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COMPARATIVE STUDY OF SPIDER DIVERSITY (ORDER: ARANEAE) IN TWO DIFFERENT HABITATS OF MALAPPURAM DISTRICT, KERALA

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Abstract

This study provides the diversity of spiders from two different habitats; sacred grove (site 1) and rubber plantation (site 2), both are located in Malappuram district adjoining Kozhikode district, Kerala, India. It is a pioneer study and no other studies have been done in this area. The spiders were collected from June 2019 to February 2020, using ground hand collection, aerial hand collection, vegetation beating, kerchief method and tree bark searching. A total of 112 species of spiders belonging to 70 genera of 18 families were recorded from this area during the study. This represents 29.5% of the total families recorded in India. Amongst the families, Salticidae was the most abundant (26 species) followed by Araneidae (22). From sacred grove, a total of 88 species and from rubber plantation 54 species were recorded. Spider populations in the Monsoon, Post monsoon and winter seasons exhibited slightly different species abundance and composition. Among the 112 species of spiders collected during the study, high species diversity was reported during post monsoon season. Different indices were calculated. Results show that the influence of seasons on spider abundance was significant for Shannon, Richness and Evenness indices, but non-significant for Simpson's index. Population fluctuation of spiders showed significant difference between the 3 seasons.

Keywords **:** *Spiders, Species, richness, Evenness and diversity.*

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Introduction

Spiders are one of the most diversified groups amongst invertebrates and they ranked seventh in the global biodiversity (Penney et al. 2003). Spiders are abundant and ubiquitous in most of the terrestrial habitats, thus forming a valuable component of ecosystem functioning (Riechert 1974). 'World Spiders Catalog' has provided good insights into standardized approaches for understanding spider diversity and taxonomy around the world. Spiders, which globally include about 48,903 described species under 4,184 genera and 128 families, comprise a significant portion of arthropod diversity (WSC, 2020). The spider fauna of India represented by 1,843 spider species belonging to 471 genera and 61 families (Caleb and Sankaran 2020).

Spiders contribute a major role in the regulation of insect populations in forest communities (Lawrence and Wise 2000). So, documentation of spider fauna is very important. Spiders are considered as the major agent controlling insect populations due to their high abundance as well as their insectivorous foraging behavior (Reichert and Lockley 1984; Nyffeler and Benz 1987). These characteristics make spiders, a good indicator for comparing the biodiversity of various environments and for evaluating the effects of disturbances on biodiversity. Kerala is one of the Indian states having rich floral and faunal diversity but, till date, detailed study on diversity and distribution of spiders is less as compared with other areas of the country. Joseph et al. (1998), Patel (2003), Sudhikumar et al. (2005), Sebastian et al. (2005), Sunil et al. (2008), Adarsh and Nameer (2015, 2016) Jose et al. (2018) and Smitha and Sudhikumar (2020) are some of the former workers who have done diversity study on spider fauna in Periyar Tiger reserve, Parambikulam Wildlife Sanctuary, Mannavan shola forest, irrigated rice ecosystem, Parambikulam Wildlife Sanctuary, Western Ghat, Kerala agricultural university campus, Chinnar Wildlife Sanctuary, Kavvayi river basin and cashew ecosystem respectively.

Present study focuses on spider diversity in two different habitats: sacred grove and rubber plantation. Studies in these types of habitats are very less compared with studies in sanctuaries and biosphere reserves. Most recently Sumesh and Sudhikumar (2020) reported 257 species of spiders belonging to 130 genera and 28 families from 15 sacred groves of Northern Kerala. 81 species of spiders under 51 genera belonging to 19 families were enlisted in sacred groves of Odisha (De and Palita 2018). The aim of this study diversity of spiders from these two ecologically different unique habitats and to compare them. Spider diversity also determined by availability of prey density. Prey density is mainly based on seasonal variation and vegetation structure which may keep changing throughout the year which in turn affecting spider abundance and diversity. Thus, the study was also planned with the objective to determine seasonal changes in spider's community membership.

