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Diversity of spiders (Arachnida: Araneae) in natural and altered ecosystems in Salem district, Tamil Nadu, India

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Abstract

A detailed investigation of the spider diversity in Salem district, Tamil Nadu was carried out across different habitats for a period of five years. A total of 184 spider species belonging to 97 genera in 29 families were recorded, which represented nearly 10% of Indian and 65% of Tamil Nadu spider diversity. Among them 25 spider species are endemic to India. From the 29 families, the 3 most abundant families based on number of specimens sampled were Lycosidae (21%), Araneidae (18%), and Eresidae (17%), constituting 56% of the spider species. Simpson diversity indices ranged between 0.88 to 0.30 for all the studied habitats. The species richness was highest in bamboo fields (2.78), and the lowest was observed in grasslands (0.76). The highest abundance of spider species was observed in the sugarcane fields (0.83), followed by the grasslands (0.57) and paddy fields (0.53). Further, these spiders were categorized into nine types based on their foraging guilds. Among them, the highest species richness was observed in foliage runners. A maximum of nine spider guilds were observed in the shrub ecosystem. Natural ecosystems such as shrublands, treescapes, and grasslands had higher spider diversity than altered agricultural and domestic ecosystems. This is the first report on spider diversity in Salem District, Tamil Nadu revealing the varying spider diversity along with their guild types across different habitats.

Key words: Arachnida, ecosystem, guild, habitat, species diversity

Introduction

Spiders are widely distributed across the globe, except in Antarctica (Foelix, 2011), and thrive in various habitats such as trees, shrublands, under stones or logs, leaf litter on the forest floor, and even in household environments (Mathew et al., 2009). Globally, about 51,075 spider species have been documented, belonging to 4,314 genera in 132 families (WSC, 2023). Of these, 1,945 spider species belonging to 493 genera in 61 families have been reported in India (Caleb and Sankaran, 2023; WSC, 2023). They have unique patterns of abundance, diversity, biomass, and functional roles in different ecosystems (Foelix, 2011; Mammola et al., 2018).

Spiders serve as good ecological indicators and aid in evaluating habitat quality, such as plant diversity and pollution, especially pesticides in the ecosystem (Marc et al., 1999; Pearce and Venier, 2006; Cardoso et al., 2011; Robertson et al., 2011). They have notable impact on the agroecosystems as predators and play a prominent role in the food chain as pest controllers (Marc et al., 1999; Sharma et al., 2010; Michalko et al., 2019), consuming 400–800 million tonnes of prey, mostly insects, every year (Nyffeler and Birkhofer, 2017). Furthermore, they are also become prey to higher vertebrates like lizards and birds (Sebastian and Peter, 2009; Nyffeler and Birkhofer, 2017; Palem et al., 2017; Kaltsas et al., 2019; Michalko et al., 2019; Milano et al., 2021).

According to Rodriguez-Artigas et al. (2016), a thorough understanding of the composition and distribution of spider species in different habitats will not only help to increase scientific knowledge about the dynamics of spider assemblages but also enable us to understand the habitat quality of the ecosystem. Globally, increasing anthropogenic interventions such as clearing of forests, urbanization, and indiscriminate usage of pesticides in agricultural lands, have greatly affected the diversity and abundance of spiders (Tanaka, 1989; Wise, 1995; Halaj et al., 1998; Sørensen, 2004; Foelix, 2011). In recent times, organic farming has been gaining prominence, especially to avoid pesticide pollution and improve soil quality (Rasool et al., 2022; Walia et al., 2022). In organic farming, pest management through spiders is one of the prominent strategies in reducing the use of chemical pesticides as well as to control insect pests (Batary et al., 2012).

The species composition of spider assemblages is influenced by variations in plant community structure, ecosystem dynamics, and abiotic factors including soil, ambient humidity, and temperature (Foelix, 2011; Gallé and Schweger, 2014; Rodriguez-Artigas et al., 2016). The diversity and abundance of spiders have been documented in different types of agricultural areas such as coffee plantations (Rendón et al., 2006), sugar cane (Khan et al., 2017), cashew farms (Smitha and Sudhikumar, 2020), and rice fields in the Indian subcontinent (Kapoor, 2008; Rajeevan et al., 2019; Prasad et al., 2020).

