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Study on the Diversity and Distribution of Spider Fauna at Sree Krishna College Campus of Thrissur District, Kerala, India

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Authors' contributions

This work was carried out in collaboration among all authors. Authors have equal contribution in bringing out this research work. All authors read and approved the final manuscript.

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ABSTRACT

Field survey was conducted to record the diversity of spiders at different sites in the Sree Krishna College Campus of Thrissur district during September 2022 to February 2023. Around 51 species of spiders belonging to 36 genera under 14 families were recorded. Salticidae family was represented with twelve species followed by Araneidae (10 sps.), Oxyopidae (5 sps.), Theridiidae (4 sps.), Lycosidae, (3 sps.), Tetragnathidae (3 sps.) and Sparassidae (3 sps.), Thomisidae (2 sps.), Pholcidae (2 sps.). But, Hersilidae, Linyphiidae, Uloboridae, Cheiracanthiidae and Sicariidae family members were very less. Spider population in different sites exhibited variation in species abundance and richness. Shannon index, Simpson index, Margalef Richness index, Berger-Parker index and Menhinick's Index evaluated were 3.423, 0.9580, 9.540, 0.9101and 3.709 respectively.

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The abundance and percent occurrence of different spider species revealed variation in their distribution. For the study the entire campus has been surveyed, by dividing the area into four sites, Site A, Site B, Site C and Site D. Species composition and diversity indices studies revealed that more diversity in the site C followed by Site D, Site B and Site A. These types of surveys are important for the study of the prevalence of the spider population in given habitats and to create a biodiversity database of spider.

Keywords: Abundance; evenness; diversity; richness; species.

1. INTRODUCTION

"Spiders are the largest group of arachnids having unique habitat and they live in almost all the environments. They are the most abundant predator of insects of terrestrial ecosystem and consume large number of preys without damaging the plants. Globally, about 51,075 spider species have been documented, belonging to 4,314 genera in 132 families" [1]. Among them, India has recorded 1,945 spider species from 493 genera across 61 families [1,2]. "An undisturbed natural habitat may have a high species abundance of spiders. Because they consume insects that harm crops, spiders serve as pest control agents. They are beneficial bio-control agents of insect pest in the ecosystem and are known to occupy most of the terrestrial habitats. They are general predators, which can act against a broader range of insect pests" [3-5]. Spiders serve as good ecological indicators and aid in evaluating habitat quality, such as plant diversity and pollution, especially pesticides in the ecosystem [6-9]. "Spiders are of economic value to farmers as they play valuable role in pest management by consuming large number of preys in the agriculture fields without any damage to crops. In addition to advancing scientific understanding of the dynamics of spider assemblages, a comprehensive grasp of the distribution and composition of spider species in various habitats would help us comprehend the ecosystem's habitat quality" [10].

"Spider diversity, distribution and their insect feeding habits play an important role in the balance of nature" [11]. "They are potential biological indicators of natural habitats and are used for determining how communities react to environmental changes or disturbances" [12]. "Spiders are an important but generally poorly studied group of arthropods that play a significant role in the regulation of insect pests and other invertebrate populations in most ecosystems" [3,5,13]. Spiders are becoming more and more popular as potential biological pest control agents in agricultural fields due to decreased pesticide use and ecological sustainability. Spiders are environmentally sensitive in their distribution [14-16] and their abundance and ease of collection, makes them appropriate indicators of ecological change [15]. In an ecosystem, spiders are a naturally occurring biological control agent. The present study of Spiders was carried out in Sree Krishna College Campus of Thrissur district of Kerala during September 2022– February 2023.

2. MATERIALS AND METHODS

The present study explored the diversity of spiders in different locales of the Sree Krishna college campus, Thrissur, Kerala. The study was carried out during the period from September 2022 to February 2023. The selected study area is Sree Krishna College Campus which is situated in Thrissur district of Kerala. It is located between 10.6072^{o} N and 76.0881^{o} E with an elevation of 11.13 meters. Total area is 40 acres. For the study the entire campus has been surveyed, by dividing the area into four sites. Site A is the Main block of the campus, Site B is the south region of the campus, Site C botanical garden and Site D is the women's hostel and its premises. The sites were selected based on the habitat variation. The campus areas are comprised of mixed habitats of grasslands, small trees, shrubs and has well maintained garden and open field. Except site C, all other sites consist of roads that connect departments, and consists of people and buildings. Survey was done three or four times a week in the morning and evening hours.

