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Spatial Mapping of Spiders (Arachnida: Araneae) under Different Habitats of District Raigarh, Chhattisgarh, India

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

The objective of the present study was to document the spider fauna of Raigarh, geographically situated at 21°54'49.2" N & 83°25'40.4" E, Chhattisgarh, India. Raigarh district of Chhattisgarh state is rich in vegetation. Raigarh area of state Chhattisgarh is still untouched; little information is available on documentation of spider diversity. Hence the present study will be carried out in Raigarh district, Chhattisgarh to explore the natural biodiversity of the spider. The study was conducted in different habitats viz. riverine forest, grassland, plantation and mixed sal forest. Sampling site was randomly selected by using Grid-point sampling method. Data was analyzed using PAST (Paleontological Statistics Version 3.25) that reveals where significance is indicated.

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The diversity of spiders was analyzed by widely used indices viz., Dominance, Simpson index and Shannon index. A total of 121 species belonging to 49 genera representing 16 families were collected during the entire field survey. The result indicated that the members of family Araneidae are dominated in both richness and abundance; family Theraphosidae have been relatively minor components of the spider community. Values of Fishers alpha were high at all sites, but varied considerably (range= 20.33 - 29.17). Value of dominance indicate presence of all taxa in mixed Sal habitat (0.0096) as compared to grassland habitat (0.011) The study revealed that spider assemblages can provide reliable assessment of the habitat condition in response to habitat heterogeneity and disturbance.

Keywords: Diversity; habitats; raigarh; species richness spiders.

1. INTRODUCTION

Spiders are reported to be diverse and ubiquitous predators that have colonized in different habitats of terrestrial ecosystems (Radermacher, et.al., 2020; Das, et.al., 2021). Spiders are a fascinating creature, the fossil record reveals them as ancient living organisms emerged during the Devonian period about 380 million years ago (Shear, et.al., 1989). They belong to the Kingdom- Animalia; Phylum- Arthropoda; Class- Arachnida and Order- Araneae. Spiders have already established themselves as model organisms in the eyes of researchers and scientists as: Bio-indicator (Pearce and Venier, 2006; Basumatary and Brahama, 2017), Architect (Su, et.al., 2018) and Biological control agents (Riechert and Lockley, 1984). Spiders represent itself at the top of lower food web across different ecosystems. The contribution of spiders towards the dynamics of terrestrial ecosystems is significant (Floren and Sprick, 2007).

In India, 1906 species of spiders belong to 507 genera under 62 families were documented (Araneae of India, 2024). Spiders are one of the most speciose and abundant arthropod order globally, and a hectare of tropical forests contains about 300-800 species (Coddington et. al, 1991). Spiders comprising the second most taxon after insects with 52,573 described species to the date (Platnick, 2024). The updated checklist of Indian spiders in “Spiders of India”, compiled by Mathew, et.al., (2014) provides detail information. The further checklist was provided by Keshwani, et.al., (2012) which provide information about the presence of 1686 species of spiders belongs to 438 genera under 60 families. Chhattisgarh is situated at the center of Indian sub-continent, endured with rich flora and fauna. Raigarh district of Chhattisgarh state is rich in vegetation. Raigarh area of state Chhattisgarh is still untouched; little information is available on documentation of spider diversity. Hence the present study will be carried out in Raigarh district, Chhattisgarh to explore the natural biodiversity of the spider.

Spiders have a very wide distribution, and exist in almost all types of habitats (Rajeevan et.al., 2019). The diversity of spiders differs in response to environmental abiotic and biotic factors (Gunnarsson, 1990). It would be predicted that the fundamental changes in the natural habitats would also affect the diversity of this large group (Atauri and De- Lucio, 2001). Elite spatio-temporal information on the diversity of spiders can be effective for lying out prior conservation strategies of these species. Since, Chhattisgarh is a newly formed state of central India. Very little information about the spider diversity and their preferred habitat have been done. In this context, the present study was designed to provide a checklist of spiders present in Raigarh district with respect to variation in function of habitats.