Study Area

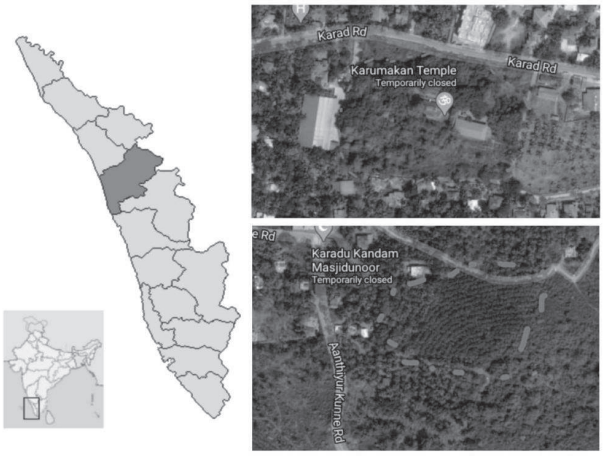
Spider diversity and abundance are mainly dependent on the nature of vegetation. So, two different habitats were selected for this study located in Malappuram district, adjoining Kozhikode district.

Site 1: Sacred grove

Sacred groves are fragments of forest areas with rich diversity that have been protected by the local community for several years based on their cultural and religious beliefs. They serve as excellent centers for biodiversity conservation. It belongs to Vazhayur Panchayath of Malappuram district (11.12 NL, 75.76 EL). It consists of an area of about 1 acre and the soil is moist and rich with litter composition. The major plant species include Strychnos nux-vomica, Chassalia curviflora, Alpinia, Costus speciosus, Maesa, Caryota, Ziziphus oenoplia, Gnetum ula, Mussaenda frondosa, Ageratum conyzoides, Rauwolfia serpentina and Mimusops elengi. Due to the developmental activities of the temple some of the vegetation cover has been cleared.

Site 2: Rubber plantation

Rubber plantations are monoculture plantations to improve target crop productivity. The study area (11.17 NL, 75.93 EL) is located in Karadukandam, which belongs to Pulikkal panchayath of Malappuram district. The exact name of the study area is Mullanmada, situated along Anthiyurkunnu road. It has almost same area as sacred grove containing rubber plants with sparse vegetation, lateral soil sparsely covered with grasses, some small herbs, shrubs, climbers and creepers. The major plant species seen in this area is Hevea brasiliensis. Other vegetations include Commelina, Eupatorium, Sida cordata, Dioscorea, Flemingia and Spermacoce. The vegetation has been intensively managed frequently for regular fertilization, weeding and tapping.



Methods

The sample collection was carried out from June 2019 to February 2020 by random sampling. The sample collection was done twice in a month from both the sites. The collection time was from 9:00 am to 11:30 a.m. The time, date, habitat and the substratum were also noted down. Specimens were collected using ground hand collection, aerial hand collection, vegetation beating, kerchief method and tree bark searching. Photographs were taken by using camera attached with 15X macro lens and spiders were released to the field after identification. Rare and unidentified specimens were preserved using 70% alcohol. Then they were sorted out into separate jars with properly labelled date and time and these specimens were used for later identification. Species identification was confirmed with the help of Tikader (1970, 1977, 1980, 1982 and 1987), Sebastian and Peter (2009) and literature available from World Spider Catalog (2020). Expert opinions of taxonomists were also taken. The data was subjected for various relevant indices such as Shannon diversity index, Simpson's diversity index, species evenness and Sorenson's similarity index.

Results and Discussion

A total of 1,063 individuals belonging to 112 species, 70 genera and 18 families were observed from 2 sites.

Habitats	Site 1	Site 2
Species richness	88	54
Shannon diversity index	3.55949	3.23186
Simpson's diversity index	0.94588	0.94505
Evenness	0.795	0.8102

Table 1- Species richness, Shannon diversity index, Simpson's diversity index and Evenness between Site 1 and Site 2.