2.1 Sampling Methods

Spider collection was done during the morning (7.00 am to 10.00 am) and evening (16.00 pm to 18.00 pm) time to maximize the species richness Spiders were collected by adopting standard sampling techniques such as sweep netting, beating sheets, active searching, hand picking and Umbrella collection. Spider collection also made use of pitfall sampling. While visible webs

and tree leaves were examined for signs of arboreal spiders, fallen logs and leaf litter were extensively examined for ground-dwelling spiders. With the aid of brushes dipped in alcohol, smaller spiders were captured by guiding them into tubes filled with alcohol. Collected spiders were photographed in the field itself with the help of Samsung galaxy J5 and then released to their natural habitat. A small number of spiders were studied under a microscope to identify and analyse certain morphological traits.

2.2 Identification

The spiders were identified using field guide [17-19]. World spider catalogue [20] was used for the taxonomy and nomenclature of spiders and done at the Centre for Animal Taxonomy and Ecology (CATE), Dept. of Zoology, Christ College, Irinjalakuda. The specimens were preserved in 70% alcohols with proper labelling of locality, date of collection and other notes of importance.

2.3 Data Analysis

Data was analysed statistically to determine species diversity, species richness, species abundance and evenness. Microsoft Excel was used to construct different graphs according to analysed data. The data analysis discussed in this study includes the abundance of the species (n), the richness of the species (s), the diversity of the species (H) and the evenness of the species (E). The abundance of the species is the number of individual species found in each site of sampling while the richness of the species is based on the number of species appear in each location of the study. The diversity of the species is determined by the diversity index (H) of Shannon – Weaner, Marg alef's, Menhinick's Index, Berger-Parker's Index and Simpson index, using the following formula:

1. Shannon's diversity index, $H' = - \sum (pi \ln Pi)$

where H'= Shannon Index, Pi = Proportion of individuals belonging to the i^{th} species, ln = Natural logarithm (natural number)

2. Simpson's value, $D = \sum ni (ni-1) /N (N-1)$

Where ni = the number of individuals of a species N = Total number of all individuals

3. Margalef's index (R) =S-1/In(N)

where R= Margalef's richness index, S= total of species, N= total no of individual sample

4. Menhinick's Index (M) = $S/\sqrt{N}$

where M= Menhinicks Diversity Index, S = Number of species Recorded, N = total number of individuals in the sample

5. Berger-Parker's Index (d)=

Nmax / N or Berger-Parker Compliment index (1-d)

where Nmax = the number of individuals in the most abundant species, N=total number of individuals in the sample.

The evenness of the species is determined by the evenness index of Shannon (E) using the following formula:

$E = H/\ln(S);$

Where E = evenness; S = the number of species.

3. RESULTS

The present study discloses the spider diversity of Sree Krishna College campus, Ariyannur, Thrissur. A total of 189 individuals belonging to 51 species under 36 genera and 14 families were recognized.

Salticidae and Araneidae are the dominant families. Of these, most of the species are recorded from the family Salticids (14 sps.). Both diversity and density of spiders are more in garden as compared to other sites. Among the 51 identified species, 14 species were belonging to Salticidae. The family Araneidae graded second with 10 species, followed by the family Oxypidae with 5 species. There are four species in the family of Theridiidae. There were three species each in the family Lycosidae, Sparassidae and Tetraganthidae and two species each under family Thomisiidae and Pholcidae. The least common families noted were Hersilidae, Uloboridae, Sicarridae, Linyphidae and cheiracanthidium. Salticidae was the most dominant family corresponding 14 species from 10 genera constituting 25.40 % of total spider population. The second dominant family was Araneidae with 10 species from 7 genera constituting 24.87 % of the total population (Table 1 and Fig. 1).

