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Research Article

Assemblage of spider diversity in Okkarai region of Pachamalai hills, Eastern Ghats, Tiruchirappalli district, Tamil Nadu, India

MIRIAM CECILIA VASSOU[1], SUREENTHIRA TAMILPERIYARDHASAN[1], SUBRAMANIAN ARIVOLI[2] and SAMUEL TENNYSON[3*]

[1]*Department of Zoology, Thanthai Periyar Government Arts and Science College (Affiliated to Bharathidasan University), Tiruchirappalli – 620023, Tamil Nadu, India*

[2]*Department of Zoology, Thiruvalluvar University, Vellore – 632115, Tamil Nadu, India*

[3]*Department of Zoology, Madras Christian College, Chennai – 600059, Tamil Nadu, India*

**Corresponding author E-mail:* samtennyson@gmail.com

ABSTRACT: The Okkarai area of Pachamalai hills, Eastern Ghats, Tiruchirappalli district, Tamil Nadu, India, was studied for spider diversity in the current study. In total, 178 spiders were recorded, belonging to 12 distinct families (Araneidae, Desidae, Linyphiidae, Nephilidae, Oxyopidae, Pholcidae, Pisauridae, Salticidae, Sparassidae, Tetragnathidae, Theridiidae and Thomisidae), and 17 and 20 different genera and species, respectively. Araneidae family dominated the spider population, and the family dominance curve was in the ascending order of Araneidae (25.28%) > Oxyopidae (14.04%) > Pholcidae (14.04%) > Thomisidae (10.11%) > Tetragnathidae (7.86%) > Linyphiidae (6.74%) > Nephilidae (6.17%) > Sparassidae (5.05%) > Theridiidae (4.49%) > Pisauridae (3.37) > Salticidae (2.24%) > Desidae (0.56%). Araneidae (17.64%) had the most genera per family, and Araneidae and Oxyopidae (20.00%) had the most species per family; and about species composition, *Pholcus phalangioides* dominated with 14.04%. Spider guilds were represented by web patterns as well as hunting patterns. Web pattern comprised orb web (60.86%), cobweb (34.78%) and sheet web (4.34%). Orb web was represented by families Araneidae, Nephilidae and Tetragnathidae; cobweb by Desidae, Pholcidae, Pisauridae and Theridiidae; while Linyphiidae for sheet web. Ambushers (53.22%) and stalkers (46.77%) represented the hunting pattern wherein Pisauridae, Sparassidae and Thomisidae represented ambushers, and Oxyopidae and Salticidae represented stalkers. Araneidae and Oxyopidae had high species richness indicated by Hill's (4), Margalef's (1.33), and Menhinick's (0.299) indices. Salticidae had high species evenness denoted by Alatalo's (0.578), Pielou's (0.488), Shannon's (1.471) and Sheldon's (1.413) indices; while Linyphiidae represented Heip's index (1.347). Araneidae scored high on other indices, viz., Berger-Parker dominance (25.28%), community dominance (1.24), and relative dominance (20.00%); while Salticidae had a high Hill's number abundance (1.413%), and Pholcidae had a high relative frequency (0.55). This study will contribute to the data on spider biodiversity, taxonomy, it's abundance, distribution, and community organization.

KEYWORDS: Diversity, evenness, guilds, richness, species, spiders

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INTRODUCTION

Spiders are the most diverse group of chelicerates (Wheeler *et al*., 2017), found all over the world, and adapted to every form of habitat (John & Tom, 2018), except the open sea and the atmosphere (Foelix, 2011). Spiders are an ancient taxon that has diversified beyond extinction over a long period, and it is estimated that they have 400 million years of origin, dating back to the Middle Devonian (Decae, 1984; Coddington & Levi, 1991; Guruswamy *et al*., 2022; Singh & Goswami, 2023). Selden and Penney (2010) suggest that spiders may have been among the first animals to live on Earth, existing more than 150 million years before dinosaurs. Arachnida: Araneae, a megadiverse order of arthropods, includes spiders, which rank seventh globally in terms of overall species diversity among all animal orders (Ezeonyejiaku *et al*., 2019). The World Spider Catalogue in 2023 has listed 51, 229 species, organised into 4,329 taxa and 132 families (World Spider Catalog, 2023). As the most copious, female-dominated, obligate carnivores, and abundant predatory order in terrestrial ecosystems (Turnbull, 1973; Uetz *et al*., 1999; Nyffeler, 2000; Nyffeler & Birkhofer, 2017), spiders makes them to be exceptional arthropods of predation as a trophic strategy. Their small size, short generation time, high sensitivity to temperature and moisture changes, and ability to accumulate numerous trace metals make them suitable biological indicators in environmental habitats (Kremen *et al*., 1993; Gerlach *et al*., 2013), and are good indicators of ecotoxicological studies (Sebastian & Ryszard, 2012; Stojanowska *et al*., 2020). Furthermore, by lowering insect densities and stabilising pest populations, their role as generalist predators has a significant impact on the structure of the community, particularly in the food chain and food web (Nyffeler & Benz 1987; Marc *et al*., 1999; Nyffeler 2000; Ludwig *et al*., 2018; Michalko *et al*., 2019; Saranya *et al*., 2019; Benamu, 2020). This helps to promote integrated pest management, which in turn lessens the need for indiscriminate use of pesticides.

