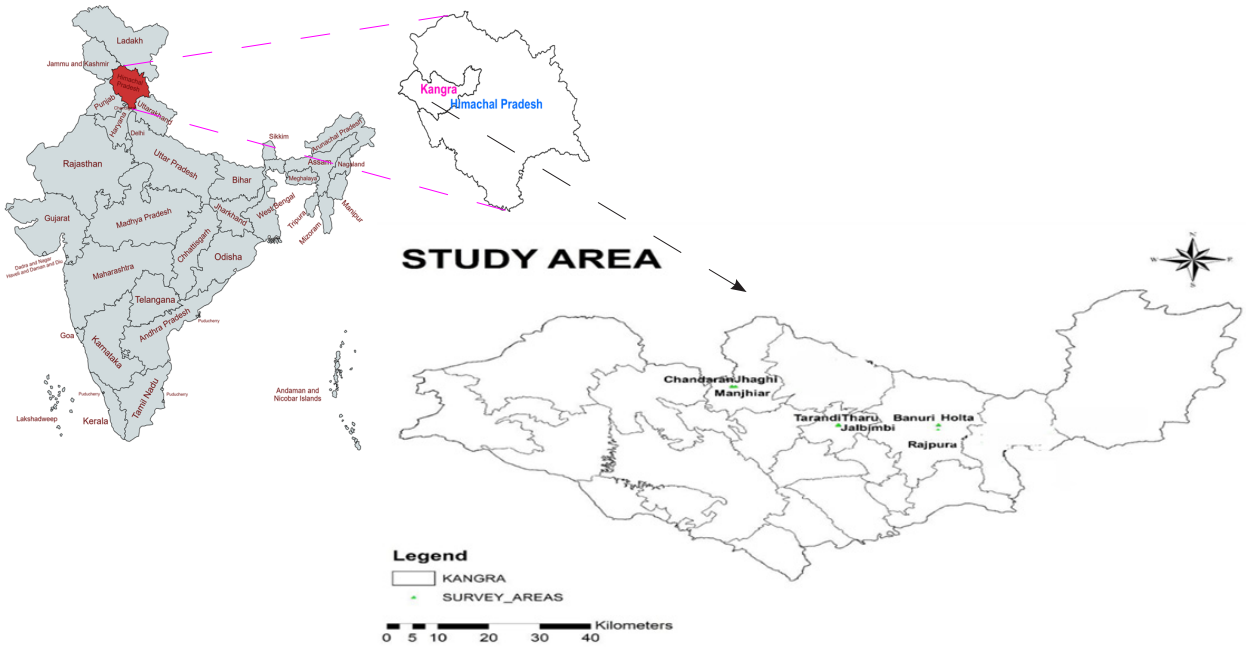

Figure 1. Different locations surveyed in Kangra District, Himachal Pradesh, India

Table 1. The relative abundance of spider species associated with paddy ecosystems of Kangra Valley, Himachal Pradesh.

Family/ Species	Collection based on quadrates and sweeps nets July–October 2023 (number of individuals)				Relative abundance (in %)
	Nagrota Bagwan	Palampur	Shahpur	Total	
Araneidae Clerck, 1757					
Argiope aemula (Walckenaer, 1841)	0	18	0	18	3.31
Neoscona theisi (Walckenaer, 1841)	0	11	0	11	2.03
Neoscona vigilans (Blackwall, 1865)	0	0	27	27	4.97
Lycosidae Sundevall, 1833					
Hippasa lycosina Pocock, 1900	21	0	0	21	3.87
Oxyopidae Thorell, 1869					
Oxyopes hindostanicus (Pocock, 1901)	12	14	0	26	4.79
Oxyopes javanus (Thorell, 1887)	55	61	47	163	30.02
Oxyopes shweta (Tikader, 1970)	0	18	0	18	3.31
Oxyopes sp.	0	0	11	11	2.03
Peucetia sp.	0	8	6	14	2.58
Peucetia viridana (Stoliczka, 1869)	0	4	1	5	0.92
Pisauridae Simon, 1890					
Nilus phipsoni (F.O. Pickard-Cambridge, 1898)	19	0	25	44	8.10
Salticidae Blackwall, 1841					
Plexippus paykulli (Audouin, 1826)	15	16	22	53	9.76
Tetragnathidae Menge, 1866					
Leucauge celebesiana (Walckenaer, 1841)	20	0	0	20	3.68
Leucauge fastigata (Simon, 1877)	31	22	34	87	16.02
Tetragnatha sp.	12	0	13	25	4.60
Total	185	172	186	543	100.00