A total of 283 spider species of spiders belonging to 33 families and 120 genera have been reported from Tamil Nadu so far (Caleb and Karthikeyani, 2022). Recently, several studies have dealt with the spider diversity from various localities of Tamil Nadu such as Yercaud, a hilly resort and a part of the Salem district (38 species; Sugumaran et al., 2007), Puthanampatti of Trichy (18 species; Rajendran et al., 2017), Nilgiris (59 species; Dharmaraj et al., 2018), scrub jungle of Madras Christian College campus in Tambaram, Chennai (108 species; Caleb, 2020), Coimbatore (35 species; Devika et al., 2022), Kanyakumari Wildlife Sanctuary (82 species; Sen et al., 2022), and Swamimalai Region of Cauvery Delta (31 species; Veeramani et al., 2023). The present work aims to document and report the spider diversity of Salem district from different ecological habitats along with their guild types.

Material and methods

Study area

The study area, Salem district (11.6643° N, 78.1460° E) is located in western Tamil Nadu, India (Fig 1). It is surrounded by hillocks on all sides and its landscapes are rapidly being urbanized. This region has a mean annual temperature of 31.2 °C (range 24.1–38.5 °C), and exhibits a dry climate from March to May, followed by the southwest monsoon from June to July. About 70% of annual precipitation (i.e., 690–825 mm/year) occurs during the rainy season (Earth System Science Organization, Regional Meteorological Centre, Chennai). Two types of ecosystems with a different vegetation gradient and anthropogenic interference were selected to study the spider diversity across Salem. These included both natural and altered ecosystems, and were further classified into different habitats such as grasslands, treescapes, shrublands, paddy fields, sugarcane fields, turmeric fields, coffee plantations, bamboo fields, bean fields, human settlements, and road verges (Fig. 1).

Study design

Spider surveys were conducted over a five-year period from March 2017 to February 2022 during the morning and evening hours. A total of 170 transects (100 cm in length each) were sampled across eleven habitat types as per León-Cortés et al. (2004). The number of transects per habitat was proportional to the total cover of each habitat type. Ten sampling points were designated along each transect. In each habitat, ten sampling plots (1 m x 1 m) were placed randomly to census spiders, with a distance of at least 100 m maintained between each plot to avoid pseudo-replication (as per the diameter of an area). Subsequently, the spiders in each plot were collected using semi-quantitative sampling. This semi-quantitative sampling design was selected to produce a relatively complete species list and the associated spider abundance data for each vegetation habitat (Lia et al., 2022). This comprised of aerial collection, ground collection, and sweeping methods. Aerial sampling (for upper layer spiders up to 1.5 m) involved searching leaves, branches, tree trunks, and spaces in between, from knee high-up to maximum overhead arm's reach, and ground collection (for ground layer spiders) involved searching on hands and knees, exploring the leaf litter, logs, rocks, and plants below knee level. Sweep netting (for middle-layer spiders up to 1 m) was carried out to access foliage-dwelling spiders (Coddington and Levi, 1991; Coddington et al., 1996).

Spider collection and identification

The collected spiders were kept in plastic bottles with small holes for aeration. In the laboratory, only voucher specimens were transferred to 70% alcohol for identification in labelled tubes, and the remaining common spiders were released back into the wild (Skerl, 1999; Milano et al., 2021). The detailed examination for species identification was carried out by observing spiders under a stereo zoom binocular microscope (Magnus MS24). Photographs of the spiders were taken using a digital camera (Nikon P520). Voucher specimens are deposited in the repository of Department of Zoology, Periyar University.

Spiders were recognized to the family, genus, and species levels using existing literature and standard diagnostic taxonomic keys provided by Tikader and Malhotra (1980), Tikader and Biswas (1981), Tikader (1987), Sethi and Tikader (1988), Majumder and Tikader (1991), Gajbe (2007, 2008), Prószyński

(1992, 2019), and Caleb (2016, 2020). The spider guild categorization was based on the dietary habits and ecological traits of the respective families (Cardoso et al., 2011). The scientific names are in accordance with the World Spider Catalog (2023). Verification of the identified spiders was confirmed with the help of arachnologists.

Statistical analysis

The total number of individuals, families, species/morphospecies, and relative abundance for each vegetation habitat were calculated, to analyze the abundance and richness of spider species in each habitat. The alpha diversity index was calculated using PAST4.03 software (Hammer et al., 2001).

Results and Discussion

Spider diversity

During the study period, a total of 12,433 individual spiders were collected and the immature spiders were released back into the field and omitted from the identification process. We recorded a total of 184 spider species (Plate 1 and 2) belonging to 97 genera and 29 families (Table 1) in 11 different habitat types in Salem district, Tamil Nadu, and this accounted for nearly 10% of India's total spider diversity. Among these, 25 species are endemic to India (Table 1) (WSC, 2023). It is interesting to note that about 65% of spider species from Tamil Nadu State was documented in Salem district (Caleb and Karthikeyani, 2022). The presence of 184 spider species in Salem might be due to the presence of diverse habitat types. However, the keen eye of an arachnologist is also needed to record the precise spider diversity. For example, Caleb (2020) reported about 108 species of spiders in a small area of 1.48 km^2.