Table 1. Spider species recorded from different sites of Sree Krishna College Campus of Thrissur district

			No. of spiders collected from each site				Total no. of spiders observed
Sl. No.	**Family**	**Species**	**Site A**	**Site B**	**Site C**	**Site D**	
1	Araneidae	*Argiope ansuja*	4	3	4	3	14
		Argiope pulchella	0	0	2	0	2
		Eriovixia sps	0	0	0	1	1
		Gasteracantha geminate	0	0	2	0	2
		Nephila pilipes	3	0	2	2	7
		Araneus quadratus	0	0	0	1	1
		Cyrtophora moluccensis	0	0	0	3	3
		Cyrtophora cicatrosa	2	5	5	3	15
		Anepsion maritatum	1	0	0	0	1
		Cyrtophora sps	0	0	1	0	1
2	Hersiliidae	*Hersilia savignyi*	3	0	1	1	5
3	Linyphiidae	*Linyphiidae sps.*	2	0	0	0	2
4	Lycosidae	*Pardosa sumatrana*	0	0	1	0	1
		Pardosa sps1	0	0	0	1	1
		Paradosa sps2	0	0	0	1	1
5	Oxyopidae	*Oxyopes birmanicus*	0	0	2	3	5
		Oxyopes javanus	0	0	0	2	2
		Oxyopes shweta	0	0	0	1	1
		Oxyopes salticus	0	0	2	0	2
		Oxyopes sps.1	0	0	0	3	3
6	Pholcidae	*Crossopriza lyoni*	2	0	4	0	6
		Pholcus phalangioides	6	3	3	6	17
7	Saliticidae	*Carrhotus viduus*	4	0	2	0	6
		Epeus tener	0	0	1	0	1
		Hasarius adansoni	1	1	1	0	3
		Hyllus semicupreus	1	0	1	0	2
		Plexippus paykulli	2	4	4	6	15
		Plexippus petersi	0	0	3	0	5
		Siler semiglaucus	0	0	0	1	1
		Telamonia dimidiata	0	4	5	0	9
		Myrmarachne plateleoides	0	0	1	0	1
		Phidippus sps.	0	0	1	0	1
		Indopadilla sps.	0	0	1	0	1
		Curubis tetrica	0	1	0	0	1
		Evarcha sps.	1	0	0	0	1
		Hyllus sps.	0	0	0	1	1
8	Sparassidae	*Heteropoda venatoria*	6	2	7	2	17
		Olios milleti	0	0	1	0	1
		Heteropoda sps.1	0	1	1	0	2
9	Tetragnathid-ae	*Tetragnatha mandibulata*	0	0	0	1	1
		Tylorida ventralis	0	3	1	4	8
		Tetragnatha cochinensis	0	0	1	1	2
10	Theridiidae	*Argyrodes flavescens*	0	1	1	0	2
		Theridion sps.	0	1	1	0	2
		Argyrodes sps. 1	0	1	1	0	2
		Argyrodes sps.2	0	1	0	0	1

Sl. No.	Family	Species	No. of spiders collected from each site				Total no. of spiders observed
			Site A	Site B	Site C	Site D	
11	Thomisidae	*Thomisus sps.*	0	0	1	1	2
		Camaricus sps.	0	0	1	0	1
12	Uloboridae	*Zosis genuculata*	0	0	1	1	2
13	Cheiracanthii-dae	*Cheiracanthium inclusum*	0	1	0	0	1
14	Sicariidae	*Loxosceles reclusa*	2	1	1	0	4
			40	33	67	49	189