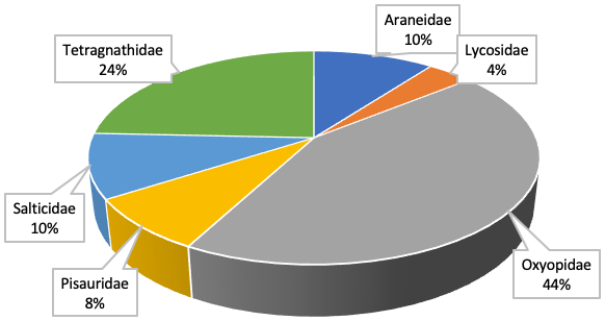

Figure 2. Family composition of spiders recorded from paddy ecosystems of Kangra Valley.

revealed notable variation in species composition and family-level abundance, indicating distinct assemblage structures across the locations. Perusal of the data contained in Figure 2 revealed that based on 543 collected individuals, Oxyopidae was the most abundant family, comprising 44% individuals, followed by Tetragnathidae (24%), Salticidae (10%), and Araneidae (10%). The remaining families, Pisauridae, and Lycosidae were sparsely represented. *Oxyopes javanus* was the most dominant species across all sites, contributing to 30.02% of the total species abundance, followed by *Leucauge fastigata* (16.02%), and *Plexippus paykulli* (9.76%). The spiders present in the paddy ecosystem were categorized into the four guilds based on their foraging behaviour. Specialist/Stalkers (Oxyopidae, Salticidae) were the most dominant guild in the selected localities, encompassing 53.4%, followed by orb web weavers (34.6%), ambushers (8.1%), and ground hunters (3.9%) (Table 2).

The spider diversity indices showed disparities across the localities of Nagrota Bagwan, Palampur, and Shahpur. Nagrota Bagwan had the Shannon-Wiener index of 1.94 and Pielou evenness index of 0.93, indicating a highly diverse, and evenly distributed spider community (Table 3). This indicates that distribution of spider species in Nagrota Bagwan was more uniform. In contrast, Palampur had the lowest Pielou's Evenness index (0.88), supporting a relatively more uneven distribution of spiders, although the Shannon-Wiener index (1.93) remained high, indicating relatively high diversity but less balanced. The Margalef index was the highest in Palampur (1.55), indicating a slightly greater variety of species with regard to the other two localities, while Nagrota Bagwan had the lowest MI (1.34), indicating moderate species richness. The Shannon-Wiener diversity index (H) was calculated for three localities namely Nagrota Bagwan, Palampur, and Shahpur. The obtained values were 1.94, 1.93, and 1.95,

Table 2. Different foraging guilds of spider groups recorded from Kangra Valley.

	Foraging guild	Family	Proportion (in %)
1	Ground hunters	Lycosidae	3.9
2	Orb web weavers	Araneidae Tetragnathidae	34.6
3	Ambushers	Pisauridae	8.1
4	Specialists/ stalkers	Oxyopidae Salticidae	53.4

Table 3. Diversity indices of spider fauna in different localities of Kangra Valley.

Parameters/ Diversity indices	Localities		
	Nagrota Bagwan	Palampur	Shahpur
Species richness (S)	8	9	9
Total individuals (N)	185	172	186
Margalef index (MI)	1.34	1.55	1.53
Shannon-Wiener index (H)	1.94	1.93	1.95
Simpson index (D)	0.83	0.81	0.84
Pielou evenness index (J')	0.93	0.88	0.89

respectively. These values indicate that species diversity is relatively consistent across the three localities, with minor variations suggesting a relatively stable ecological balance. Shahpur had the highest Simpson index (0.84), followed by Nagrota Bagwan (0.83), suggesting a more balanced spider community in these areas compared to Palampur (0.81), where the community was more dominated by spider species namely, *Oxyopes javanus*, *Oxyopes shweta*, and *Argiope aemula*.