Among the 184 spider species of the 29 families, the top 3 highly abundant families, representing a greater number of individuals were Lycosidae (21%), Araneidae (18%), and Eresidae (17%), contributing to about 56% of the species abundance. The top families in terms of species richness were Araneidae (42 species), Salticidae (29 species), and Lycosidae (17 species) (Figure 2), similar to other studies (Deshmukh and Raut, 2014; Smitha and Sudhikumar, 2020). Eleven families were represented with a single representative: Dictynidae, Eresidae, Oonopidae, Oecobiidae, Selenopidae, Sicariidae, Hahniidae, Idiopidae, Philodromidae, Prodidomidae and Theraphosidae (Table 1).

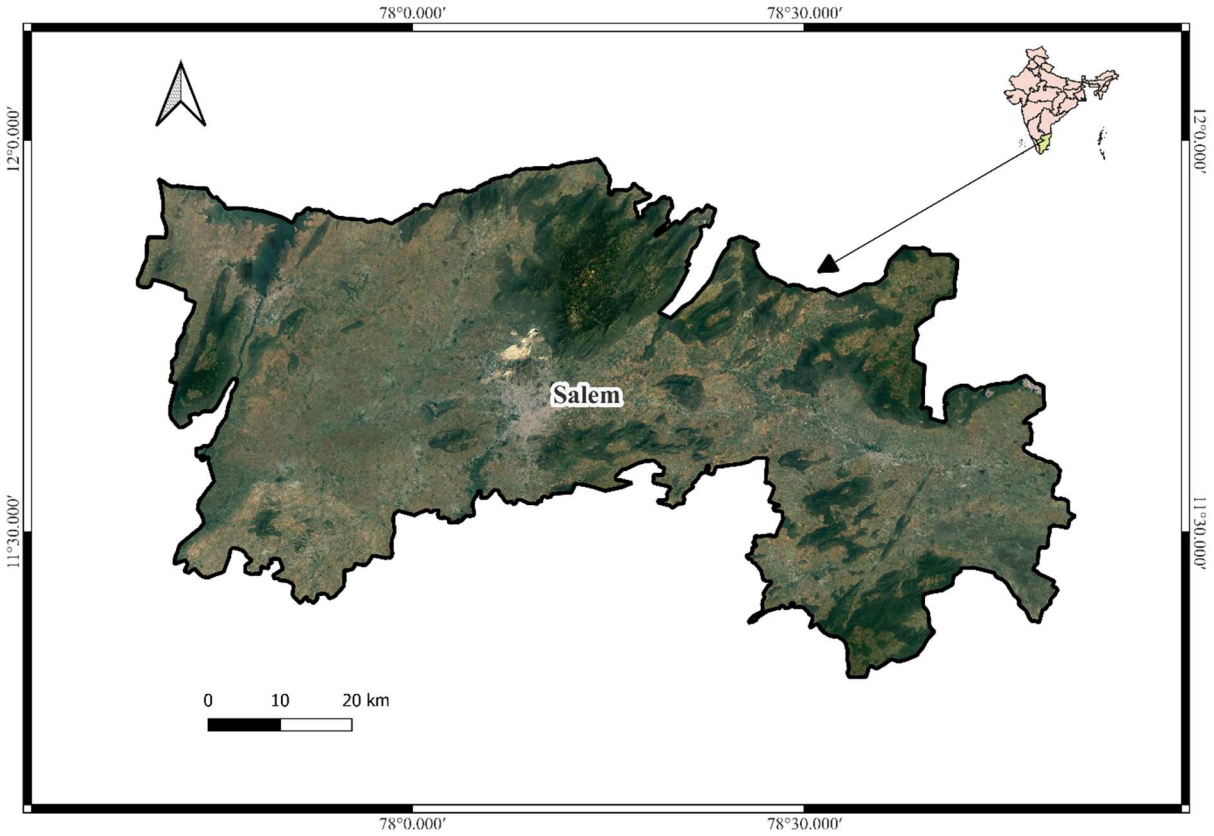

Figure 1: Map showing the study area, Salem district in Tamil Nadu, India.