Simpson's index (0.94588) of site 1 was very slightly higher than site 2 (0.94505) (Table 1). It can be concluded that a high floral diversity assists a high faunal diversity by providing diverse microhabitat especially for invertebrates (Sudhikumar et al. 2005). Species richness was high in site 1 (88) followed by site 2 (54). Culin and Yeargan (1983) noted that the species richness of spiders is significantly higher in the areas that have not been heavily manipulated. The Shannon diversity index was higher in site 1 i.e., 3.5594 than site 2 i.e., 3.2318 (Table 1). As we usually expect, sacred groves with higher vegetation type show maximum spider diversity than the monocultural plantation site, dominated by a single tree species (Hevea brasiliensis). However, this was not the case and although the monoculture plantation appears to be a more barren habitat (floristically). It still has a high spider diversity. More interestingly species evenness is higher in rubber plantation (0.81020) than site 1(0.79500) indicated that common species are more in rubber plantation. Here the results showed that all sites have unique species composition. Additionally, there

are many factors that determine the species composition at a site and not simply the habitat type.

Out of the 54 species reported from site 2, spider species associated with rubber trees were only Gasteracantha geminata, Strigoplus netravati. ie 3.7% of the total spider population. So, if it is purely homogeneous, the species loss will be much more. Detailed study on the effect of rubber cultivation on biodiversity by He and Martin (2015) concluded that expanding rubber cultivation changes structure and function of the natural ecosystem at different spatial and temporal scales. It gives support to present study. During this study 30 species are common in both sites. The commonness between the two habitats was estimated through Sorensen's similarity index which is 0.42253, indicating similarity is less. 62% spiders were seen to prefer site 1 whereas 38% spiders seemed to prefer site 2. The diversity of spiders found in the habitat can be influenced by the structure of the vegetation. Studies have illustrated that a correlation exists between the structural complexity of habitats and species diversity (Uetz 1979; MacArthur 1964; Andow 1991; Rosenzweig 1995).

The period of study was divided into three seasons: Monsoon, Post monsoon and winter which is enlisted in Table 2.

	Species	Site 1			Site 2		
		M	PM	W	M	PM	W
	I. Araneidae						
1	*Anepsion maritatum* (O. Pickard - Cambridge, 1877)				+	+	-
2	*Araneus* sp.	-	-	+			
3	*Argiope pulchella* Thorell, 1881	+	+	+	+	+	+
4	*Cyclosa bifida* Doleschall, 1859				+	+	+
5	*Cyclosa hexatuberculata* Tikader, 1982	-	-	+	-	-	+
6	*Cyclosa neilensis* Tikader, 1977	-	+	+	-	+	+
7	*Cyclosa* sp. 4				+	+	-
8	*Cyrtophora cicatrosa* (Stoliczka, 1869)	+	+	+	+	+	+
9	*Eriophora* sp.	-	+	-			
10	*Eriovixia excelsa* (Simon, 1889)	+	-	-	+	-	-
11	*Eriovixia gryffindori* Ahmed, Khalap & Sumukha, 2016	+	+	-			
12	*Eriovixia laglaizei* (Simon, 1877)	+	+	-			
13	*Eriovixia* sp. 4	-	+	-			
14	*Gasteracantha geminata* (Fabricius, 1798)	-	+	+	+	+	+
15	*Gea subarmata* Thorell, 1890				+	-	-
16	*Neoscona bengalensis* Tikader & Bal, 1981	+	-	-	+	+	+
17	*Neoscona mukerjei* Tikader, 1980	+	+	+	+	+	+
18	*Neoscona pawida* (Simon, 1906)				-	+	-
19	*Neoscona theisi* (Walckenaer, 1841)				+	+	-
20	*Neoscona* sp. 4	+	-	-			
21	*Neoscona* sp. 5	-	-	+			
22	*Parawixia dehaani* (Doleschall, 1859)	-	+	-			
	II. Cheiracanthiidae						
23	*Cheiracanthium danieli* Tikader, 1975	-	+	+			
24	*Cheiracanthium melanostomum* (Thorell, 1895)	-	+	-			
25	*Cheiracanthium* sp. 3	-	-	+			
26	*Cheiracanthium* sp. 4	-	-	+			
	III. Clubionidae						