DISCUSSION

In the present study, six spider families, namely, Araneidae, Lycosidae, Oxyopidae, Pisauridae, Salticidae, and Tetragnathidae, were recorded across three localities of paddy ecosystem of Kangra Valley. The majority of spider species belonged to the families Oxyopidae, Tetragnathidae, and Araneidae. Earlier studies have also identified Oxyopidae, Tetragnathidae and Araneidae as dominant spider families in paddy ecosystem from various parts of India (Sebastian et al. 2005; Premila 2003; Moses et al.2023).

Foraging guild classification was done by Uetz et al. (1999). The data on different foraging guilds of spiders are presented in Table 2. The dominance of specialists/ stalkers (53.4%) over web builders in the paddy

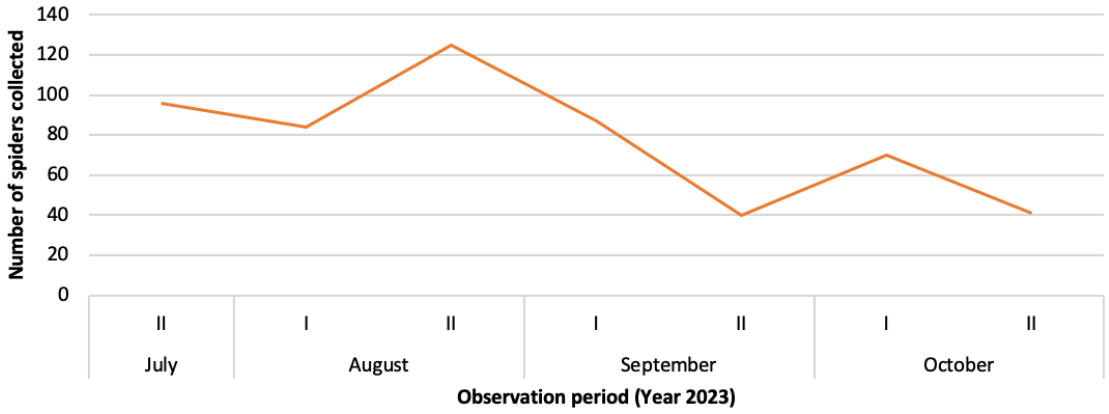

Figure 3. Seasonal abundance of spiders in paddy ecosystem of Kangra Valley.

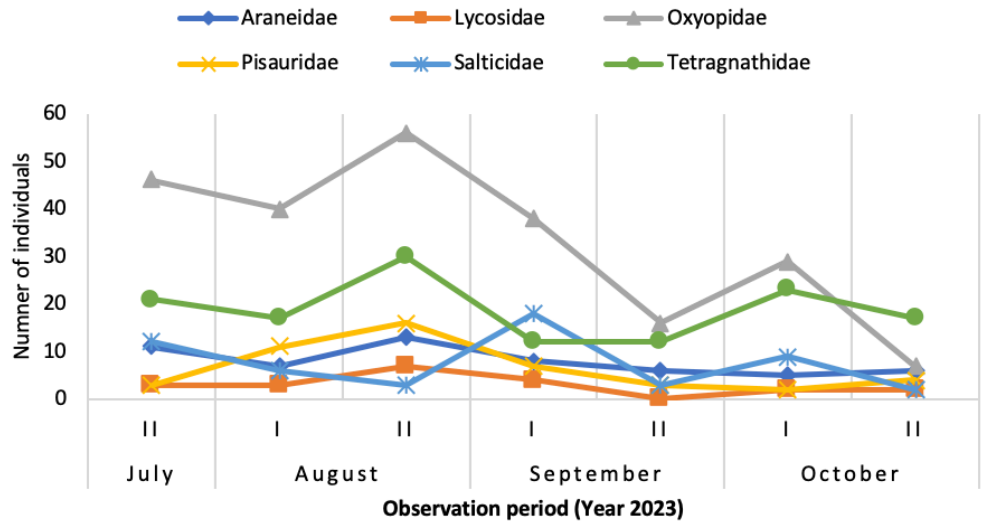

Figure 4. Month-wise population fluctuation of individuals of different spider families.