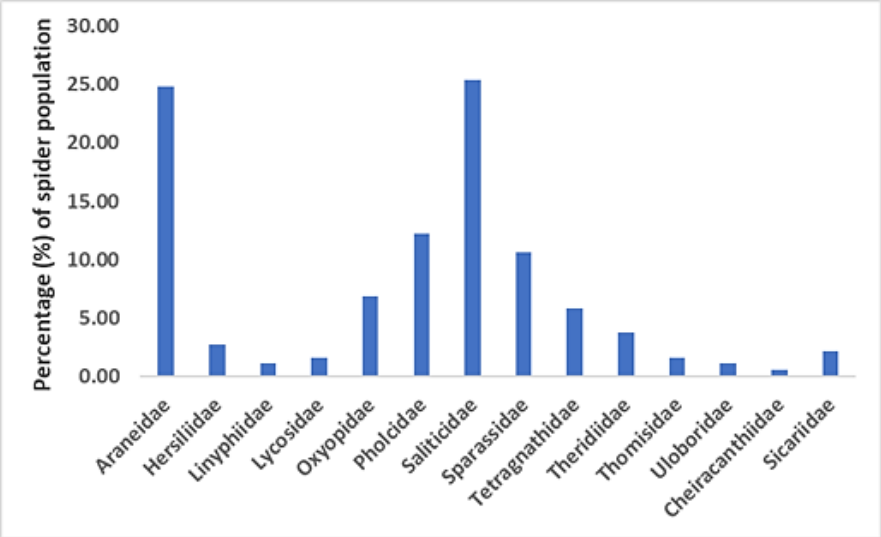

Fig. 1. showing the diversities of genera and species in each family

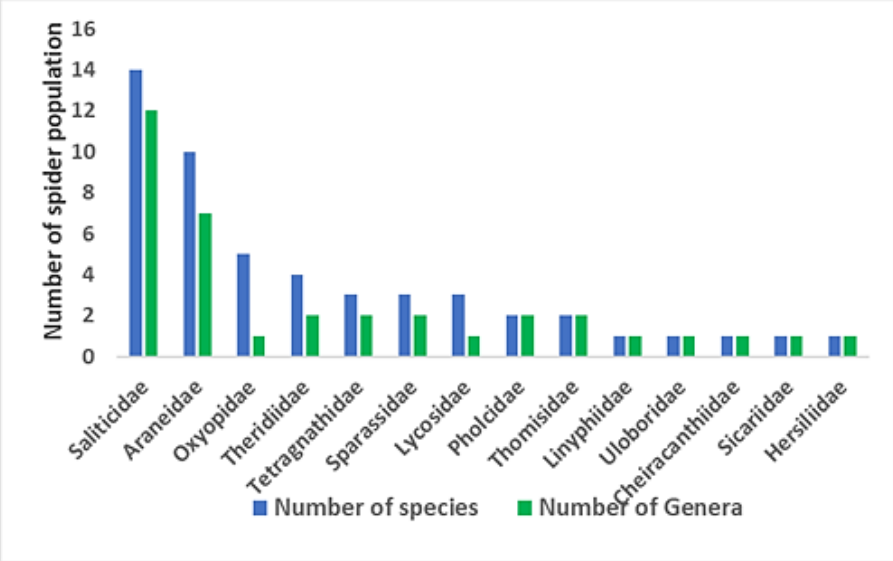

Fig. 2. Percentage of spider population in Sree Krishna College Campus

The Oxyopes genera shows high species diversity. Maximum generic diversity was found in families Salticidae (10) followed by Araneidae (7) and there were two family each with Theridiidae (2) and Thomisidae (2), Sparassidae (2), Tetraganthidae (2), Thomisiidae (2) and Pholcidae (2) (Table 1 and Fig. 2).

3.1 Diversity indices of spider at Sree Krishna College Campus

To examine spider diversity and abundance, various diversity indices were computed. The values of Shannon-Weiner index (H = 3.423), Marg alef's Index (R = 9.540), Menhinick's Index (M = 3.709) and Simpson's Diversity Index (D = 0.9529) showed that Sree Krishna College Campus holds species richness and diversity of spiders. Evenness (Shannon Evenness, E_H = 0.8705) displayed that the distribution of spider is not even throughout the Campus (Table 2).

3.2 Species Richness of Each Site

A total of 15 species of spiders from 15 genera under seven families were collected from the sample Site A. The observed families were Araneidae (10), Hersiliidae (3), Linyphiidae (2), Pholcidae (8), Saliticidae (9), Sparassidae (6), and Sicariidae (4). Salticidae was the dominant family with five species, *Carrhotus viduus* (4), *Plexippus paykulli* (2), *Hasarius adansoni* (1), *Hyllus semicupreus* (1), and *Evarcha sps*. (1), followed by family Arenidae with four species, *Argiope ansuja* (4), *Nephila pilipes* (3) *Cyrtophora cicatrosa* (2) and *Anepsion maritatum* (1). *Carrhotus viduus* was the most common among Salticidae family and *Argiope ansuja* was among the Areniade family. The most abundant species, *Pholcus phalangioides* (6) *and Heteropoda venatoria* (6) were observed from Pholcidae and Sparassidae families (Table 1).