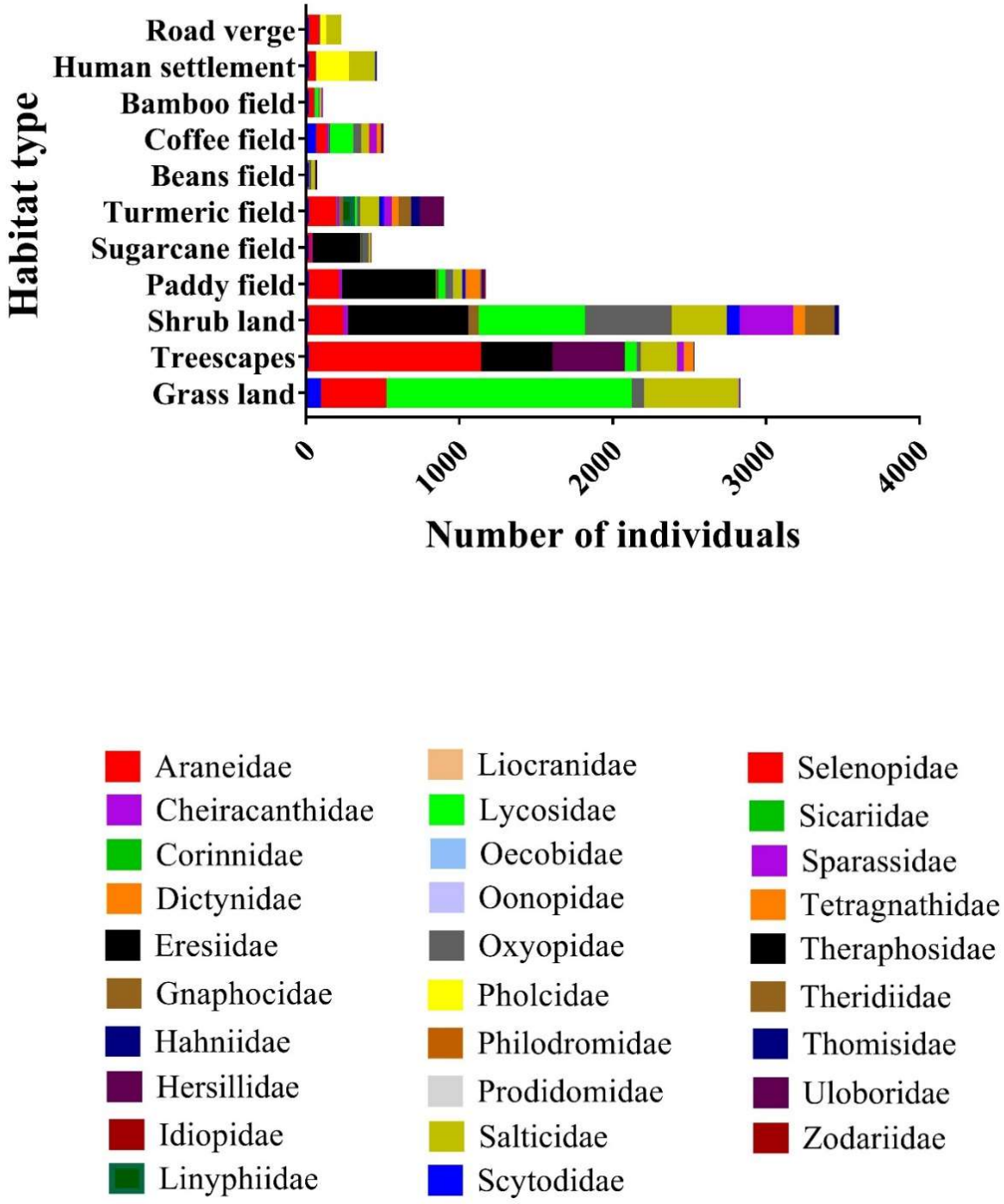

Figure 2: Spider abundance in different habitat types in Salem, Tamil Nadu with reference to families.

Eresidae was the predominant family in rice fields, sugarcane fields, and shrub lands, whereas families such as Uloboridae and Pholcidae were predominant in turmeric fields and human settlements, respectively. Hence, the diversity and dominance of spiders varied depending on the types of flora in a particular location (Anindita et al., 2017; Rajendran et al., 2017). Spider families such as Lycosidae, Araneidae, and Eresidae were more abundant in the study area, and this could be attributed to the influence of edaphic and vegetation structure, as previously reported (Rendón et al., 2006; Baba et al., 2019). Compared to other ecosystems using alpha diversity indices, shrublands had more spider diversity, as it is a natural ecosystem which may offer more ecological niches for several guild types (Table 2).

Table 1: List of spider species in Salem, Tamil Nadu along with their guild type.

