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Assessing spider diversity in Puducherry: Rural richness and urban constraints

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Abstract
A study on spider species diversity was undertaken in specific locations within and around Puducherry from October 2023 to March 2024. The study sites yielded 29 spider species, classified into 22 genera and six families. *Araneidae* and *Salticidae* were identified as the most prevalent, with species from 6 and 7 genera, respectively. Throughout the study period, there were notable variations in the diversity and distribution of spider species across all the study locations. Kalapet exhibited the most diversity of spider species, with 23 species. In contrast, Lawspet had the lowest spider species diversity, with 12 species. Among the 29 species observed, *Argiope anasuja*, *Cyrtophara cicatrosa*, *Cyrtophora citricola*, and *Myrmarachne bengalensis* exhibited the highest levels of dominance in rural settings (namely Kalapet). The presence of their prey and a wide variety of plants suggests that these species are dominating. Our research indicates that spider diversity was more significant in rural habitats with excellent ecological conditions but lower in urban habitats with the most undisturbed ecological environment.

Keywords: Puducherry, urban habitat, spider diversity, shannon's index, species richness

Introduction

Spiders play a crucial role in ecosystems as they are predatory and help maintain ecological balance in agroecosystems. They are also considered indicators of ecosystem health, as they are sensitive to habitat loss, climate change, and environmental disruptions [1, 2, 3]. The current global spider list comprises 46,879 species distributed across 4,062 genera, further classified into 114 families. India is home to 1447 species and 15 Spiders subspecies, as Pandit *et al*. documented in 2017 [4, 5]. The spider has been categorized into *Mesotelae* and *Opisthothelae*, consisting of infraorders such as Mygalomorphae and *Araneomorphae* [6, 7]. Multiple entomologists have long acknowledged that spiders play a crucial role as predators in regulating pests that affect various crops [8, 9]. According to Keswani and Vankhede, spiders play a beneficial role in agriculture by regulating various pests that infest different types of crops [10].

Human activities have caused substantial alterations in the composition and diversity of most recognized ecosystems, especially in spider and other animal populations [11, 12]. Due to insufficient studies comparing sampling procedures and faunal species in Indian tropical regions [13], there is a lack of knowledge on spider diversity and assemblages in and around Puducherry. This study investigates spider species' community structure, variety, and richness in two habitats inside and surrounding Puducherry. Precise documentation of spider diversity patterns will be highly beneficial for insect pest management among agriculture farmers in Puducherry.

Materials and methods

Study area

A survey to assess the variety of spider species was carried out in the vicinity of Puducherry, focusing on specific locations with coordinates 12°00′57″N 79°51′31″E. Puducherry, previously referred to as Pondicherry acquired its prominence as "the French Riviera of the East" with the establishment of French colonial rule in India. Puducherry, derived from the Tamil term "new town," mainly originates from "Poduke," the designation for the marketplace or "port town" used for Roman commerce during the 1st century. Erudite scholars formerly inhabited the settlement well-versed in the Vedas, which is why it was also referred to as Vedapuri. The Bay of Bengal borders Puducherry to the east and the state of Tamil Nadu, with which it shares a majority of its culture, legacy, and language.

The study sites were categorized into two groups:

1. Rural habitats: characterized by minimal human interference (e.g., agricultural fields in Kalapet) and
2. Urban habitats: characterized by significant human activity (e.g., educational institutes and residential areas: Lawspet).

Data collection and analysis

The study was conducted over six months, specifically from December 2023 to March 2024. Spider diversity and abundance data were collected for four hours each day, specifically from 7:00 a.m. to 11:00 a.m., for four days per month. During the study period, 64 hours of data were

gathered in each designated habitat. Using the all-out-search strategy, researchers physically saw as many spider species as possible in each one-hectare plot [14]. The level of effort required for data collection was maintained at a consistently high level.

Specimen collection was minimized to the greatest extent feasible. Photography was the primary method used for documenting the majority of the information. The spider population was categorized as Common (C), Rare (R), and Abundant (A). The spider diversity data was inputted into Excel spreadsheets to facilitate the investigation of ecological indices. The density and relative abundance of spider species were determined using the method proposed by Michael [15]. Species diversity was calculated using Shannon's and Simpson's indices, while richness was assessed using Menhinick's and Margalef's indices [9]. Additionally, evenness was measured using Pielou's index. All calculations were conducted using the PAST statistical software developed by Hammer *et al*. in 2001 [16].

Results

The four-month investigation documented 29 spiders belonging to six different families and 22 different genera. In Table 1, out of the total of 29 species found, 16 (55.17 percent) were classified as rare, 8 (27.58 percent) were classified as common, and 5 (17.24 percent) were classified as abundant. The peak abundance of spiders was observed in January, while the minimum abundance was recorded in March. The Araneidae family had nine species, accounting for 31.03 percent. The *Salticidae* family had eight species, representing 27.60 percent. The *Tetragnathidae* family had five species, making up 17.24 percent. The *Sparassidae* family had three species, accounting for 10.34 percent. The *Oxyopidae* family had two species, representing 6.90 percent. The *Pholcidae* and *Hersiliidae* families had one species, accounting for 3.45 percent. The family *Araneidae* is the most populous, consisting of nine species. The spiders were categorized into five functional groups based on their foraging behavior. The most common feeding guild was Orb-web builders, accounting for 48.27 percent of the spiders. Stalkers comprised 27.58 percent, Ambushers accounted for 10.34 percent, Foliage runners made up 10.34 percent, and Irregular-web builders represented 3.44 percent.