Since these arthropods are indicative of both ecological and evolutionary success, many researchers view spiders as a successful group (Bond & Opell, 1998; Blackledge *et al*., 2003; Kuntner & Agnarsson, 2011; Platnick & Raven, 2013; Dimitrov & Hormiga, 2021), and additionally, as a model group for the study of diversity patterns (Cardoso *et al*., 2011; Malumbres-Olarte *et al*., 2018). However, they have historically been disregarded or overlooked (Palem *et al*., 2016), and have been marginalised in terms of mainstream documentation, research, and conservation. As a result, it is imperative to explore their diversity and preserve their ecosystem sustainability and biodiversity, systematic documentation is required (Smitha & Sudhikumar, 2020). Periodic recording of spider diversity is essential for sustainable management and conservation of diversity, as it enriches worldwide databases and catalogues that may support taxonomy and diversity conservation (Kashmeera & Sudhikumar, 2019). Since humans tend to favour some organisms over others of equal importance due to their lack of universal appeal, spiders have received little attention from the conservation community despite their high diversity, ecological role in ecosystems, documented threats, and the known imperilment of some species (Humphries *et al*., 1995). A lack of collated data on the state and distribution of spider conservation may be a more pressing concern than the general public's unfavourable opinions towards spiders, which may be the cause of this lack of attention. The biodiversity of spiders in Tamil Nadu was updated by Singh (2023), and Rajendran *et al*. (2017) recorded the variety and distribution of spiders in the various habitats of Puthanampatti, in the Tiruchirappalli district of Tamil Nadu. Conversely, Sugumaran *et al*. (2007) and Palem *et al*. (2016) made significant contributions to the Eastern Ghats' spider biodiversity. The biological literature of the Pachamalai hills villages in the Eastern Ghats, Tiruchirappalli district of Tamil Nadu, has regrettably neglected and inadequately described the diversity of this natural biological control group, and it is not possible to compare the spider diversity of this region based on prior research. Hence, this study, in addition to providing a baseline checklist of spiders and exploring their diversity and distribution, will be the first study in this part of India and will lay the groundwork for future research on the ecology of spider communities in this study area.

MATERIALS AND METHODS

Study area, period and design

Spider diversity was recorded in Okkarai village located in Thuraiyur taluk, 39Km east south of Pachamalai hills, Tiruchirappalli district, Tamil Nadu, India (11.2151° N, 78.5341° E). The Pachamalai hills are low mountain ranges which are part of the Eastern Ghats of India, splashed with water streams and covered with lush green foliage. A preliminary survey was carried out to gain a direct understanding of the study region's topography, nature, and spider presence. The survey was conducted from July 2022 to February 2023. Various collection techniques/methods viz., active searching, aerial and ground hand collection, inverted umbrella method, litter sampling, pitfall trapping, sweep netting, and vegetation beating were applied to survey and collect spiders because spiders are distributed throughout a habitat's strata and cannot be collected using a single, standard method (Green, 1999). Throughout the course of the study a field record was maintained, and random sampling was conducted three days a week, from 06:00 to 08:00 hours, and from 16:00 to 18:00 hours. The collected specimens were carefully labelled with the location and further details and were preserved in glass vials or bottles filled with formalin.

Depository of spiders and data analysis

The data gathered was analysed and tabulated. Taxonomic identification was performed in the laboratory using a stereo-zoom microscope and standard identification keys. Given the intrinsic complexity of the taxonomy, morphological traits were utilised to identify the collected specimens up to the species level for each family of each order with the aid of taxonomic dichotomous keys, and a checklist was created using standardised common and scientific names (Pocock, 1900; Gravely, 1931; Tikader, 1980, 1982, 1987; Davies & Zabka, 1989; Biswas & Biswas, 1992; Barrion & Litsinger, 1995; Sebastian & Peter, 2009; Caleb, 2016).

Spider guilds

Spider guilds are arranged based on the families of spiders that are gathered. The ecological traits of each family or a core species that embodies each family designate spiders (Post & Reichert, 1977; Nyffeler & Benz, 1987; Uetz *et al*., 1999), derived from the characteristics of their web patterns and hunting techniques (Cardoso *et al*., 2011).

Diversity indices

Diversity indices: diversity, richness and evenness were computed. Brillouin (1956), Hill (1973), Shannon and Weiner

(1964), Simpson (1949) dominance, and species diversity were among the indices used to measure diversity. Hill (1973), Margalef (1958), and Menhinick (1964) were used to measure species richness. Alatalo (1981), Heip (1974), Heip and Engels (1974), Pielou (1966), Shannon (Shannon & Weiner, 1964), and Sheldon (1969) were the indices used to measure evenness among the species. In addition to these, several diversity indices were calculated in the wake of Ludwig and Reynolds (1968), such as relative dominance, relative frequency, Hill's (1973) number abundance, Berger-Parker's dominance (1970), and community dominance index.