S. No.	Family/ Guild type	Species name
1	Araneidae (Orb web builders)	*Araneus* sp.
2	,,	*Argiope aemula* (Walckenaer, 1841)
3	,,	*Argiope anasuja* Thorell, 1887
4	,,	*Argiope caesarea* Thorell, 1897
5	,,	*Argiope catenulata* (Doleschall, 1859)
6	,,	*Araneus ellipticus* (Tikader and Bal, 1981) *
7	,,	*Argiope pulchella* Thorell, 1881
8	,,	*Argiope* sp.
9	,,	*Bijoaraneus mitificus* (Simon, 1886)
10	,,	*Chorizopes* sp.
11	,,	*Cyclosa bifida* (Doleschall, 1859)
12	,,	*Cyclosa* sp.
13	,,	*Cyclosa confraga* (Thorell, 1892)
14	,,	*Cyclosa hexatuberculata* Tikader, 1982
15	,,	*Cyclosa insulana* (Costa, 1834)
16	,,	*Cyclosa neilensis* Tikader, 1977
17	,,	*Cyclosa spirifera* Simon, 1889
18	,,	*Cyrtophora* sp.
19	,,	*Cyrtophora cicatrosa* (Stoliczka, 1869)
20	,,	*Cyrtophora citricola* (Forsskål, 1775)
21	,,	*Eriovixia excelsa* (Simon, 1889)
22	,,	*Eriovixia laglaizei* (Simon, 1877)
23	,,	*Gasteracantha geminata* (Fabricius, 1798)
24	,,	*Gasteracantha* sp.
25	,,	*Guizygiella indica* (Tikader and Bal, 1980) *
26	,,	*Guizygiella melanocrania* (Thorell, 1887)
27	,,	*Larinioides* sp.
28	,,	*Macracantha hasselti (C. L. Koch, 1837)*
29	,,	*Neoscona* sp. 1
30	,,	*Neoscona* sp. 2
31	,,	*Neoscona* sp. 3
32	,,	*Neoscona* sp. 4
33	,,	*Neoscona bengalensis* Tikader and Bal, 1981 *
34	,,	*Neoscona molemensis* Tikader and Bal, 1981
35	,,	*Neoscona mukerjei* Tikader, 1980
36	,,	*Neoscona nautica* (L. Koch, 1875)
37	,,	*Neoscona punctigera* (Doleschall, 1857)
38	,,	*Neoscona theisi* (Walckenaer, 1841)
39	,,	*Neoscona vigilans* (Blackwall, 1865) *
40	,,	*Nephila pilipes* (Fabricius, 1793)
41	,,	*Thelacantha brevispina* (Doleschall, 1857)
42	Corinnidae (Ground runners)	*Castianeira zetes* Simon, 1897
43	,,	*Coenoptychus pulcher* Simon, 1885
44	,,	*Corinnomma severum* (Thorell, 1877)
45	Cheiracanthiidae (Ground runners)	*Cheiracanthium danieli* Tikader, 1975 *
46	,,	*Cheiracanthium melanostomum* (Thorell, 1895)
47	,,	*Cheiracanthium* sp.
48	Dictynidae (Irregular web builders)	*Dictyna* sp.
49	Eresidae (Sheet web builders)	*Stegodyphus sarasinorum* Karsch, 1892
50	Gnaphosidae (Ground runners)	*Drassodes* sp. 1
51	,,	*Drassodes* sp. 2
52	,,	*Poecilochroa* sp.
53	,,	*Scotophaeus* sp.

Table 1: (Continued).

S. No.	Family/ Guild type	Species name
54	Hahniidae (Sheet web builders)	*Hahnia mridulae* Tikader, 1970 *
55	Hersiliidae (Ambushers)	*Hersilia savignyi* Lucas, 1836
56	,,	*Hersilia tibialis* Baehr and Baehr, 1993
57	Idiopidae (Ambushers)	*Idiops* sp.
58	Linyphiidae (Sheet web builders)	*Atypena* sp. 1
59	,,	*Atypena* sp. 2
60	,,	*Neriene* sp.
61	Liocranidae (Ground runners)	*Oedignatha* sp.
62	,,	*Sphingius* sp.
63	Lycosidae (Ground runners)	*Evippa* sp.
64	,,	*Hippasa agelenoides* (Simon, 1884)
65	,,	*Hippasa holmerae* Thorell, 1895
66	,,	*Hippasa madraspatana* Gravely,1924 *
67	,,	*Hippasa* sp. 1
68	,,	*Hippasa* sp. 2
69	,,	*Lycosa* sp.
70	,,	*Lycosa barnesi* Gravely, 1924 *
71	,,	*Lycosa bistriata* Gravely, 1924
72	,,	*Lycosa tista* Tikader, 1970 *
73	,,	*Pardosa pseudoannulata* (Bösenberg and Strand,1906)
74	,,	*Pardosa* sp.
75	,,	*Pardosa sumatrana* (Thorell, 1890)
76	,,	*Trochosa* sp.
77	,,	*Wadicosa fidelis* (O. Pickard-Cambridge, 1872)
78	,,	*Wadicosa* sp.
79	,,	*Wadicosa quadrifera* (Gravely, 1924)
80	Oecobiidae (Ground runners)	*Oecobius* sp.
81	Oonopidae (Ground runners)	*Opopaea indica* (Simon, 1891) *
82	Oxyopidae (Stalkers)	*Hamataliwa* sp.
83	,,	*Oxyopes birmanicus* Thorell, 1887
84	,,	*Oxyopes javanus* Thorell, 1887
85	,,	*Oxyopes* sp. 1
86	,,	*Oxyopes* sp. 2
87	,,	*Oxyopes* sp. 3
88	,,	*Oxyopes shweta* Tikader, 1970
89	,,	*Oxyopes sunandae* Tikader, 1970
90	,,	*Peucetia* sp.
91	,,	*Peucetia viridana* (Stoliczka, 1869)
92	Prodidomidae (Ground runners)	*Zimiris* sp.
93	Pholcidae (Scattered line builders)	*Artema atlanta* Walckenaer, 1837
94	,,	*Crossopriza lyoni* (Blackwall, 1867)
95	,,	*Pholcus phalangioides* (Fuesslin, 1775)
96		*Smeringopus* sp.
97	Philodromidae (Ambushers)	*Psellonus* sp.