ecosystem may be attributed to frequent agricultural disturbances, such as worker movement during the cropping season, and heavy rains. These disturbances often damage webs, making it difficult for web-building spiders to thrive. Consequently, stalker spiders, which do not rely on webs, are more successful in such disturbed environments. Data on seasonal abundance of spider shows that spider populations fluctuated throughout paddy cropping period (July 2023 to October 2023), including peak of 125 individuals in the second fortnight of August (Figure 2). The population was higher from the second fortnight of July to the first fortnight of September. Our results demonstrated that spider diversity was significantly higher in locations exhibiting greater habitat complexity, characterized by intense pest (prey) buildup smothered with intensive coverage of weedy vegetation in the field bunds. These findings are in line with Uetz (1991), who documented that structurally complex habitats offer a broader range of ecological niches, and resources, thereby facilitating higher spider species richness. Spiders are sensitive to habitat structure and more complex habitats, such as complex vegetation, inclined to propel more diverse spider population. Adjoining habitats also play a role in determining spider composition by affecting prey and predator movements (Polis et al. 1998). These observations are supported by the findings of Sudhikumar et al. (2005), who emphasized the need for further studies on adjoining habitats and bunds to understand their impact on spider populations in paddy fields.

Although all collections were made in paddy fields, variation in spider species abundance across the locations may be attributed to differences in plant density, growth stages, water levels, pesticide use, surrounding

Image 1. Habitus Images: A—*Argiope aemula* (♂) | B—*Neoscona theisi* (♀) | C—*Neoscona vigilans* (♂) | D—*Nilus phipsoni* (♀) | E—*Oxyopes hindostanicus* (♀) | F—*Oxyopes javanus* (♂) | G—*Oxyopes shweta* (♂) | H—*Oxyopes* sp. | I—*Peucetia viridana* (♀) | J—*Hippasa lycosina* (♀) | K—*Plexippus paykulli* (♀) | L—*Leucauge celebesiana* (♀). © Manoj Salunkhe and M. Sampathkumar.

vegetation, prey availability, and microhabitat conditions. These local factors play a significant role in supporting spider communities. Overall, complexity of habitat, and availability of prey are determining factors in buildup of spider populations and their ecological role in pest regulation in paddy ecosystems.

Richness and abundance of spider recorded in the current investigation highlight the pivotal role of habitat structure, and vegetation complexity in impacting the prevalence of spider species. The physical structure and complexity of crop plants provide favourable conditions for spiders by facilitating web construction, prey availability, shelter, and favourable microclimatic factors, viz., temperature and humidity, which also support mating and predatory activities. These findings are in line with the observations of Young & Edwards (1990), who documented variations in the habitat structure, including plant density, and vegetation cover, significantly affect the diversity, distribution, and ecological distribution of spider species. In a nutshell, we encountered six spider families, with Oxyopidae as the most abundant family. *Oxyopes javanus* was the most numerically prominent, followed by *Leucauge fastigata*. Among the selected localities, species richness was highest in Shahpur (1.95) and Nagrota Bagwan (1.94) compared to Palampur (1.93). A higher dominance of foraging guild specialists/stalkers was observed across all localities. Considering all aspects, the spider community is influenced by various factors, like habitat complexity, prey species type, adjacent fields, and various abiotic factors (Padma & Sundararaj 2021; Dave & Trivedi 2024). The findings of this investigation provide information on the spider diversity recorded in the paddy ecosystem of Kangra District, thereby strategies can be worked out for conservation of these spiders in regulating insect pests, as farmers of this region are in favour of biocontrol-based approaches in pest management. Future research directions should prioritize on prey preference, habitat selection, adaptability of climatic factors, and predatory potential of dominant spider species.

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