Based on data gathered from specific study sites, 29 spider species were recorded across two habitats: kalapet had 23 species, and Lawspet campus had 13 species. Out of the 29 different categories, three specific species, *Argiope anasuja*, *Cyrtophara cicatrosa*, and *Pholcus phalangioides*, were discovered in nearly all of the research locations. *Argiope anasuja, Cyrtophara cicatrosa, Cyrtophora citricola*, and *Myrmarachne bengalensis* were found to be the most common spider species in rural settings such as Kalapet. *Pholcus phalangioides* and *Argiope anasuja*, in contrast, have been documented to exhibit greater abundance in urban environments, specifically at Lawspet. The ant-like spider *Myrmarachne bengalensis* has been discovered in the Kalapet region.

Eight of 29 spider species are listed as "Threatened" according to the IUCN classifications. The following spider species are *Plexippus paykulli, Plexippus petersi, Pseudicius picaceus, Telamonia dimidiate, Opadometa fastigata, Tetragnatha mandibulata, Olios millet, and Heteropoda venatoria. Araneus mitificus, Neoscona theisil, Zygiella atrical, Oxyopes shweta, Pholcus phalangioides, and Tetragnatha montana* are included in the list of five species designated as Schedule IV under the Wildlife (Protection) Act of 1972. These species are rated as Least Concern (LC) by the IUCN. The IUCN Not Evaluated category includes the following eighteen spider species: *Araneus dimidiatus, Argiope anasuja, Cyrtophora cicatrosa, Cyrtophora citricola, Gasteracantha geminate, Neoscona nautical, Peucetia viridians, Hyllus semicupreus, Menemerus bivittatus, Myrmarachne bengalensis, Platycryptus undatus, Leucauge argyra, Leucauge decorate, Heteropoda jugulans*, and *Hersilia savignyi* (Table 1).

Table 1: An Observation of Spider species diversity and distribution in selected localities in and around Puducherry

S. No	Family / Species	No. of Individuals observed			
		Rural Habitats		Urban Habitats	
		Kalapet		Lawspet	
I	Family: *Sparassidae*				
1	*Olios millet*	19	AB	AB	AB
2	*Heteropoda jugulans*	AB	5	AB	AB
3	*Heteropoda venatoria*	35	AB	AB	AB
II	Family: *Oxyopidae*				
4	*Oxyopes shweta*	3	4	AB	AB
5	*Peucetia viridians*	4	6	AB	AB
III	Family: *Salticidae*				
6	*Hyllus semicupreus*	33	AB	AB	AB
7	*Menemerus bivittatus*	AB	3	AB	AB
8	*Myrmarachne bengalensis*	175	AB	AB	AB
9	*Platycryptus undatus*	12	AB	AB	AB
10	*Plexippus paykulli*	3	AB	AB	AB
11	*Plexippus petersi*	AB	7	5	5
12	*Pseudicius picaceus*	AB	13	AB	AB
13	*Telamonia dimidiate*	29	7	11	AB
IV	Family: *Araneidae*				
14	*Araneus dimidiatus*	10	6	AB	AB
15	*Araneus mitificus*	3	AB	AB	AB
16	*Argiope anasuja*	60	55	187	28
17	*Cyrtophora cicatrosa*	39	122	8	20

18	*Cyrtophora citricola*	59	82	AB	26
19	*Gasteracantha geminata*	16	119	9	AB
20	*Neoscona theisi*	7	4	AB	AB
21	*Neoscona nautical*	AB	1	2	AB
22	*Zygiella atrica*	3	AB	6	9
V	Family: *Hersiliidae*				
23	*Hersilia savignyi*	AB	AB	6	AB
VI	Family: *Tetragnathidae*				
24	*Leucauge argyra*	2	8	AB	AB
25	*Leucauge decorate*	11	AB	12	2
26	*Opadometa fastigata*	7	AB	2	AB
27	*Tetragnatha mandibulata*	2	5	AB	AB
28	*Tetragnatha montana*	3	AB	AB	AB
VII	Family: *Pholcidae*				
29	*Pholcus phalangioides*	5	6	50	192

The Kalapet exhibited the highest levels of spider species variety, richness, and evenness indexes. The sites exhibit variation in ecological indices of species diversity, including Simpson's and Shannon's indices, richness indices such as Menhinick's and Margalef's, and evenness index like Pielou's. The values for these indices at each site are as follows: Kalapet (Simpson's: 0.83; Shannon's: 2.23; Menhinick's: 0.98; Margalef's: 3.37; Pielou's: 0.45), and Lawspet (Simpson's: 0.57; Shannon's: 1.35; Menhinick's: 0.69; Margalef's: 1.93; Pielou's: 0.32). The variations in spider species diversity, richness, and evenness across different habitats may be attributed to the introduction of disturbances, transportation activities, and food availability.