Table 1: (Continued).

S. No.	Family/ Guild type	Species name
98	Salticidae (Stalkers)	*Aelurillus* sp.
99	,,	*Afraflacilla* sp.
100	,,	*Carrhotus* sp.
101	,,	*Carrhotus viduus* (C.L. Koch, 1846)
102	,,	*Chrysilla volupe* (Karsch, 1879)
103	,,	*Curubis erratica* Simon, 1902
104	,,	*Cyrba ocellata* (Kroneberg, 1875)
105	,,	*Epocilla aurantiaca* (Simon, 1885)
106	,,	*Hasarius adansoni* (Audouin, 1826)
107	,,	*Hyllus semicupreus* (Simon, 1885)
108	,,	*Hyllus* sp. 1
109	,,	*Hyllus* sp. 2
110	,,	*Langona* sp.
111	,,	*Maripanthus* sp.
112	,,	*Menemerus bivittatus* (Dufour, 1831)
113	,,	*Menemerus fulvus* (L. Koch, 1878)
114	,,	*Myrmarachne melanocephala* MacLeay, 1839
115	,,	*Phintella vittata* (C.L. Koch, 1846)
116	,,	*Plexippus paykulli* (Audouin, 1826)
117	,,	*Plexippus petersi* (Karsch, 1878)
118	,,	*Pseudicius* sp.
119	,,	*Rhene flavigera* (C.L. Koch, 1846)
120	,,	*Stenaelurillus arambagensis* (Biswas and Biswas, 1992) *
121	,,	*Stenaelurillus* sp. 1
122	,,	*Stenaelurillus* sp. 2
123	,,	*Telamonia dimidiata* (Simon, 1899)
124	,,	*Thyene calebi* (Kanesharatnam and Benjamin, 2018)
125	,,	*Thyene imperialis* (Rossi, 1846)
126	,,	Unidentified sp. 1
127	,,	Unidentified sp. 2
128	Scytodidae (Foliage runners)	*Scytodes fusca* Walckenaer, 1837
129	,,	*Scytodes thoracica* (Latreille, 1802)
130	,,	*Scytodes pallida* Doleschall, 1859
131	Selenopidae (Ground runners)	*Selenops* sp.
132	Sicariidae (Sheet web builders)	*Loxosceles rufescens* (Dufour, 1820)
133	Sparassidae (Foliage runners)	*Gnathopalystes flavidus* (Simon, 1897)
134	,,	*Heteropoda bhaikakai* Patel and Patel, 1973 *
135	,,	*Heteropoda leprosa* Simon, 1884
136	,,	*Heteropoda venatoria* (Linnaeus, 1767)
137	,,	*Olios bhavnagarensis* Sethi and Tikader, 1988*
138	,,	*Olios gravelyi* Sethi and Tikader, 1988 *
139	,,	*Olios lamarcki* (Latreille, 1806)
140	,,	*Olios milleti* (Pocock, 1901)
141	,,	*Olios* sp.
142	,,	*Olios wroughtoni* (Simon, 1897) *
143	Tetragnathidae (Orb web builders)	*Leucauge* sp.
144	,,	*Leucauge decorata* (Blackwall, 1864)
145	,,	*Tetragnatha* sp. 1
146	,,	*Tetragnatha* sp. 2
147	,,	*Tetragnatha* sp. 3
148	,,	*Tetragnatha cochinensis* Gravely, 1921 *
149	,,	*Tetragnatha javana (*Thorell, 1890)
150	,,	*Tetragnatha keyserlingi* Simon, 1890
151	,,	*Tetragnatha mandibulata* Walckenaer, 1841
152	,,	*Tylorida striata* (Thorell, 1877)
153	,,	*Tylorida ventralis* (Thorell, 1877)

Table 1: (Continued).