27	*Clubiona drassodes* (O. Pickard - Cambridge, 1874)	+	+	+			
	IV. Corinnidae						
28	*Castianeira zetes* Simon, 1897	+	-	-			
	V. Gnaphosidae						
29	*Zelotes ashae* Tikader & Gajbe, 1976	-	-	+			
	VI. Hersiliidae						
30	*Hersilia savignyi* Lucas, 1836	+	-	+			
31	*Hersilia sumatrana* (Thorell, 1890)				+	-	-
	VII. Lycosidae						
32	*Hippasa agelenoides* (Simon,1884)	+	+	+	+	+	-
33	*Hippasa greenalliae* (Blackwall, 1867)	+	+	+			
34	*Pardosa pseudoannulata* (Bosenberg & Strand, 1906)	+	-	-			
	VIII. Linyphiidae						
35	*Linyphia* sp.	+	-	-			
	IX. Oxyopidae						
36	*Hamadruas sikkimensis* (Tikader, 1970)	+	+	+	-	+	-
37	*Oxyopes birmanicus* Thorell, 1887	+	+	+	+	-	-
38	*Oxyopes javanus* Thorell, 1887	+	+	-	-	+	+
39	*Oxyopes shweta* Tikader, 1970	+	+	+			
40	*Oxyopes sunandae* Tikader, 1970	+	+	+	-	+	-
41	*Peucetia viridana* (Stoliczka, 1869)	-	+	-			
	X. Pholcidae						
42	*Crossopriza lyoni* (Blackwall, 1867)	+	-	-	-	+	-
43	*Pholcus phalangioides* Fuesslin 1775	+	+	+	+	+	+
44	*Smeringopus* sp.	+	+	+			
45	*Uthina* sp.	+	-	-			
	XI. Salticidae						
46	*Asemonea tenuipes* (O. Pickard-Cambridge, 1869)	-	+	+			
47	*Bavia insularis* Malamel Sankaran& amp; Sebastian, 2015	+	+	+			
48	*Brettus anchorum* Wanless, 1979	+	-	-			
49	*Brettus* sp. 2	-	+	-			
50	*Carrhotus viduus* (C.L. Koch, 1846)	+	+	+			
51	*Chalcotropis pennata* Simon 1902	+	+	+			
52	*Chalcotropis* sp. 2	+	+	-	-	+	-
53	*Chrysilla volupe* (Karsch, 1879)				-	-	+
54	*Epeus tener* Simon 1877	-	+	+			

55	*Epeus triangulopalpis* Malamel, Nafin, Sudhikumar & Sebastian, 2019	-	-	+			
56	*Hasarius adansoni* (Audouin, 1826)	+	+	-			
57	*Hyllus semicupreus* (Simon, 1885)	+	+	-	+	-	-
58	*Menemerus bivittatus* (Dufour, 1831)	+	-	-			
59	*Myrmaplata plataleoides* (O.Pickard-Cambridge, 1869)	+	+	+	+	+	-
60	*Myrmarachne ramunni* Narayan, 1915				+	-	-
61	*Myrmarachne* sp. 2	-	-	+			
62	*Phaeacius* sp.	+	-	-			
63	*Phintella vittata* (C.L. Koch, 1846)	+	+	+	+	-	-
64	*Plexippus paykulli* (Audouin, 1826)	-	-	+	+	-	+
65	*Siler* sp.				+	-	-
66	*Stenaelurillus lesserti* Reimoser, 1934	+	-	+	-	+	+
67	*Stenaelurillus* sp. 2				-	+	+
68	*Stenaelurillus* sp. 3	-	+	-	-	-	+
69	*Telamonia dimidiata* (Simon, 1899)	-	+	+			
70	*Thiania bhamoensis* Thorell, 1887	+	-	-			
71	*Thyene bivittata* Xie & Peng, 1995				+	-	-
	XII. Scytodidae						
72	*Scytodes thoracica* Latreille, 1802	+	-	-			
	XIII. Sparassidae						
73	*Heteropoda venatoria* (Linnaeus, 1767)	+	-	+	+	-	-
74	*Olios milleti* (Pocock, 1901)	-	+	-			
	XIV. Tetragnathidae						
75	*Leucauge decorata* (Blackwall, 1864)				+	+	-
76	*Leucauge pondae* (Blackwall, 1864)				+	-	-
77	*Leucauge tesellata* (Thorell, 1877)	-	-	+			
78	*Leucauge* sp. 4				-	+	-
79	*Tylorida striata* (Thorell, 1877)				+	+	+
80	*Tylorida ventralis* (Thorell, 1877)	+	+	-	-	+	-
	XV. Theridiidae						
81	*Achaearanea* sp.	+	-	-			
82	*Argyrodes flavscence* Cambridge, 1880	+	+	+			
83	*Argyrodes* sp. 2	+	+	+			
84	*Argyrodes* sp. 3				+	-	-
85	*Argyrodes* sp. 4	+	-	-			
86	*Ariamnes flagellum* Doleschall, 1857				+	+	+
87	*Chrysso angula* Tikader, 1970	-	+	+			
88	*Chrysso* sp. 2	+	+	-	+	+	+