2. MATERIAL AND METHODOLOGY

2.1 Study Area

Raigarh district occupies the Eastern most part of state Chhattisgarh, India; covers an area of 7086 sq. km., geographically lies between 21° 20’ 32” to 22° 47’ 26” North latitude, and 82° 55’ 35” to 83° 48’ 14” East longitude. It is situated about 280 m to 1078 m above the sea level. The district is made up of various former princely states of Raigarh, Sarangarh and Dharamjaigarh. It is bounded on the North by Sarguja district, North-East by Jashpur, West by Korba and Janjgir - Champa, South by Mahasamund and Baloda Bazar district, South-East and East by Odisha state. It comprises of nine tehsil viz., Raigarh, Sarangarh, Dharamjaigarh, Baramkela, Kharsia, Pusour, Lailunga, Tamnar and Gharghoda. Forest present in Raigarh district represent climax community which is mainly dominated by

Shorea robusta. This habitat is an ideal place for the spiders to exist widely as a huge population and expand their community diversely.

2.2 Site Selection

Study was carried out consecutively for a period of two years from March 2019 to April 2021. Sampling site was randomly selected by using Grid-point sampling method (Map Info Professional 7.5 software). These sites were identified subjectively based on apparent differences in vegetation type and physiography viz.,

a) **Riverine forest**- this forest type was found along water bodies (rivers, ponds etc.) and structurally characterized by extremely diverse overstorey and understorey structure relative to other vegetation types.
b) **Grassland** - Grasslands occurred in low-lying areas or depressions. Such areas had alluvial soils, mostly sandy patches. Structurally, these grasslands are characterized by an absence of trees and moderate to very low herbaceous ground cover.
c) **Mixed Sal forest** - This was the dominant vegetation type, which occurred in approximately all patches in the entire study area. The overstorey was composed of old *Shorea robusta* with *Bauhinia racemosa*, and *Terminalia alata* etc.
d) **Plantation**. - Extensive plantations of *Eucalyptus sp*. and *Tectona grandis* have been raised as gap planting as well as after clear felling. This vegetation type mostly represents large scale mechanized plantations of teak (*Tectona grandis*) and *Eucalyptus sp*.

2.3 Collection Techniques

As spiders exploit a wide variety of spatial niches, sampling was done in order to collect the representative samples from all habitats. Sampling requires a combination of semi quantitative methods; therefore, six different collection techniques were employed i.e. pitfall trapping, sweep netting, ground hand collection, aerial hand collection, vegetation beating and litter sampling (Sorensen et.al., 2004).

2.4 Preservation and Identification

The spiders are smaller and soft bodied animal when dried and they are preserved using 70% alcohol. Care was also taken to store only one specimen per vial (6.5 cm×3.0 cm) in the case of bigger spiders and two or three per vial if they are small ones. All the collected specimens were stored in a container made up of Borosil glass for preservation with a paper labeled the name of the location, the date of collection and the name of the specimen collectors. The collected specimens of spiders were identified based on structures and taxonomic key characters provided in the available literature Pocock (1900), Tikader (1975, 1987), Tikader and Malhotra (1980), Barrion and Litsinger, (1995) Majumder (2004), Gajbe (2008) and Platnick (2013), Sebastian et.al., (2005), by experts at Zoological Survey of India, Kolkatta, West Bengal and Tropical Forest of Research Institute, Jabalpur, Madhya Pradesh. Voucher specimens were deposited and preserved in Zoological Survey of India (ZSI) for further accession.

2.5 Data Analysis

Biodiversity sample data was transferred into Excel® spreadsheets, from which graphs were generated to assist in analysis. Data was analyzed using PAST (Paleontological Statistics Version 3.25) that reveals where significance is indicated. The diversity of spiders was analyzed by widely used indices viz., Dominance, Simpson index and Shannon index.