S. No.	Family/ Guild type	Species name
154	Theraphosidae (Ground runners)	*Haploclastus* sp.
155	Theridiidae (Space web builders)	*Achaearanea durgae* Tikader, 1970 *
156	,,	*Argyrodes argentatus* O. Pickard-Cambridge, 1880
157	,,	*Argyrodes flavescens* O. Pickard-Cambridge, 1880
158	,,	*Chrysso angula* (Tikader, 1970) *
159	,,	*Coleosoma floridanum* Banks, 1900
160	,,	*Euryopis episinoides* (Walckenaer, 1847)
161	,,	*Phylloneta impressa* (L. Koch, 1881)
162	,,	*Theridula gonygaster* (Simon, 1873)
163	,,	*Theridion melanostictum* O. Pickard-Cambridge, 1876
164	,,	*Theridion* sp. 1
165	,,	*Theridion* sp. 2
166	,,	*Theridion* sp. 3
167	,,	*Thwaitesia* sp.
168	Thomisidae (Ambushers)	*Amyciaea forticeps* O. Pickard-Cambridge, 1873
169	,,	*Indoxysticus minutus* (Tikader, 1960)
170	,,	*Runcinia insecta* (L. Koch, 1875)
171	,,	*Runcinia roonwali* Tikader, 1965
172	,,	*Thomisus beautifularis* Basu, 1965 *
173	,,	*Thomisus lobosus* Tikader, 1965 *
174	,,	*Thomisus* sp.
175	,,	*Xysticus* sp. 1
176	,,	*Xysticus* sp. 2
177	Uloboridae (Orb web builders)	*Philoponella* sp.
178	,,	*Uloborus* sp. 1
179	,,	*Uloborus* sp. 2
180	,,	*Uloborus krishnae* Tikader, 1970*
181	,,	*Uloborus danolius* Tikader, 1969*
182	Zodariidae (Ground runners)	*Asceua cingulata* (Simon, 1905) *
183	,,	*Mallinella nilgherina* (Simon, 1906) *
184	,,	*Tropizodium poonaense* (Tikader, 1981)*

* = Endemic to India

Table: 2 Alpha diversity indices of spider diversity in different habitat types across Salem, Tamil Nadu.

Alpha diversity indices	Habitat types										
	Grass land	Treescapes	Shrub land	Paddy field	Sugarcane field	Turmeric field	Beans field	Coffee plantation	Bamboo field	Human settlement	Road verge
Number of taxa	7	12	19	17	10	16	8	16	14	7	5
Individuals	2822	2585	3393	1160	375	839	45	512	107	467	128
Simpson_1-D	0.61	0.74	0.85	0.68	0.30	0.88	0.75	0.84	0.81	0.61	0.62
Shannon_H	1.16	1.57	2.10	1.67	0.76	2.35	1.64	2.12	1.98	1.10	1.16
Evenness_e^H/S	0.46	0.40	0.43	0.31	0.21	0.66	0.64	0.52	0.52	0.43	0.63
Margalef	0.76	1.4	2.21	2.27	1.52	2.23	1.84	2.40	2.78	0.98	0.82
Berger-Parker	0.57	0.42	0.23	0.53	0.83	0.19	0.38	0.30	0.3	0.45	0.52

Diversity indices

The diversity values of the eleven different habitats were analyzed using five different indices. The Simpson diversity indices (SDI) of spiders ranged between 0.88 and 0.3 for all the studied habitats. The maximum value was found in the turmeric field (0.88), followed by shrubland (0.85) and coffee plantations (0.84). The highest community complexity of spiders was found in the turmeric field (2.35), followed by coffee plantations (2.12), and shrubland (2.1). The sugarcane field (0.76) showed least community complexity (Table 2). Similar observations were reported by Rendón et al. (2006) on coffee plantations that the spider diversity was higher in the plantations with organic management and lowest in conventional management.