RESULTS

A total of 178 spiders, comprising 20 species, 17 genera and 12 families (Araneidae, Desidae, Linyphiidae, Nephilidae, Oxyopidae, Pholcidae, Pisauridae, Salticidae, Sparassidae, Tetragnathidae, Theridiidae and Thomisidae) were recorded with spider guilds as per web pattern and hunting pattern (Table 1; Figure 1). The Araneidae family dominated the spider population (Figure 2). The family dominance curve was in the ascending order of Araneidae (25.28%) > Oxyopidae (14.04%) > Pholcidae (14.04%) > Thomisidae (10.11%) > Tetragnathidae (7.86%) > Linyphiidae (6.74%) > Nephilidae (6.17%) > Sparassidae (5.05%) > Theridiidae (4.49%) > Pisauridae (3.37) > Salticidae (2.24%) > Desidae (0.56%) (Figure 3). Araneidae (17.64%) had the most genera per family, with four; followed by Linyphiidae, Oxyopidae and Thomisidae (11.76%), with two genera apiece. The rest of the families were represented by a single genera (5.88%) each. Araneidae and Oxyopidae (20.00%) had the most species per family, with four each; followed by Linyphiidae and Thomisidae (10.00%), with two species apiece, and the rest of the families were represented by a single species (5.00%) each (Figure 4). About species composition, *Pholcus phalangioides* dominated with 14.04% followed by *Argiope pulchella* with 11.79%, and the least was *Badumna insignis* (0.56%) (Figure 5). Spider guilds were represented by web patterns as well as hunting patterns. Web pattern comprised of orb web (60.86%), cobweb (34.78%) and sheet web (4.34%). Orb web was represented by families Araneidae, Nephilidae and Tetragnathidae; cobweb by Desidae, Pholcidae, Pisauridae and Theridiidae; while Linyphiidae for sheet web. Ambushers (53.22%) and stalkers (46.77%) represented the hunting pattern whereas Pisauridae, Sparassidae and Thomisidae represented ambushers, and Oxyopidae and Salticidae represented stalkers (Figure 6). Table 2 displays the diversity indices for the present study, categorized under diversity, richness, evenness, and others. Diversity indices, represented by Brillouin's, Hills' Shannon's, and Simpson's were high in Desidae (0.011), Pisauridae (0.163), Salticidae (0.346) and Pholcidae (0.190), and Shannon-Weiner's species diversity index was 2.039 as a whole. Araneidae and Oxyopidae had high species richness indicated by Hill's (4), Margalef's (1.33), and Menhinick's (0.299) indices. Salticidae had high species evenness denoted by Alatalo's (0.578), Pielou's (0.488), Shannon's (1.471) and Sheldon's (1.413) indices; while Linyphiidae represented Heip's index (1.347). Araneidae scored high on other indices, viz., Berger-Parker dominance (25.28%), community dominance (1.24), and relative dominance (20.00%); while Salticidae had a high Hill's number abundance (1.413%), and Pholcidae had a high relative frequency (0.55).

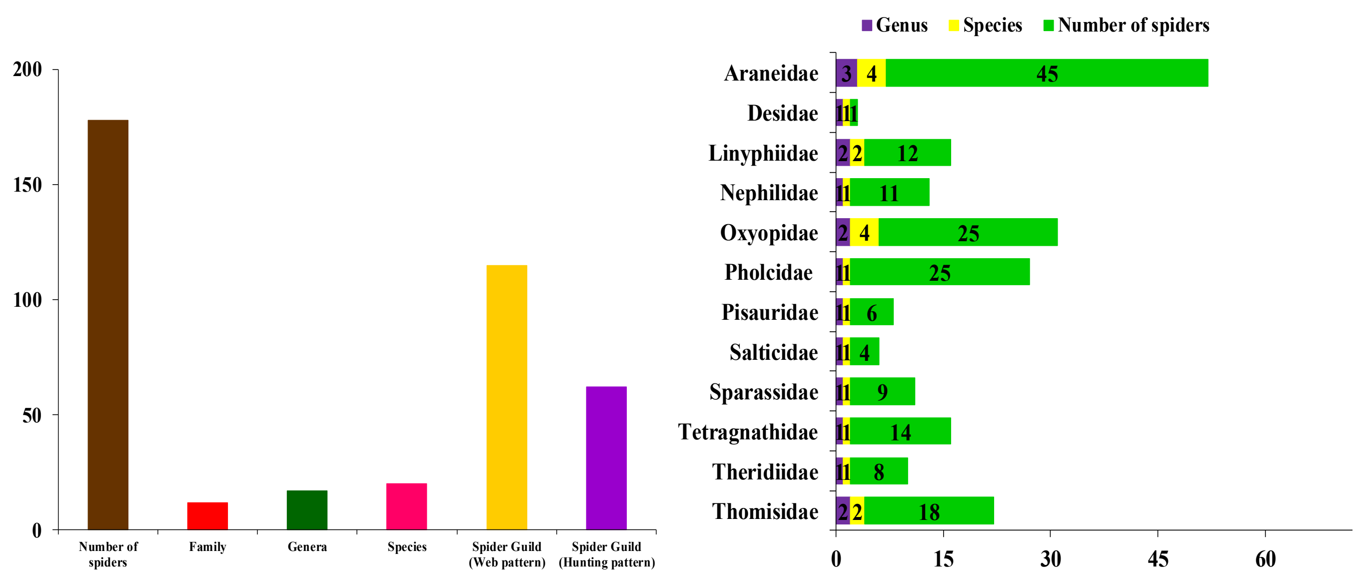

Figure 1.Overview of spider diversity at family level and guild

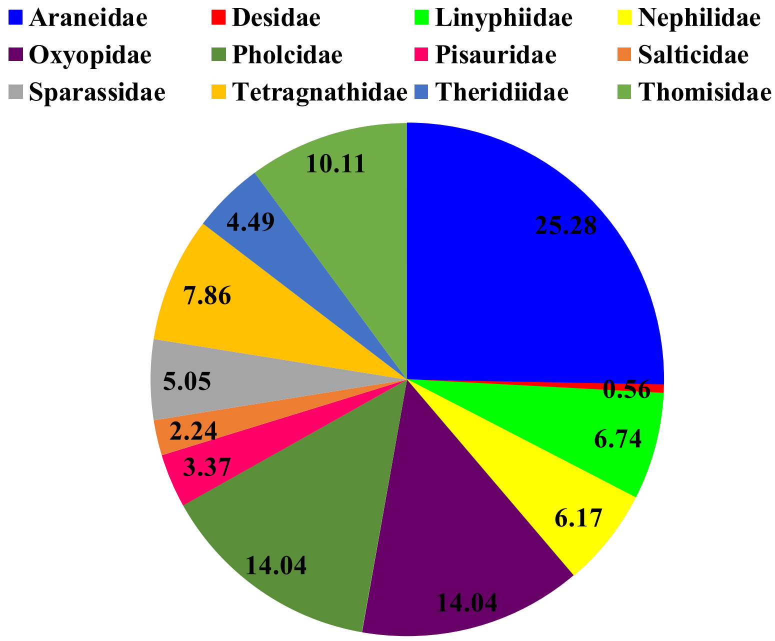

Figure 2. Percentile distribution of spider dominance in different families.