Discussion

The spider diversity, distribution, and insect feeding habits are crucial in maintaining ecological equilibrium [17, 18]. A comprehensive survey of the designated habitats in and around Puducherry revealed the presence of 29 species from 22 genera and 6 families. The Kalapet areas have the most incredible diversity and richness, encompassing 23 species from six groups. This environment has a significant abundance of diverse flora (including trees and bushes) and fauna (such as butterflies, moths, beetles, dragonflies, and ants), which plays a crucial role in creating microhabitats that support a wide range of spider species. According to Hill (1973), a greater species diversity is a sign of a healthier and more intricate community [19]. A more comprehensive range of species enables more interactions, increasing system stability. This stability is an indication of favorable environmental circumstances.

This study established five functional categories based on the foraging pattern of the subjects. Orb-web builders were the dominant feeding guild, accounting for 48.276 percent of the total, while Stalkers made up 27.58 percent. Sebastian *et al*. identified five differentiated feeding guilds within the irrigated rice ecosystem in Kerala [20]. Adarsh and Nameer studied the feeding guild structure of spider fauna at Kerala Agricultural University in Southern India [21]. Their inquiry identified five distinct functional groupings. In contrast, Pandit and Pai conducted a study on the spider fauna of the Taleigao plateau in Goa and identified nine distinct feeding guilds [4]. The composition of spider guilds is influenced by the host plant, microenvironment, and level of disturbance [22]. Nyffeler *et al*. found that orb-weaving spiders are the most numerous in agroecosystems [8]. Additionally, they observed that the structure of their webs, namely the close-meshed orb, may be advantageous for collecting many small insects compared to other groups of spiders. The current study proposes that the intricacy of vegetation's structure contributes to the preservation of resources and promotes a wider variety of spider species that construct orb webs.

Salticidae, Araneidae, Tetragnathidae, Oxyopidae, Sparassidae, Hersiliidae, and *Pholcidae* were found in urban and rural areas. The Araneidae and Salticidae families were the most prevalent, consisting of 9 and 8 species over 8 genera, respectively. This ecosystem exhibited abundant floral and faunal diversity, which plays a crucial role in forming microhabitats that support a wide range of spider species. Furthermore, more spider species were recorded in January, while fewer were observed in March. The results of the current investigation, conducted in two distinct environments (urban and rural), align with the findings published by Bultman *et al* [23]. Ried and Miller (1989) found that agroecosystems with a higher level of structural complexity can sustain a greater variety of spider species, especially within the *Araneidae* and *Salticidae* families [24]. Within agroecosystems, the *Araneidae* and *Salticidae* families are often cited as substantial spider family components [25]. The findings indicate that variations in spider species variety within families are strongly correlated with factors such as temperature, rainfall, humidity, availability of prey species, and other physical variables in the ecosystem. These factors contribute to the promotion of spider species diversity.

Spider variety, richness, and evenness varied throughout the study locations. Kalapet had the highest values for Shannon's, Margalef's, and Pielou's index, whereas Lawspet had the lowest values. There is a positive correlation between the value of Shannon's index (H') and the level of floral and faunal diversity [26]. Culin and Yearga utilized species richness indices to quantify habitat quality and spider abundance in systems considerably modified by human activity [27]. These findings are consistent with the present study, demonstrating a decline in spider diversity as anthropogenic activities intensify.

The population density and relative richness of spider species in agricultural areas can reach comparable levels in natural environments [28, 29]. According to Lee *et al*. (1997), spider species control over 90% of rice fields' brown planthopper pest population [30]. The research [31] discovered four species of spiders in cotton fields: *Peucetia viridana, Oxyopes shweta, Oxypes salticus*, and *Peucetia latikae*. These spiders can regulate the population of cotton pests such as *A. gossypii*, *leafhopper*, and *S. litura*. Faleiro *et al*. (1990) documented that the *Peucetia viridians* spider effectively controls the pest population of cowpea and soybean [32]. *Peucetia viridians* and *Oxyopes shweta* were

exclusively observed within agricultural fields in the Kalapet regions. This discovery demonstrates that these two species have the potential to serve as adequate controls for agricultural pests. In addition, *Pholcus phalangioides* exclusively inhabit structures in metropolitan regions, offering the spider shelter, sustenance, and a temperate climate. This spider fulfills a crucial function in controlling the growth of insect populations, especially in urban areas.

Conclusion

The importance of alterations in spider community composition between urban and rural environments is assessed using diversity analysis. This study uncovered that spiders are plentiful in rural habitats, specifically in the Kalapet areas, primarily in agricultural environments. Additionally, it was found that spiders play a crucial role in controlling the population of insects and other large arthropods, thereby creating a favorable habitat for various spider species. Spider diversity in urban settings is significantly reduced due to industrialization, urbanization, transportation activities, air and water pollution, and other measures to decrease spider populations. The current data indicate that the variety and distribution of spider species in different ecosystems are positively correlated with the amount of vegetation and negatively correlated with the level of human disturbances.

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