The evenness index reflects the similarity in distribution of all the species. The highest evenness was observed in the turmeric field (0.66), and the lowest was observed in the sugarcane field (0.21). Both were agricultural ecosystems. The Margalef index is a simple measure of species richness much more sensitive to sample size (Raghul et al., 2022; Wale and Yesuf, 2022). This was highest in bamboo fields (2.78), and the lowest was observed in grasslands (0.76). The Berger–Parker index of abundance ranged from 0.19 to 0.83. The highest abundance of spider species was observed in the sugarcane fields (0.83), followed by the grasslands (0.57), and paddy fields (0.53). The lowest was observed in the turmeric fields (0.19) (Table 2). Similar results on the abundance of spiders in the semiarid landscapes of southern India were obtained by Nautiyal et al. (2017). Hughes (1978) concluded in his work that the taxonomic level of identification is one of the most important factors influencing the value of the Shannon–Weiner index.

Guild type diversity

The spider populations were divided into nine guilds based on their web-building and foraging habits (Uetz et al., 1999; Cardoso et al., 2011; Anindita et al., 2017). Ground runners (56.82%) and stalkers (24.77%) were the dominant guild in the grassland. Orb web builders were dominant (47.19%) in treescapes. In shrubland, sheet web builders (22.71%) and stalkers (26.67%) were the dominant guilds. Orb web builders (53.6%) were predominately found in the paddy fields and sheet web builders (78.38%) were the most common guild type in the sugarcane fields. Interestingly, in all the habitats more than one guild types of spiders were observed and this potentially would provide effective control of insect pests (Marc et al., 1999).

In the bean fields, stalkers (69.81%) were the most common guild type. On the coffee plantations, ground runners (32.38%), orb-web builders (32.43%), and stalkers (31.52%) were the predominant guilds. The two most common guilds in human settlement were scattered line builders (47.42%) and stalkers (38.88%). This was very similar to the findings of Dal and Trivedi (2020).

Spider diversity in different habitats

Spider species richness and abundance varied greatly among habitats, with shrublands having the highest diversity with 115 species (21.46%) represented by 3,458 individuals (28.21%), followed by grasslands (22.01%), and treescapes (20.51%), and bean fields having the lowest diversity with 16 species (3%) represented by 53 individuals (0.43%). Only approximately 5% of spiders were from the domestic habitat, while about 70% came from natural ecosystems made up of shrublands, grasslands, and treescapes (Fig. 2).

Archana (2011), and Lawania et al. (2013) reported that the family Araneidae was dominant in the agricultural fields of Rajasthan and are efficient hunters of lepidopteran insect pests. Despite this study, there is very limited research on the insect pests that spiders consume and other important factors such as impact of pesticide exposure on spiders, their adaptation to anthropogenic activities and climate change. Further research focusing on these aspects will aid in the protection of these important natural biological pest control agents and effectively influence organic farming.

Conclusion

In the Salem district of Tamil Nadu, India, 184 spider species from 9 guilds were identified during this investigation, distributed in 11 different types of habitats. Twenty-five of these spider species are endemic to India. About 56% of spiders found in the study area belong to the families Lycosidae, Araneidae, and Eresidae. In the agricultural ecosystem, the presence of more than one guild type of spiders is helpful for the effective control of agricultural pests. The majority (almost 70%) of spiders were recorded in natural ecosystems such as, shrublands, grasslands, and treescapes displaying the presence of diverse ecological niches for different guilds of spiders. In the present scenario of organic farming in India, spiders could serve as one of the potential biological control agents.

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Author contributions

This work was conceptualized by P.T.N. Field works were conducted throughout Salem District, Tamil Nadu, by P.T.N., D.S., P.S.A., and G.V. Field and lab photographs of the spiders were taken by D.S. and G.V. The collected specimens were authenticated using standard manuals by D.S. Data analysis was performed by P.T.N., P.S.A., and D.S. Literature searches and the writing of the manuscript were done by P.T.N. and D.S.

Conflict of interest

All the authors declare that there are no conflicting issues related to this research article.

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Appendix 1: Spider diversity in Salem district of Tamil Nadu.

Plate 1

Amyciaea forticeps

Bijoaraneus mitificus

Argiope anasuja

Nephila pilipes

Cyrtophora cicatrosa

Thelacantha brevispina

Carrhotus viduus

Chrysilla volupe

Hyllus semicupreus

Opopaea indica

Menemerus bivittatus

Plexippus petersi

Telamonia dimidiata

Thyene imperialis

Hippasa madraspatana

Appendix 1: (Continued).

Plate 2

***Xysticus* sp.**

Heteropoda venatoria

Olios lamarcki

Gnathopalystes flavidus

Peucetia viridana

Coleosoma floridanum

Euryopis episinoides

Stegodyphus sarasinorum

Oxyopes shweta

***Atypena* sp.**

Artema atlanta

Gasteracantha geminata

Coenoptychus pulcher

Plexippus paykulli

Hersilia savignyi