Site B consisted of 17 species from 14 genera under 8 families from the total of 33 spiders collected **(**Table 1). Salticidae and Theridiidae was the predominant families with four species. The family saliticidae include the species such as *Telamonia dimidiate* (4), *Plexippus paykulli* (3), *Curubis tetrica* (1) and *Hasarius adansoni* (1). Araneidae and Pholcidae families consisted of two species each and the abundant species was *Pholcus phalangioides* from Pholcidae family (Table 1).

Among the total 67 spiders collected from the Site C (botanical garden and organic garden of the Campus), we got 34 species of spiders from 28 genera under 12 families (Table 1). Saliticidae was the dominant family with 10 species, *Telamonia dimidiate* (5), *Plexippus paykulli* (4), *Plexippus petersi* (3), *Carrhotus viduus* (2), *Epeus tener* (1), *Hasarius adansoni* (1), *Hyllus semicupreus* (1), *Myrmarachne formicaria* (1), *Phidippus sps* (1). *Indopadilla sps*. (1). Araneidae consisted of 6 species, *Argiope ansuja* (4), *Argiope pulchella* (2), *Gasteracantha geminate* (2), *Nephila pilipes* (2), *Cyrtophora cicatrosa* (5) and *Cyrtophora sps*. (1). The family Sparassidae and Theridiidae consisted of three species each and Oxyopidae, Pholcidae, Tetragnathidae and Thomisidae with two species each (Table 1). Uloboridae, Sicariidae, Hersiliidae and Lycosidae families consisted of one species only (Table 1).

A total of 23 species from 18 genera under 10 families obtained from 49 spiders collected from the site D (Women's Hostel and its premises) (Table 1). Here Araneidae was the dominant family with 6 species, *Argiope ansuja* (3), *Cyrtophora moluccensis* (3), *Cyrtophora cicatrosa* (3), *Nephila pilipes* (2), *Eriovixia sps.* (1) and *Araneus quadratus* (1). Oxyopidae was the second dominant families with four species, *Oxyopes birmanicus* (3), *O. javanus (2)*, *O. shweta* (1) and Oxyopes sps. (1). Among the genera, Oxyopes was the dominant with 4 species in the study sites of the College Campus. The family Saliticidae include species such as *Plexippus paykulli* (6), *Siler semiglaucus* (1) and *Hyllus sps*. (1). The family Tetragnathidae comprised of *Tetragnatha mandibulata* (1), *T. cochinensis* (1) and *Tylorida ventralis* (4) species (Table 2). Lycosidae include two species, Hersiliidae, Pholcidae, Sparassidae, Thomisidae and Uloboridae comprised of one species only (Table 1).

3.3 Diversity Indices of Spiders in Each Site of Sree Krishna College Campus

The diversity indices of spiders in different sites of Sree Krishna College Campus are shown in table 3. The richness value of spiders was 8.324 (Site C), 5.396 (Site D), 4.290 (Site B) and 3.795 (Site A) respectively. The diversity calculated by Shannon Weiner's index in different sites were 3.295 (Site C), 2.918 (Site D), 2.574 (Site B) and 2.536 (Site A)**.** The evenness is higher in Site D (0.944) compared to other sites, 0.936 (Site A), 0.929 (Site B), 0.919 (Site C). The Simpson indices value was higher in Site C with 0.970 value as compared to Site D with 0.950 value, Site B with 0.939 value and Site A with 0.932 value (Table 3). Berger-Parker index revealed the relative dominance of the species. The value of Berger- DBP (0.104) showed dominance is less but diversity is more in Site C than Site D (0.122), Site A (0.150) and Site B (0.152).

Species richness shows the varieties of species in the ecological community. Species abundance / evenness gives the relative number of individuals of species per unit area and how evenly they are distributed. The diversity Indices of Shannon– Wiener (H) and Simpson (1-D) showed that more diverse species were found in the site C, (H = 3.295), (1-D = 0.970) and least diversity in the Site A (H = 2.536), (1-D = 0.932) (Table 3). Berger-Parker index (1-d = 0.896) and Marg alef's Index (R = 8.324) also showed that diversity was high in the site C. Berger-Parker index (d = 0.104) showed that the species abundance was low but diversity is high in the site C. Evenness of Shannon (E_H) revealed that abundance or evenness was high in site D (E_H = 0.944). Menhinick's Index study also displayed high species richness in the site C (M = 4.398) (Table 3).