Fisher's alpha has also been extensively used in many other arthropod studies, thus facilitating comparisons between studies (Shochat, et. al., 2004). Non-parametric Kruskal-Wallis ANOVA was used to compare the diversity indices of spiders among habitats. To compare the species richness values of habitat, and to calculate expected species richness, individual-based rarefaction was used; individual rarefaction is a technique to assess species richness from different sampling site (Gotelli and Colwell, 2001).

3. RESULTS

A total of 121 species belonging to 49 genera representing 16 families were collected during the entire field survey (Table 1). It was observed that across all the reported spider families the Aranidae was the most abundant (23.27%), followed by Gnaphosidae (18.56%), Lycosidae (13.77%), Philodromidae (10.61%), Oxyopidae (10.29%), Salticidae (6.33%), Tetragnathidae (5.29%), Nephilidae (3.57%), Eresidae (2.29%), Hersilidae (1.24%), Uloboridae (1.14%), Thomisidae (1.13%), Filistidae (0.84%), Clubionidae (0.86%), Scytodidae (0.71%), and Theraphosidae (0.03%) (Fig. 1) respectively. The result indicated that the members of family

Araneidae are dominated in both richness and abundance; in contrast, the family Theraphosidae has been relatively minor components of the spider community**.**

Table 1. List of the spider species recorded from Raigarh, Chhattisgarh

S.NO	Species	Family	S.NO	Species	Family
1	*Araneus mitificus*	Araneidae	39	*Scopoides tikaderi*	Gnaphosidae
2	*Araneus nympha*	Araneidae	40	*Sergiolus meghalayensis*	Gnaphosidae
3	*Argiope aemula*	Araneidae	41	*Sergiolus poonaensis*	Gnaphosidae
4	*Argiope anasuja*	Araneidae	42	*Sergiolus singhi*	Gnaphosidae
5	*Argiope pulchella*	Araneidae	43	*Sosticus jabalpurensis*	Gnaphosidae
6	*Chorizopes tikaderi*	Araneidae	44	*Sosticus sp.*	Gnaphosidae
7	*Cyclosa bifida*	Araneidae	45	*Zelotes bharatae*	Gnaphosidae
8	*Cyclosa hexatuberculata*	Araneidae	46	*Zelotes jabalpurensis*	Gnaphosidae
9	*Cyclosa confraga*	Araneidae	47	*Zelotes poonaensis*	Gnaphosidae
10	*Cyclosa insulana*	Araneidae	48	*Zelotes sp.*	Gnaphosidae
11	*Cyclosa moonduensis*	Araneidae	49	*Hersilia savignyi*	Hersiliidae
12	*Cyrtophora bidental*	Araneidae	50	*Arctosa himalayensis*	Lycosidae
13	*Cyrtophora jabalpurensis*	Araneidae	51	*Arctosa indica*	Lycosidae
14	*Cyrtophora sp.*	Araneidae	52	*Hippasa agelenoides*	Lycosidae
15	*Eriovixia sp.*	Araneidae	53	*Hippasa greenalliae*	Lycosidae
16	*Larinia bharatae*	Araneidae	54	*Lycosa bistriata*	Lycosidae
17	*Larinia emertoni*	Araneidae	55	*Lycosa jagdalpurensis*	Lycosidae
18	*Neoscana bengalensis*	Araneidae	56	*Lycosa poonaensis*	Lycosidae
19	*Neoscana biswasi*	Araneidae	57	*Lycosa shaktae*	Lycosidae
20	*Neoscana mukerjei*	Araneidae	58	*Pardosa amkhasensis*	Lycosidae
21	*Neoscana nautica*	Araneidae	59	*Pardosa birmanica*	Lycosidae