89	*Meotipa* sp. 1	+	+	+			
90	*Meotipa* sp. 2	+	+	+			
91	*Meotipa* sp. 3	-	-	+			
92	*Meotipa* sp. 4				-	-	+
93	*Nihonhimea mundula* (L. Koch, 1872)				-	+	+
94	*Parateastoda corrugata Yoshida, 2016*				-	-	+
95	*Phycosoma* sp. 1	-	+	+			
96	*Phycosoma* sp. 2	-	+	-			
97	*Theridula gonygaster* (Simon, 1873)	+	+	-			
98	*Theridula* sp. 2	+	+	-	+	+	+
	XVI. Thomisidae						
99	*Amyciaea forticeps* (O. Pickard-Cambridge, 1873)	+	+	+			
100	*Camaricus formosus* Thorell, 1887	+	+	+			
101	*Oxytate virens* Thorell, 1891	+	+	+			
102	*Strigoplus netravati* Tikader, 1963	-	+	+			
103	*Xysticus minutus* (Tikader, 1960)				+	-	-
104	*Xysticus* sp. 2	-	-	+			
	XVII. Uloboridae						
105	*Miagrammopes extensus* Simon, 1889	+	+	+	-	-	+
106	*Uloborus krishnae* Tikader, 1970	-	-	+	-	-	+
107	*Uloborus* sp. 2	+	-	-	+	+	-
108	*Uloborus* sp. 3	+	-	-			
109	*Uloborus* sp. 4				+	+	-
110	*Zosis geniculata* (Olivier, 1789)	+	+	+	+	+	+
	XVIII. Zodariidae						
111	*Hermippus* sp.				+	-	-
112	*Suffasia* sp.	+	+	+			

Table 2- Seasonal variation of spider diversity between Site 1 and Site 2. M: Monsoon, PM: Post monsoon and W: Winter.

Family corinnidae, Linyphiidae and Scytodidae found only in the monsoon season whereas family Gnaphosidae found only in the winter season from site 1 (Table 2). Here maximum number of species (57) was recorded during monsoon and maximum number of individuals (229) was recorded during the post monsoon. The second largest number of species recorded during post monsoon (54) followed by winter season (50). 261 individuals were recorded during monsoon while 194 during winter.

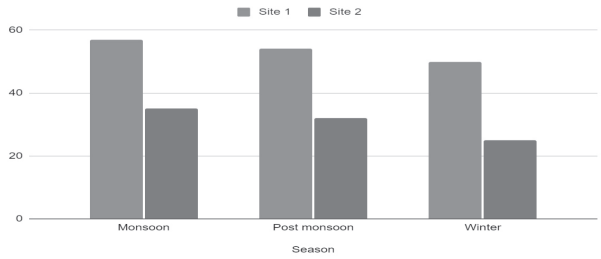


Figure 1- Species richness in various seasons between Site 1 and Site 2.