The diversity indices of Shannon Wiener (H), Simpson's(1-D), Marg alef's (R), Berger-Parker (1-d), Menhinick's Index (M) disclosed that the species richness or diversity was high and abundance or evenness was low in the site C (Table 3). Similarly, the results of Berger-Parker index (d = 0.104) and Shannon Evenness (E = 0.919) unveiled low evenness or abundance in the site C but species richness was high in the site C. Species composition and diversity indices studies revealed that more diversity in the site C followed by Site D, Site B and Site A (Table 4). The college campus offers a variety of habitats for different kinds of spiders.

3.4 Guild Type of Spiders at Sree Krishna College Campus

Two types of spiders were observed in this study: web-weavers and non-web-weavers. The web weaving spiders were belonging to the family Araneidae, Pholcidae, Tetragnathidae, Theridiidae, Cheiracanthiidae and Uloboridae. The non web weaving spiders were belonging to the family Lycosidae, Oxyopidae, Salticidae, Sparassidae, Sicariidae, Hersiliidae, Linyphiidae and Thomisidae (Table 4 and Fig. 3).

Table 2. Alpha diversity indices of spider population across Sree Krishna College Campus

Alpha Diversity indices	
Number of Taxa	51
Shannon Diversity Index H	3.423
Shannon Evenness, $EH = H'$ /ln S	0.871
Simpson's index, D = ∑n(n-1)/N(N-1)	0.042
Simpson's index of diversity 1 – D	0.958
Marg alef's Index, R = (S – 1) / ln N	9.540
Berger-Parker index, d = Nmax / N	0.089
Berger-Parker Compliment index (1- d)	0.910
Menhinick's Index M = S/√N	3.709

Table 3. Alpha diversity indices of spiders in different sites of Sree Krishna college campus, Thrissur, Kerala

Alpha Diversity indices	Different locations or sites			
	Site A	Site B	Site C	Site D
Number of Taxa	15	17	34	23
Individuals	40	33	67	49
Shannon Diversity Index H	2.536	2.574	3.295	2.918
Shannon Evenness $E_H = H'$ /ln S	0.936	0.929	0.919	0.944
Simpson's index, D = ∑n(n-1)/N(N-1)	0.068	0.061	0.030	0.050
Simpson's index of diversity 1 – D	0.932	0.939	0.970	0.950
Marg alef's Index, R = (S – 1) / ln N	3.795	4.290	8.324	5.396
Berger-Parker index d = Nmax / N	0.150	0.152	0.104	0.122
Berger-Parker Compliment index (1- d)	0.850	0.848	0.896	0.878
Menhinick's Index M = S/√N	2.372	2.785	4.398	3.143

Table 4. Guild types of spiders collected from Sree Krishna College campus

Guild type	Number of populations	Percentage (%) of Guild type
Stalkers	61	32.28
Orb weavers	60	31.75
Space web builders	30	15.87
Foliage runners	26	13.76
Ground runners	7	3.70
Ambushers	3	1.59
Wandering sheet weavers	2	1.06