22	*Neoscana pavida*	Araneidae	60	*Pardosa jabalpurensis*	Lycosidae
23	*Neoscana sanghi*	Araneidae	61	*Pardosa mukundi*	Lycosidae
24	*Neoscana sp.*	Araneidae	62	*Pardosa timidula*	Lycosidae
25	*Clubiona drassodes*	Clubionidae	63	*Nephila kuhlii*	Nephilidae
26	*Stegodyphus sarsinorum*	Eresidae	64	*Nephila pilipes*	Nephilidae
27	*Pritha poonaensis*	Filistatidae	65	*Nephila pilipes jalorensis*	Nephilidae
28	*Callilepis lambai*	Gnaphosidae	66	*Oxyopes ashae*	Nephilidae
29	*Callilepis rukminiae*	Gnaphosidae	67	*Oxyopes bharatae*	Nephilidae
30	*Drassodes meghalayaensis*	Gnaphosidae	68	*Oxyopes jabalpurensis*	Nephilidae
31	*Drassodes tikaderi*	Gnaphosidae	69	*Oxyopes pankaji*	Nephilidae
32	*Drassyllus jabalpurensis*	Gnaphosidae	70	*Oxyopes rukminiae*	Nephilidae
33	*Gnaphosa jodhpurensis*	Gnaphosidae	71	*Oxyopes sp.*	Nephilidae
34	*Gnaphosa poonaensis*	Gnaphosidae	72	*Peucetia jabalpurensis*	Nephilidae
35	*Nodocion sp.*	Gnaphosidae	73	*Peucetia pawani*	Nephilidae
36	*Poecilochroa barmani*	Gnaphosidae	74	*Peucetia yogeshi*	Nephilidae
37	*Poecilochroa tikaderi*	Gnaphosidae	75	*Philodromus ashae*	Philodromidae
38	*Scopoides maitraiae*	Gnaphosidae	76	*Philodromus barmani*	Philodromidae
77	*Philodromus bhagirathai*	Philodromidae	100	*Ozyptila jabalpurensis*	Thomisidae
78	*Philodromus domesticus*	Philodromidae	101	*Runcinia affinis*	Thomisidae
79	*Philodromus jabalpurensis*	Philodromidae	102	*Runcinia khandari*	Thomisidae
80	*Philodromus pali*	Philodromidae	103	*Runcinia yogeshi*	Thomisidae
81	*Thanatus jabalpurensis*	Philodromidae	104	*Synema decoratum*	Thomisidae
82	*Thanatus ketani*	Philodromidae	105	*Synema mysorese*	Thomisidae
83	*Tibellus jabalpurensis*	Philodromidae	106	*Thomisus bargi*	Thomisidae
84	*Tibellus poonaensis*	Philodromidae	107	*Thomisus danleli*	Thomisidae
85	*Phidippus bhimrakshiti*	Salticidae	108	*Thomisus lobosus*	Thomisidae
86	*Plexippus paykulli*	Salticidae	109	*Thomisus projectus*	Thomisidae

S.NO	Species	Family	S.NO	Species	Family
87	*Rhene haldanei*	Salticidae	110	*Thomisus Rajani*	Thomisidae
88	*Rhene sp.*	Salticidae	111	*Thomisus simoni*	Thomisidae
89	*Scytodes alfredi*	Scytodidae	112	*Thomisus sundari*	Thomisidae
90	*Tetragnatha chamberlini*	Tetragnathidae	113	*Thomisus sp.1*	Thomisidae
91	*Tetragnatha geniculate*	Tetragnathidae	114	*Thomisus sp.2*	Thomisidae
92	*Tetragnatha vermiformis*	Tetragnathidae	115	*Tmarus jabalpurensis*	Thomisidae
93	*Leucauge decorate*	Tetragnathidae	116	*Xysticus jabalpurensis*	Thomisidae
94	*Leucauge celebesiana*	Tetragnathidae	117	*Xysticus joyantius*	Thomisidae
95	*Poecilotheria sp.*	Theraphosidae	118	*Xysticus kali*	Thomisidae
96	*Misumenoides gwarighatensis*	Thomisidae	119	*Xysticus minutus*	Thomisidae
97	*Monoeses jabalpurensis*	Thomisidae	120	*Xysticus sp.*	Thomisidae
98	*Oxytate elongata*	Thomisidae	121	*Uloborus danolius*	Uloboridae
99	*Ozyptila amkhasensis*	Thomisidae			