Season	Monsoon		Post monsoon		Winter	
	site 1	Site 2	site 1	Site 2	site 1	site 2
Species richness	57	35	54	32	50	25
Shannon diversity index	3.21435	2.80519	3.40403	2.9331	3.12017	2.80678
Simpson's diversity index	0.92977	0.90613	0.94886	0.92722	0.91491	0.92723
Evenness	0.795	0.789	0.8533	0.8463	0.7975	0.8719

Table 3- Species richness, Shannon diversity index, Simpson's diversity index and Evenness in different seasons- Site 1 and Site 2.

The Shannon index of diversity in site 1 (3.40403) exhibited highest with the evenness index of species distribution (E= 0.8533) during post monsoon as compared to monsoon (H= 3.21435); and winter (H= 3.12017). Evenness was more in winter (E= 0.7975) than monsoon (0.7950). Simpson's index also supported this with highest diversity in post monsoon (D= 0.8533) followed by monsoon (D= 0.7950) and winter (D= 0.7975) (Table 3). Study of Mineo et al. (2010) and Mahalakshmi and Jeyaparvathi (2014) also supports the present study. The richness of spider species based on the alteration in different months may be the seasonal fluctuation and harvesting in the nearby fields of the study area. Difference in vegetation architecture during different seasons accounts for the different community structure of spiders in the present study.

The availability of prey population is directly proportional to the plant growth of that area which in turn effect the spider diversity. The population density of spiders coexists with an increase of insect pests (Kiritani et al. 1972). Studies pointed out that the values of correlation coefficients between the population density of insect pests and that of spiders tend to increase from negative to positive form as crop growth advances. As no quantitative evaluation was done on the insect pest density

in this study, further investigations should be carried out to reveal the influence of insect pests on the resident spider community.

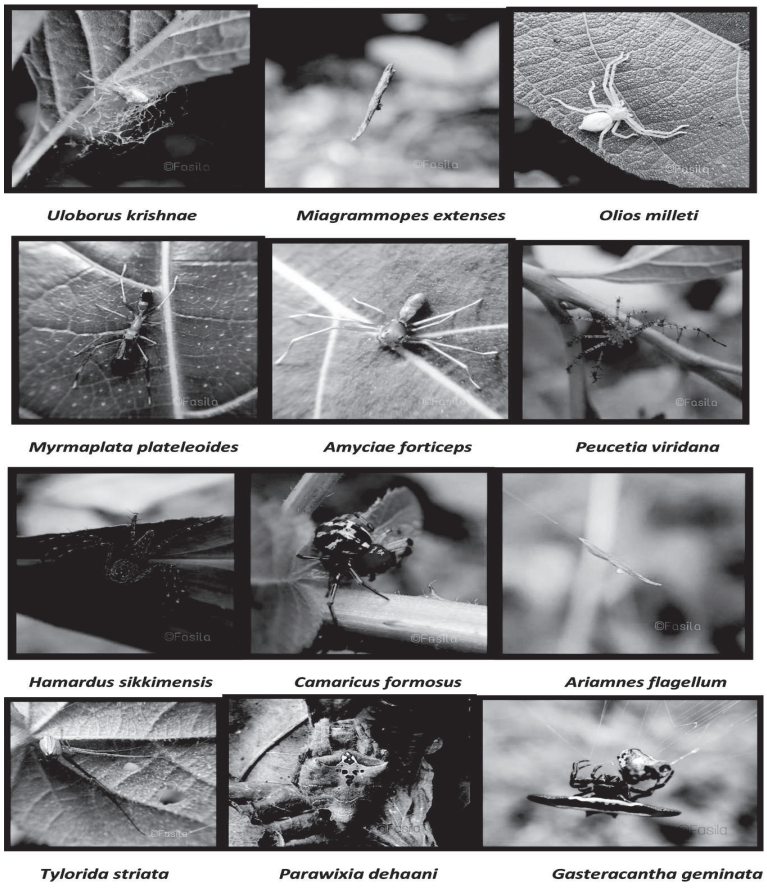
From site 2, the number of spider species (35) was maximum during monsoon with maximum number of individuals (161). The second largest number of species recorded during post monsoon (32) with 199 individuals followed by winter (25) with 99 individuals. Shannon index of diversity in site 2 (2.93310) exhibited the highest in post monsoon as compared to winter (2.80678) and monsoon (2.80519). Simpson's index of diversity exhibited highest in winter (0.92723) followed by post monsoon (0.92722) and monsoon (0.90613). Evenness was more in winter (E= 0.8719) followed by post monsoon (0.8463) and monsoon (E= 0.7890) (Table 3). Study of Sudhikumar et al. (2005) showed that spiders are more abundant in the kharif season (November, December, January and February). The present study also supporting the same view. The diversity in site 1 during different seasons was dominated during post monsoon followed by monsoon and winter. In site 2 it was in the order of post monsoon followed by winter and monsoon. Study of Deshmakh and Raut (2014) in Salbardi forest Maharashtra described that spiders are most abundant during monsoon and winter season which is conflicting to findings of this study.