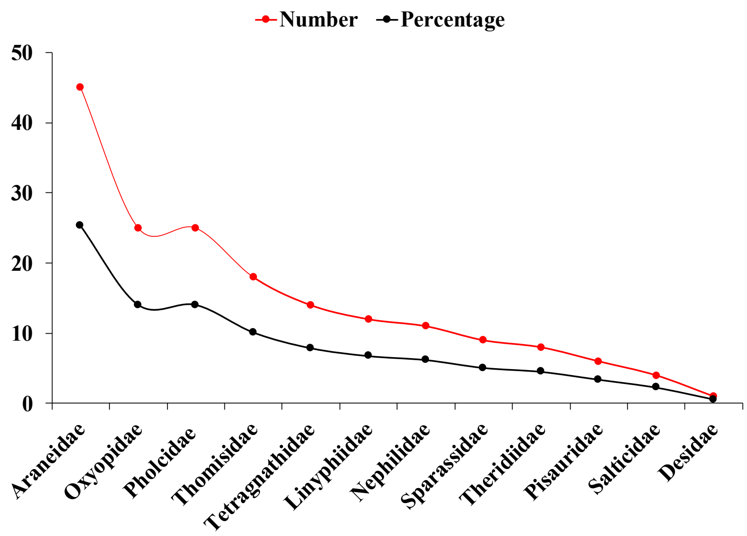

Figure 3.Spider family dominance curve.

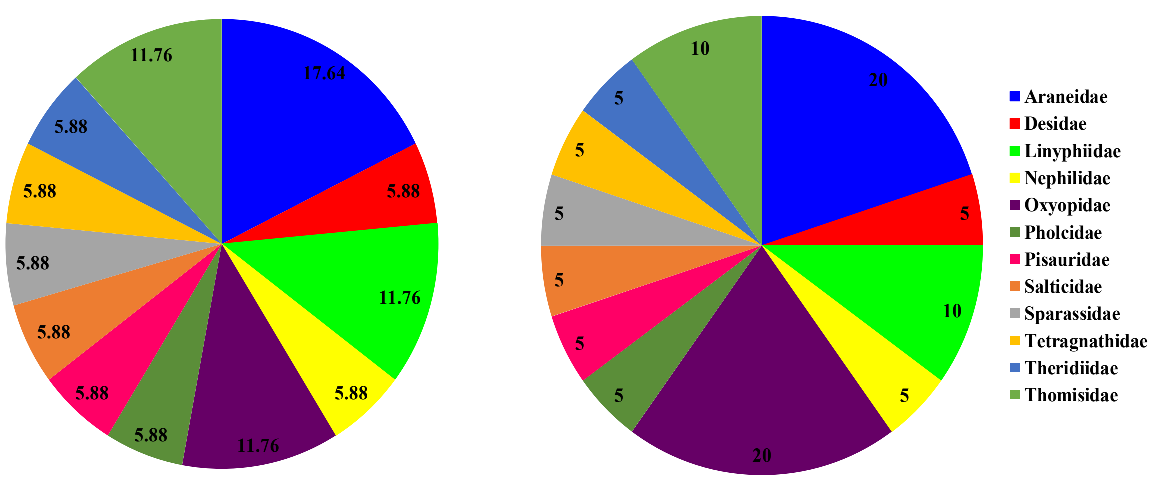

Figure 4. Percentile distribution of generic and species diversity of spiders in different families.