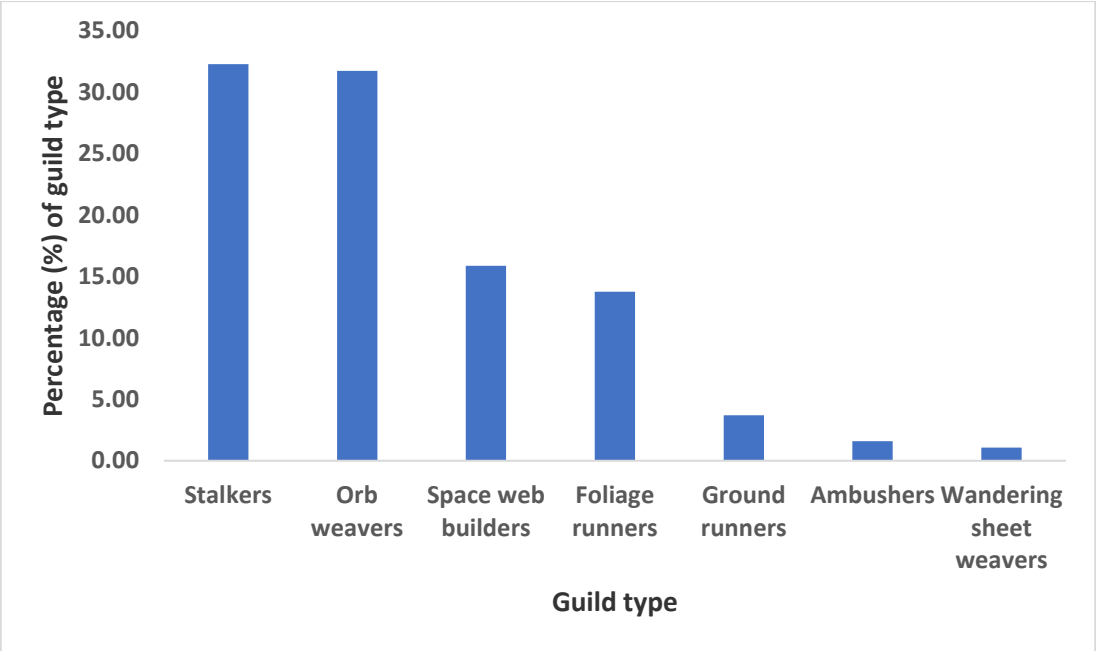

Fig. 3. Guild types of spiders collected from Sree Krishna College campus

The collected spiders are divided into seven functional groups or guilds based on the proposed classification system [21]. Stalkers (32.28%) and orb weavers (31.75%) was the dominant feeding guild of the total population, which was followed by space web builders with 15.87%, foliage runners with 13.76%, ground runners with 3.70%, ambushers with 1.59%, and wandering sheet weavers with 1.06 % (Table 4 and Fig. 3).

In the present study, seven functional groups were identified based on their foraging mode. Similarly, Sebastian et al. [22] recorded "seven different foraging guilds in the irrigated rice ecosystem of Kerala". Adarsh and Nameer [23] recorded "spider fauna of Kerala Agricultural University, Southern India and the feeding guild structure analysis revealed seven types of functional groups". But, Pandit and Pai [24] documented "nine foraging guilds of the spider fauna from the Taleigao plateau, Goa". "The common explanation for the observed pattern of spider guilds are structural diversity, microenvironment, or the level of disturbance of the habitat" [25]. "Guild composition can provide insight into the effect of habitat alteration and disturbances on arthropod diversity" [26]. "So, the most promising option for utilizing the predatory characteristics of spiders for the biological control of pests is to increase their density and diversity" [27].

4. DISCUSSIONS

Spider diversity is a significant limiting factor when assessing biological organisation at the community level. Higher species diversity is an indication of a healthier and complex community because a greater variety of species allows more interactions, hence greater system stability which in turn indicates good environmental conditions [28].

The vegetation structure of the habitat supports both the web building and non-web building spiders. Furthermore, the presence of a good microclimate and/or sufficient web support for many spider species may be connected to their exclusive occurrence in a particular location. In addition, the area received less exposure to chemical pesticide applications. The web building and plant wandering spiders depend on vegetation for some part of their lives, either for finding food or for web building [29]. The structural complexity of the habitat and the diversity of spider species have been shown to be positively correlated in numerous previous studies [30-32].

A crucial part of the natural equilibrium is played by the diversity, distribution, and insect-feeding behaviors of spiders. [33]. They are potential biological indicators of natural habitats and are used for determining how communities react to environmental changes or disturbances [34]. According to Shamna [35], the Mokeri village near Thalasseri thaluk, Kannur, Kerala, has 12 species of Salticidae, making it the dominant family. The present study shows that Sree Krishna college campus supports rich diversity of spiders in various habitats of the campus. The 51 species indicate that the area still have a healthy population of spiders. The microhabitats in the campus such as ground, litter, bushes, tree trunks, foliage, and water bodies support the spider diversity.

5. CONCLUSION

This was the first attempt to document spider diversity in the Sree Krishna College campus. The study provides data on how a species responds to its surroundings and food availability in relation to its distribution within a specific habitat. Because of their capacity for predation, spiders are an integral component of all ecosystems and clearly contribute to their equilibrium. This study provides updated checklist and base-line data of spider diversity from Sree Krishna College campus. This ecosystem with rich floral diversity provides a favourable environment to the spider fauna and emphasizes the need for conservation of this ecosystem by characterizing species diversity.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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