Eriovixia excelsa, *Castianeira zetes, Linyphia sp., Phaeceus sp., Stenaellurillus sp. 3, Scytodes thoracica, Uloborus sp. 2* and *Uloborus sp. 3* were found only during monsoon season from site 1 whereas *Hersilia sumatrana, Hyllus semicupreus, Phintella vittata, Leucauge pondae, Argyrodes sp. 3, Xysticus minutus* and *Hermippus sp.* were reported only during monsoon from site 2 (Table 2). *Hamadruas sikkimensis, Oxyopes sunandae and Chalcotropis sp. 2* had only one sighting during post monsoon in site 2 but these species are present in all seasons in site 1. *Eriovixia sp., Parawixia dehaani, Brettus sp. 2, Olios milleti and Phycosoma sp. 2* had only one sighting (post monsoon) during the entire study period from site 1 and they were not even recorded from site 2 during the study (Table 2). *Araneus sp. 1, Neoscona sp. 5, Zelotes ashae, Myrmarachne sp. 2, Leucauge tessellata, Xysticus sp. 2* and Uloborus krishnae found only during winter season from site 1 whereas *Chrysilla volupe, Stenaellurillus sp. 3, Pardosa pseudoannulata, Meotipa sp. 4, Miagrammopes extensus* and *Uloborus krishnae* reported only during winter season from site 2 (Table 2).

A total of 25 species had commonly occurred in all seasons in site 1 than site 2 (12 species). Others are occured in any of the two seasons. Seasonal variation study of Sudhikumar et al. (2005) shows 68 species had commonly occurred in both crop seasons. All families besides Amaurobiidae, Pisauridae and Pholcidae were present in both seasons. In addition, the variation in patterns of activity of individual spiders and the phenology of the total spider community may cause a difference in the seasonal abundance of spiders (Corey et al. 1998). It might be expected that climatic changes through different seasons would influence the abundance of spiders (Kato et al. 1995).

Conclusion

This study gives baseline information of spider diversity and distribution in the both the study sites; sacred grove and rubber plantation, Malappuram district adjoining Kozhikode district. The rich fauna and flora of the sacred grove is the key to build the microhabitats that support diverse spider species. Looking at the seasonal variation, the post monsoon season was observed to be more diverse than the other two seasons followed by monsoon and winter in sacred grove. Rubber plantation had the spider diversity dominated in post monsoon followed by winter and monsoon. Since the sacred grove supporting a variety of species in great numbers, transformation of this diversity rich zone into monoculture plantations should strictly be restricted in the conservation point of view. In rubber plantations low species are probably due to habitat destruction. So, it is important to conserve such areas by not degrading it further not only to maintain spider diversity but for the conservation of other species as well. Spider fauna is ubiquitous in nature and their diversity depends on many other factors apart from seasonal variation and habitat structure. It would surely bring in more interesting results but it needs long term intense study.



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