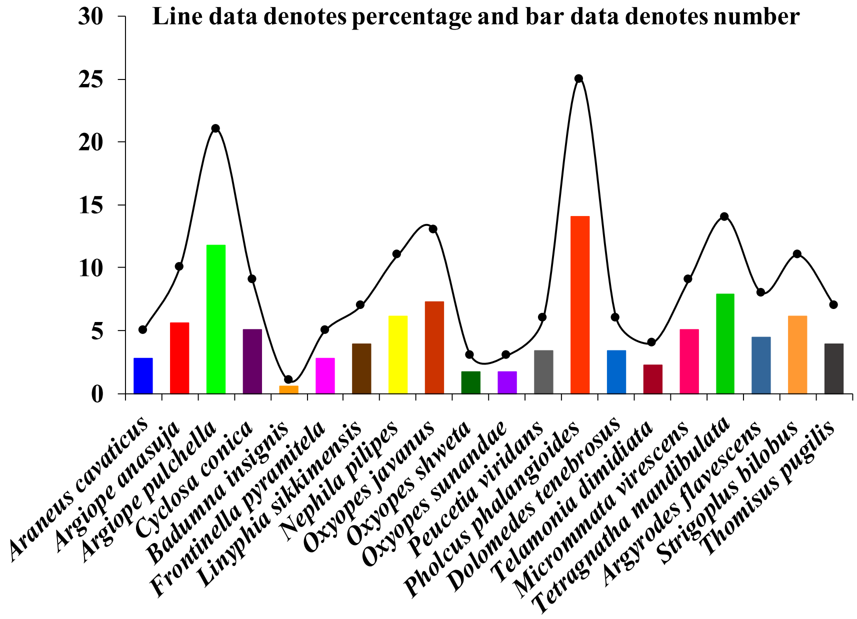

Figure 5. Species composition of documented spiders

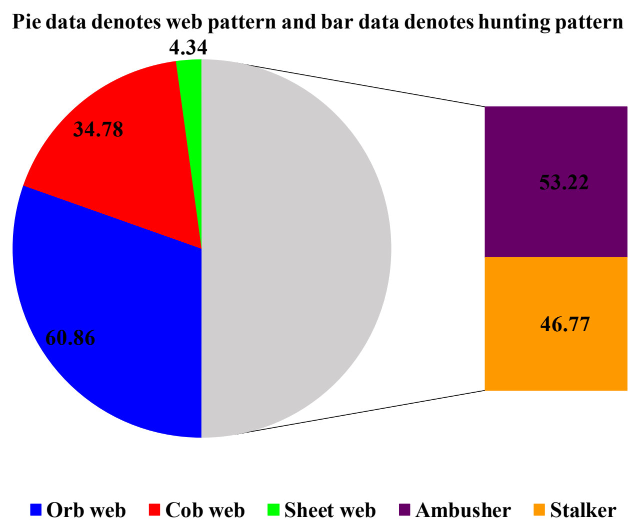

Figure 6. Per cent composition of spider guild structure.

DISCUSSION

Small to regional scale studies of alpha and beta diversity comprise spider diversity, and only small number of extensive studies have examined other aspects of diversity (phylogenetic and functional), with spiders receiving even less attention in this regard (Cardoso *et al.*, 2011; Majer *et al.*, 2015). Phylogenetic diversity is rarely addressed, even at a local or regional scale (Cardoso, 2012; Carvalho *et al.*, 2020). The patterns and relationships between taxonomic, functional, and phylogenetic diversity are fascinating and much-needed research topics because they are critical to understanding the past and present causal processes that have shaped diversity and community structure at various spatial scales (Swenson, 2011). Understanding the functions of spiders in various forested settings will be aided by knowledge of species richness and functional diversity (Schuldt *et al.*, 2011). Owing to their wide range, predilection for certain habitats, and function as predators, spider ecology is exceptional (Pekar *et al.*, 2017). The first step towards expanding scientific understanding of the dynamics of spider assemblages is to comprehend their composition and distribution throughout various habitats (Rodrigues *et al.*, 2014). Documentation of spider diversity research

Table 1. Checklist of spiders surveyed during the study period

S. No.	Common Name	Scientific Name (Author citation, Year)	No. Observed
Family: Araneidae (Clerk, 1757) – Orb weaver spiders			
1	Barn spider	*Araneus cavaticus* (Keyserling, 1882)	05
2	Giant cross spider	*Argiope anasuja* (Thorell, 1887)	10
3	Garden cross spider	*Argiope pulchella* (Thorell, 1881)	21
4	Thrashline orbweaver	*Cyclosa conica* (Pallas, 1772)	09
Family: Desidae (Pocock, 1895) – Intertidal spiders			
5	Black house spider	*Badumna insignis* (L. Koch, 1872)	01
Family: Linyphiidae (Blackwall, 1859) – Sheet weaver or money spiders			
6	Bowl and doily spider	*Frontinella pyramitela* (Walckenaer, 1841)	05
7	Dwarf spider	*Linyphia sikkimensis* (Tikader, 1970)	07
Family: Nephilidae(Simon, 1894) – Golden or long-legged orb weaver spiders			
8	Giant wood spider	*Nephila pilipes* (Fabricius, 1793)	11
Family: Oxyopidae (Thorell, 1870) – Lynx spiders			
9	Striped lynx spider	*Oxyopes javanus* (Thorell, 1887)	13
10	White lynx spider	*Oxyopes shweta* (Tikader, 1970)	03
11	Orange lynx spider	*Oxyopes sunandae* (Tikader, 1970)	03
12	Green lynx spider	*Peucetia viridans* (Hentz, 1832)	06
Family: Pholcidae(L.C. Koch, 1850) – Cellar or daddy long-leg spiders			
13	Skull spider	*Pholcus phalangioides* (Füssli, 1775)	25
Family: Pisauridae (Simon, 1890) – Nursery web spiders			
14	Dark fishing spider	*Dolomedes tenebrosus* (Hentz, 1844)	06
Family: Salticidae (Blackwall, 1841) – Jumping spiders			
15	Two striped jumper	*Telamonia dimidiata* (Simon, 1899)	04
Family: Sparassidae (Bertkau, 1872) – Huntsman or giant crab spiders			
16	Green huntsman spider	*Micrommata virescens* (Clerck, 1757)	09
Family: Tetragnathidae (Menge, 1866) – Long-jawed orb weaver spiders			
17	Dark tetragnathid spider	*Tetragnatha mandibulata* (Walckenaer, 1841)	14
Family: Theridiidae (Sundevall, 1833) – Comb-footed or cobweb spiders			
18	Red silver spider	*Argyrodes flavescens* (O.P. Cambridge, 1880)	08
Family: Thomisidae (Sundevall, 1833) – Crab or flower spiders			
19	Crab spider	*Strigoplus bilobus* (Saha&Raychaudhuri, 2004)	11
20	Flower crab spider	*Thomisus pugilis* (Stoliczka, 1869)	07

requires an understanding of guilds, their makeup, and the variables impacting the structure of spider communities. Ecosystem processes including nutrient availability and ecosystem dynamics are impacted by changes in functional diversity (Goswami *et al*., 2017). Spiders have particular traits that make measuring functional diversity easier. These include foraging strategy, prey range, vertical stratification, circadian activity, body size, phenology, preferred stratum (grass, foliage, tree trunk), type of web (funnel, orb, nursery, sensing, sheet, silk retreats, space, trashline, tent, tangled, kleptoparasite, jumpers and no web), and hunting mode (cursorial, ambush, foliage, cannibalism, foliage spitting, kleptoparasitism and nocturnal).