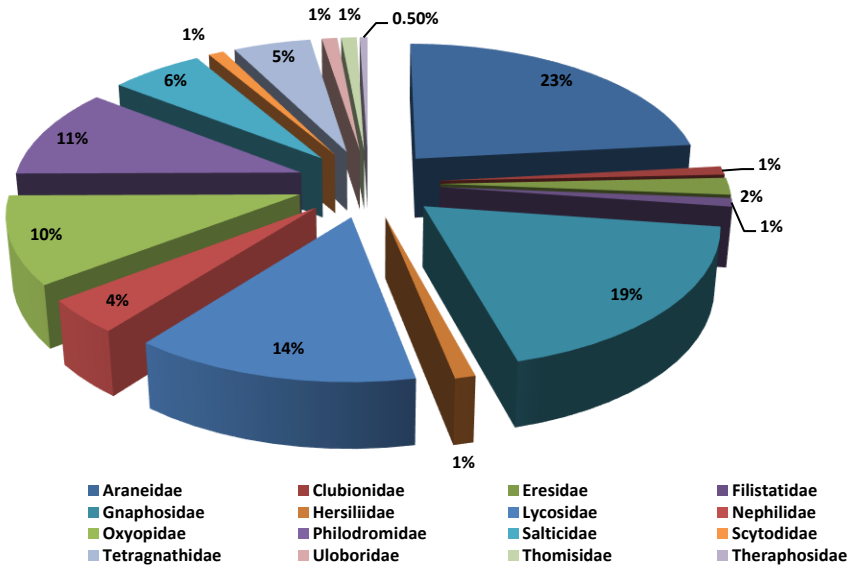

Fig. 1. Family composition of spider abundance (% occurrence of individual captured per family) from different sites of Raigarh, Chhattisgarh

In the present study, a total of 13,359 individual of spiders were recorded during the study period in Raigarh district, of which 70.29% were adult individuals. Maximum number of spider individuals (7802) was observed in mixed sal forests and the minimum (103) were observed in plantation sites. Among various families observed, twenty-four species were recorded from family Thomisidae, twenty-four species from Araneidae, thirteen species were recorded from Lycosidae, ten species were recorded from family Oxyopidae and Philodromidae; five from Tetragnathidae, four species were found from Salticidae three species were recorded from family Nephilidae, and one each from Clubionidae, Eresidae, Filistatidae, Hersilidae, Scytodidae, Theraphosidae and Uloboridae. Based on the observations, it can be established that the dominant species belong to family Thomisidae (24 species under 9 genera) and Araneidae (24 species under 8 genera).

Diversity indices like Simpson, Shannon-Wiener, Dominance and evenness of different habitat site in Raigarh district report a significant difference (Table 2). It was also reported that the individuals and taxa of spiders reported in Raigarh were significantly different across different land uses. Values of Fishers alpha were high at all sites, but varied considerably (range= 20.33 - 29.17). Highest spider diversity was observed in tropical mixed sal forest, while it was significantly lower in the plantation habitat (Table 2). Value of dominance indicate presence of all taxa in mixed Sal habitat (0.0096) as compared to grassland habitat (0.011) where *Plexippus paykuili* and

Phidippus bhimrakshiti dominates over the other species in the whole community. According to Individual rarefaction curves (species richness curve) 95% confidence interval indicates richness tended to be highest in mixed sal and riverine habitat (Fig. 2).

The non parametric one_way ANOVA shows that there is a significant difference between the relative abundance of spider species in different types of habitats (Table 3). The data were calculated as per the method of Analysis of Variance. The recorded value, when compared P-value is less than 0.005 which is significant (Table 3).