Spider guilds

Groups of species that fight for the same resources within an environment are referred to as guilds. Identification of the guilds present in an ecosystem facilitates a better knowledge of the ecological influence the communities are having on the trophic web, and classifying the guilds aids in the development of an understanding of the effects of land use in a habitat. Since functional organisation can be regarded as independent of the individualistic response a single species may make to local conditions, functional analysis of community organisation has been applied in studies of spider communities (Uetz, 1975). The examination of assemblage response to climatic change, habitat disturbance, and management can be facilitated by identifying the ecological guild (Voigt *et al*., 2007; Cardoso *et al*., 2011). As a method to characterise biodiversity, the characterization of spider guilds indicates the impact of habitat type on spider composition (Freitas *et al*., 2013). According to Post and Riechert (1977) and Nyffeler and Benz (1987), the ecological traits of each family or a key species that represented it were used to classify spiders. The ecological guild and functional classification of spiders are determined by several ecological

Table 2. Diversity indices for the present study

Diversity indices	Spider family											
	AR	DE	LI	NE	OX	PH	PI	SA	SP	TE	TH	TO
Diversity indices												
Brillouin's index	0.002	0.011	0.005	0.006	0.004	0.004	0.007	0.008	0.006	0.005	0.006	0.004
Hill's index	0.112	0.00	0.034	0.025	0.235	0.155	0.163	0.009	0.021	0.030	0.015	0.046
Shannon's diversity index	0.213	0.00	0.298	0.216	0.293	0.128	0.298	0.346	0.244	0.187	0.259	0.244
Simpson's dominance index	0.060	0.00	0.004	0.003	0.190	0.190	0.0009	0.0003	0.002	0.005	0.001	0.009
Species diversity index	0.022	0.005	0.011	0.005	0.022	0.005	0.005	0.005	0.005	0.005	0.005	0.011
Richness indices												
Hill's species index	4	1	2	1	4	1	1	1	1	1	1	2
Margalef's index	1.33	0.00	0.44	0.00	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.44
Menhinick's index	0.299	0.074	0.149	0.074	0.299	0.074	0.074	0.074	0.074	0.074	0.074	0.149
Evenness indices												
Alatalo's index	0.348	0.00	0.510	0.438	0.305	0.201	0.528	0.578	0.471	0.401	0.492	0.446
Heip's index	0.412	0.00	1.347	0.00	0.446	0.00	0.00	0.00	0.00	0.00	0.00	1.276
Pielou's index	0.263	0.00	0.401	0.268	0.392	0.144	0.401	0.488	0.311	0.224	0.334	0.311
Shannon's index	0.535	0.00	0.820	0.850	0.633	0.633	1.138	1.471	0.928	0.772	0.980	0.705
Sheldon's index	0.309	1.00	0.673	1.241	0.335	1.136	1.347	1.413	1.276	1.205	1.295	0.638
Other indices												
Berger-Parker dominance (%)	25.28	0.56	6.74	6.17	14.04	14.04	3.37	2.24	5.05	7.86	4.49	10.11
Community dominance index	1.24	0.04	0.58	0.44	0.76	1.00	0.24	0.16	0.36	0.56	0.32	0.72
Hill's number abundance (%)	1.237	1.00	1.347	1.241	1.340	1.136	1.347	1.413	1.276	1.205	1.295	1.276
Relative dominance (%)	20	5	10	5	20	5	5	5	5	5	5	10
Relative frequency	0.46	0.02	0.15	0.24	0.28	0.55	0.13	0.08	0.20	0.31	0.17	0.24

AR: Araneidae, DE: Desidae,LI: Linyphiidae, NE: Nephilidae,OX: Oxyopidae,PH: Pholcidae,
PI: Pisauridae,SA: Salticidae, SP: Sparassidae, TE: Tetragnathidae, TH: Theridiidae, TO: Thomisidae

traits, including the sort of web that they produce, their hunting tactics, whether they live in vegetation or on the ground, and if they are nocturnal or diurnal habit (Uetz *et al*., 1999; Cardoso *et al*., 2011). Essentially, spider guilds allow researchers to examine how an assemblage reacts to habitat disturbance and climate change by bringing together phylogenetically related animals that share similar niche needs and means of subsistence (Uetz *et al*., 1999; Voigt *et al*., 2007; Dias *et al*., 2010). A wide variety of guilds are found in spider families. In the current study, the spiders were divided into guilds based on the way they built their webs, and how they hunted. Web builders include the following: sheet web weavers (Linyphiidae), hackled band weavers (Dictynidae), space weavers (cobweb spiders) (Desidae, Pholcidae, Pisauridae, and Theridiidae), and orb web weavers (Araneidae, Nephilidae, Tetragnathidae, and Uloboridae) (Coddington & Levi, 1991). The orb web type demonstrated dominance in the current investigation. Web-building spiders are sedentary predators that wait for prey to enter their webs so they can feast on it and impede its escape. The spider quickly wraps its silk around its victim before delivering the lethal bite. The prey might be preserved for subsequent use or consumed right once. According to Uetz *et al*. (1999), hunting spiders include wolf/grassland spiders (Lycosidae), ambushers (Pisauridae, Sparassidae, and Thomisidae), rapid hunters (Cheiracanthiidae), nocturnal hunters (Gnaphosidae), and agile hunters (stalkers) (Oxyopidae and Salticidae). Ambushers and stalkers made up about equal percentages in the present study. In contrast to ambushers, who hunt by ambushing or assaulting their prey upon coming into contact and seizing them with their powerful, spiky, curled front legs, stalkers hunt their prey by moving slowly, and leaping upon them (Brady, 1975).

Diversity indices

Ecology and evolution produce diversity as these processes can be deterministic (connected to a niche) or stochastic (neutral). Diversity is the most commonly used criterion for assessing conservation plans since it has a direct correlation with ecosystem stability and will be high in biologically regulated systems. Due to their attempt to incorporate several characteristics that define community organisation, all diversity indices have limits. The widely spread spiders are more dominating in terms of zoogeography, and the local character of the fauna is reflected in their faunistic composition. The seasonal abundance of spiders varies according to the phenology of the entire spider population as well as individual spider variation (Mac Arthur, 1965; Corey *et al*., 1998). The diversity of flora and fauna increases with a larger value of Shannon's index (Malumbres-Olarte *et al*., 2013). According to Richardson (1977), the Shannon diversity index typically has values between 1 and 3, indicating intermediate species variety. Values below 1 denote low diversity, whereas values over 3 denote great diversity. The value found in this study was 2.039. The status of spider diversity is an important constraint to evaluate the community level of biological organization. As a wider range of species promotes more interactions and, consequently, greater system stability, which in turn shows favourable environmental circumstances, higher species diversity is a sign of a healthier and more complex ecosystem (Hill, 1973). As there is a relationship between species diversity and habitat structural complexity, diversity often rises when there is a wider variety of habitat types present. Spiders have shown this assertion to be true (Uetz, 1979a; Androw, 1991). Furthermore, seasonality, spatial heterogeneity, competition, predation, habitat type, environmental stability, species composition, and productivity are other environmental factors that impact species diversity (Rosenzweig, 1995).

A fundamental and necessary first step towards the timely and efficient monitoring and management of biological communities is the accurate assessment of species richness (May, 1988; Colwell & Coddington, 1994; Boulinier *et al*., 1998; Shen *et al*., 2003). It is also a useful tool for evaluating the uniqueness of species composition and the quality of the habitat. Research has attempted to identify the factors that determine the makeup of assemblages and the richness of species in a given area (Hendrickx *et al*., 2007; Jiménez-Valverde *et al*., 2010). In environments that are not altered and have a varied plant life, spider diversity and species richness are higher. The size of the research region is likely a contributing factor to the high spider community richness (Greenstone, 1984), as larger areas tend to contain more microhabitats. Species richness indexes were used by Culin & Yeargan (1983) to gauge the quality of the environment and the number of spiders. However, the vegetation structure acts as a pressure factor because, unless fragmentation favours spider families with preferences for sunny places, it may result in a decrease in the number of sites for spider web construction and lower spider richness due to plant diversity fragmentation in the edge (Oliveira *et al*., 2004). Living in edge habitats increases the likelihood of finding more food, mates for sexual activity, and refuge in brighter locations because Salticidae is known for its keen vision and fondness for sunny locations (Romero & Vasconcellos-Neto, 2004, 2005a,b). Microhabitats like the edge are home to a range of niches occupied by Theridiidae (Silva & Coddington, 1996). The present study may find validity in these arguments, given that the study location is located within the Eastern Ghats of India. According to Dutoit *et al*. (2007), the edge zone is characterised by variations in vegetation structure, plant species richness, and microclimate, and it differs from the patch interior both structurally and in species composition. There is a correlation between the richness of spider species and environmental factors, with more species found in places with higher temperatures and precipitation. Nonetheless, it is anticipated that seasonal variations in the climate will affect the variety and quantity of spider species (Kato *et al*., 1995). According to Quinones *et al*. (2016), a value nearer one for species evenness indicates that the compared species' abundance is typically the same, whereas a value nearer zero denotes the presence of a dominant species in a given area. Sheldon's index exceeded the value of one in the current study, but Heip's index displayed a zero value. Excessive evenness levels indicate that no particular species predominates in the community of spiders and that over the study period, the individuals were distributed nearly equally across the many species.

Factors influencing spider diversity

Spiders are very sensitive to even little variations in the complexity of the vegetation and the structure of their habitat (Uetz, 1991; Downie *et al*., 1999; New, 1999). Studies on spider diversity provide information that helps monitor changes in vegetation characteristics and habitat disturbances more effectively (Mithali and Pai, 2018). Given its significant influence on spider development, reproduction, and fitness, habitat selection is extremely important to spiders (Campuzano *et al*., 2019). The density and diversity of spider species are significantly impacted by habitat variability, which is reflected in the structure of the topsoil, vegetational architecture, diversity, stratification level, and water availability (Greenstone, 1984). Spider communities are greatly impacted by the type of habitat and land use (Weeks & Holtzer, 2000). The variety and quantity of spider species may decline as a result of intensified land usage. Spider diversity and richness are influenced by habitat structure, and complex ecosystems should be predicted to have a higher diversity of species (Stratton *et al*., 1979; Sorensen, 2004). Spider species diversity varies according to the habitats that they like. The least number of species associated with agricultural practices, anthropogenic disturbances, and clearings are found in open-area agroecosystems. Nevertheless, secondary forests maintain the greatest species diversity because of their high plant species richness and vegetation height, which show a significant influence on spider assemblages and provide a variety of habitat structures and possible nesting locations (Galle *et al*., 2011). Strong species diversity is positively correlated with high species richness in secondary forests due to the heavy leaf litter that these forests support (Zhang *et al*., 2013).