4. DISCUSSION

The diversity and distribution of spiders plays a vital role in an ecosystem (Yong and Edward, 1990). They are regarded as best bio-indicators of natural habitats, thus determines the response of different biological communities towards environmental changes or disturbances (Marc and Canard, 1997). Spiders seem well suited to discriminate habitat type and quality, since play important role as diverse and abundant invertebrate predators in terrestrial ecosystems. Despite their demonstrated ecological role diverse ecosystems, spider diversity and assemblage are poorly studied in Chhattisgarh. For laying out prior conservation strategies and preservation of spider diversity, its essential to understand the pattern of spider diversity and distribution (Uniyal, 2004). In this context, the present study was conducted to record the diversity and distribution of spiders under different land uses of Raigarh, Chhattisgarh.

Spider diversity is regarded as powerful biodiversity indicators in tropical ecosystems. In the present study 121 species have been recorded in Raigarh, Chhattisgarh in four different ecosystems viz. plantation, sal forest, grass land and riverine ecosystem. These recorded spiders fall in 16 families' viz., Araneidae, Clubionidae, Eresidae, Filistatidae, Gnaphosidae, Hersiliidae, Lycosidae, Nephilidae, Oxyopidae, Philodromidae, Salticidae, Scytodidae, Tetragnathidae, Theraphosidae, Thomisidae, and Uloboridae. Out of the 16 families, Thomisidae followed by Araneidae and Gnaphosidae was found to be the predominant group in terms of distribution. Twenty-four species have been recorded under nine genera, thus showing the abundance of thomisids in the study area. Many authors have conducted studies on spider diversity in different landscapes. Galle et.al., (2018) reported a higher spider functional diversity in plantations. Jose et.al., (2018) reported 112 spider species belonging to 81 genera and 21 families in a riverine habitat. Hu, et.al., (2022) observed that more recovered grassland harbors high spider diversity. Tabasum et.al., (2018) reported 50 spider species belonging to 19 families in and around a university campus of Ballari. Shabnum et.al., (2021) reported 93 spider species belonging to 19 families in different plantation habitats of Western Ghats, Wayanad, India. Das et.al., (2021) reported 32 spider species belonging to 13 families and 18 genera in Kaila Shahar, Tripura, India. Furthermore, there are many authors who have successfully documented the spider diversity in different

Table 2. Diversity indices of different habitat site in Raigarh district of Chhattisgarh

S.No	Diversity Indices	Mixed Sal	Plantation	Riverine	Grassland
01	Taxa_S	121	103	117	116
02	Individuals	7802	967	2572	1977
03	Dominance_D	0.0097	0.012	0.0095	0.012
04	Simpson_1-D	0.99	0.98	0.99	0.98
05	Shannon_H	4.71	4.53	4.71	4.62
06	Fishers_alpha	20.33	29.17	25.25	26.91
07	Evenness_e^H/S	0.92	0.9	0.95	0.87

Table 3. ANOVA (one way) for the relative abundance of spider species in different habitat site in Raigarh, Chhattisgarh

Source of Variation	*SS*	*Df*	*MS*	*F*	*P-value*
Between Groups	231304.86	3	77101.2	345.2	0.0035
Within Groups	107195.35	480	223.324		
Total	**338500.21**	**483**			