A more varied spider community can be supported by structurally complex plants and shrubs (Uetz, 1991). Spider species are incredibly diverse in tropical forests. The canopy cover is mostly determined by the richness of the tree species. Shading is significant because it modifies the forest floor's microclimate (Galle & Schweger, 2014). According to Morse (1984), spiders prefer habitats that allow them to spend as much time as possible seeking for prey, are safe from nest or web destruction, are easy to tie their web to, and are sheltered from the heat. The physical structure of the vegetation and the presence of websites affect the abundance of orb weavers (Greenstone, 1984). Sparse ground layer vegetation and undisturbed bushes may be able to support a larger population of orb-weaving spiders, which need larger spaces to build webs (Chen & Tso, 2004). These statements support the present study as there was an abundance of orb-web weavers amongst the surveyed spider population. Spider life is also influenced by the leaf litter on the forest floor. As the layer of leaf litter increases, so will the number of spiders. A variety of microhabitats, from trash to canopy, are frequently home to orb web weavers. Additionally, stalkers are frequently observed grazing on vegetation and trash (Silva & Coddington, 1996). More places for spiders to hide and escape the intense heat are provided by the deep leaf litter (Foelix, 1996). Accordingly, variations in the physical structure and complexity of leaf litter affect the variety, species composition, and abundance of spiders (Uetz, 1979; Buddle & Rypstra, 2003).

Several factors affect the diversity of spiders (Larrivee & Buddle, 2010). One of the most important elements influencing the variety, quantity, and distribution of spider species is the structure of the vegetation (Lubin, 1978; Samu *et al*., 1999; Raizor & Amaral, 2001). A habitat's species composition is significantly influenced by the architecture of the surrounding vegetation (Scheidler, 1990). More structurally complex vegetation can support a greater variety and number of spider species (Hatley & MacMahon, 1980). The species composition and diversity of spider assemblages are significantly impacted by the composition and structure of the surrounding vegetation (Ysnel & Canard, 2000; Heikkinen & MacMahon, 2004). The factors that most closely reflect vegetation structure, viz., vegetation closure and complexity, which include vegetation height, dwarf shrub cover, and low shrub cover are the best ones to explain spider assemblages (Lafage *et al*., 2019). Additionally, vegetation closure is positively correlated with litter depth, a critical factor in the explanation of spider assemblages (Uetz, 1979a, b). More spider species become available as vegetation ages, becoming denser and more stratified (Uetz, 1991), confirming the theory that plant structural complexity affects spider abundance and species richness (Hatley & MacMohan, 1980; Wise, 1993, 2004). Spider diversity will decline if vegetation diversity declines (Reichert and Lockley, 1984; Samu *et al*., 1996). However, an ecosystem's complexity and structure will also lead to a rise in the number of spiders (Chew, 1961; Riechert & Lockley, 1984). Spider diversity and composition are determined by physical structure and species composition as determined by vegetation (Uetz, 1991; Langellotto & Denno, 2004; Malumbres-Olarte *et al*., 2013). As more species are present when more guild types are supported, vegetation and stratum complexity raise the number of active guilds, which in turn increases biodiversity (Cardoso *et al*., 2011). Spiders make use of the structure of vegetation to construct webs, hunt via ambush, or for food. Web building spiders choose areas with more insect activity, and places where they can ambush to capture prey (Venner, 2005). A spider's stratospheric range can be used to determine its taxonomy and guild (Yanoviak *et al*., 2003). Spiders will be more susceptible to changes in vegetation if they depend on a particular vegetation structure for their web-building or foraging needs (Thery & Casas, 2002). In terms of the overall diversity of spiders, these avowals can apply to the current study, since the strong link between characteristics pertaining about vegetation (Jiménez-Valverde *et al*., 2010; Loboda & Buddle, 2018) and/or habitat heterogeneity (Finch *et al*., 2008) suggest that spider diversity is influenced by the vegetation's structural diversity.

Spider population dynamics are significantly impacted by climatic changes and environmental variables, even though they are dependent on the architectural structure of their habitat (Mac Arthur *et al*., 1972). This is because spiders respond to these factors to maximise their fitness, growth, reproduction, and survival (Scharf & Ovadia, 2006). Furthermore, according to Gunnarsson (2007), bird predation lowers spider numbers, and abiotic elements and meteorological conditions, viz., precipitation, humidity, and high temperatures (Pétillon *et al*., 2008), have an impact on spider survival, web production, its prey and habitat selection (Gillespie, 1987). All these factors tend to have an impact on the quantity, variety, and seasonality of spider life. Though the availability and kind of prey have a significant impact on the richness of spider species (Horváth *et al*., 2005), habitat structural diversity is thought to be more important (Harwood *et al*., 2001, 2003), since the seasons of plant development affect the types and amount of prey. The population of prey that is readily available is strongly correlated with the growth of plants in that region, which influences the diversity of spiders. As crop growth progresses, the correlation coefficients between the population densities of insect pests and spiders tend to go from negative to positive form, indicating a coexisting increase in both species' populations (Kiritani *et al*., 1972). Since the study did not assess the density of insect pests, more research is necessary to determine the impact of insect pests on the spider community.

CONCLUSION

Araneidae family dominated the spider population, and had the most genera and species per family, and *Pholcus phalangioides* belonging to the family Pholcidae dominated species composition. About spider guilds, the orb web was represented by families Araneidae, Nephilidae and Tetragnathidae; the cobweb by Desidae, Pholcidae, Pisauridae and Theridiidae; and Linyphiidae for sheet web. Ambushers and stalkers represented the hunting pattern wherein Pisauridae, Sparassidae and Thomisidae were ambushers, and Oxyopidae and Salticidae were stalkers. Diversity indices were high in Desidae, Pisauridae, Salticidae and Pholcidae. Araneidae and Oxyopidae had high species richness, while Salticidae had high species evenness. This study will lay the groundwork for future research on the ecology of spider communities in this study area. This work can form a baseline for further investigations on diversity and distribution of spiders over a period of time in the specified localities. Building on this checklist, future investigations can continue to catalogue the sparsely known spider fauna, and possibly even find new species in this study area.

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