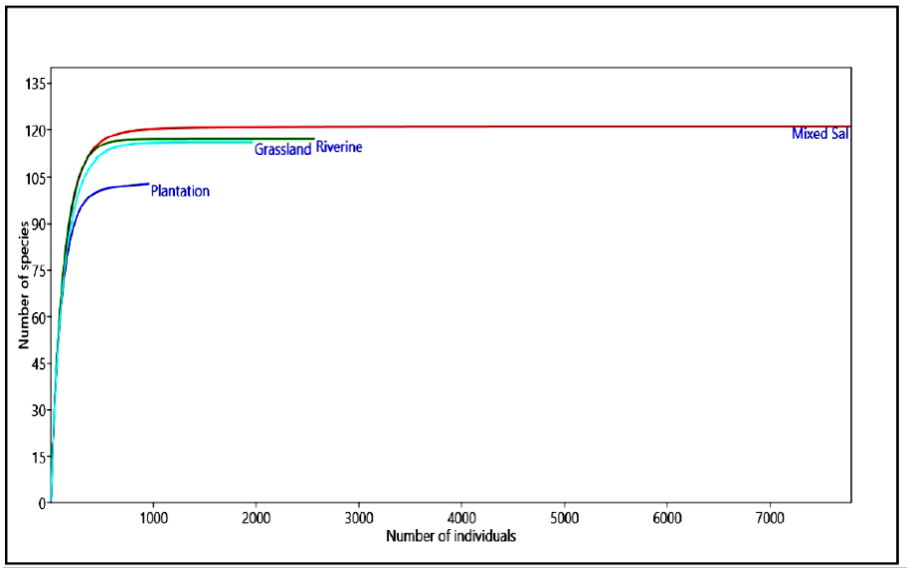

Fig. 2. Individual Rarefaction curve (species richness curve) of spiders caught at the different sites (all sampled pool) in Raigarh, Chhatisgarh

Nephila pilipes jalorensis *Oxyopes bharate* *Poecilotheria* sp.

Plate 1. Photographs of Spiders

habitats (Sudhikumar, et.al., 2005; Rendon, et.al., 2006; Rodríguez, et.al., 2015; Adarsh and Nameer, 2013; Sebastian, et.al., 2005: Pandit and Pai, 2017).

The "habitat heterogeneity hypothesis" is one of the key stones of ecology (Simpson, 1949). It states that structurally complex habitats may provide more niches and diverse ways of exploiting the environmental resources and thus increase species. Thus, the heterogeneity of landscapes results in diversity of spider communities (Wersebeckmann et.al., 2021). In most habitats, plant communities determine the physical structure of the environment, and therefore, have a considerable influence on the distributions and interactions of animal species (Lawton, 1983). The results of the present study indicated that there is a significant difference between the relative abundance of species in different types of habitats. Highest spider diversity was observed in tropical mixed sal forest, while it was significantly lower in the plantation habitat. Value of dominance indicate presence of all taxa in mixed Sal habitat (0.0096) as compared to grassland habitat (0.011) where *Plexippus paykuili* and *Phidippus bhimrakshiti* dominates over the other species in the whole community. Since in sal forests there are less anthropogenic activities, as it has been reported that the anthropogenic activities cause threat to the spider diversity (Lubin et.al., 2020). Since sal forests provide a diverse habitat for spiders thus it assembles diversity in spider communities. The results are inconsistent with those of Lubin et.al., (2020), who examined the spider diversity in

Negev, Israel. One of the reasons for the diversity of spiders in sal forest might be the identity of sal trees by spiders. Moreover, tree identity plays an important role for spiders than richness in tree species (Matevski and Schuldt, 2021). The findings of this study, combined with previous discoveries, lead to the conclusion that habitat structure and environmental conditions may have a significant role in defining the composition of the local spider community. As a result, recording spider diversity trends can be useful in demonstrating the ecosystem's conservation importance.

5. CONCLUSION

In conclusion, spiders can be used as ecological indicators of Raigarh district. Provided checklist was the first documentation on Araneae fauna of Chhattisgarh. The study revealed that spider assemblages provide reliable assessment of the habitat condition in response to habitat heterogeneity and disturbance. Spiders seem well suited to discriminate habitat type and quality, since play important role as diverse and abundant invertebrate predators in terrestrial ecosystems. Forest managers should encourage the growth of ground layer vegetation species at all stages of the forest cycle, whilst retaining features typical of a mature forest in order to enhance the diversity of both open and forest species within a plantation patches. At a landscape scale, a mosaic of different aged plantations will provide the heterogeneity of habitat types necessary to sustain both open and forest specialists.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declares 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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