Journal of Advanced Zoology

ISSN: 0253-7214

*Volume **44** Issue **02 Year 2023** Page **233:239***

Seasonal Diversity of Spiders (Arachnida: Araneae) and Collection Methods in Barpeta District, Assam, India

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Article History

Received: 06 June 2023
Revised: 25 August 2023
Accepted:11Sept 2023

Abstract

Barpeta district, Assam, India covers an area of 2754 square kilometers. The Spider specimens were collected by visual search method and the collection methods adopted were Aerial hand collection, Ground hand collection and Beat sheet method. 70 spider species from the different habitats of Barpeta District were documented. The study shows the difference in quantity and quality of spider fauna concerning the seasons and collection method. The spider species were more active in the post-monsoon season and some were inactive during winter. Almost 75% of spider species were collected by the beat sheet method which shows that it is more significant than all other trapping techniques. The spider species richness and spider abundance were significantly affected by seasons, studied by Simpson's diversity index and Shannon – Weiner's diversity index. However, further study needs to be carried out for the effective conservation of these species.

Keywords: *Spider, Visual search, Seasons, Collection methods.*

1. Introduction

Spiders included in class Arachnida, order Araneae under Phylum Arthropoda, are an ancient and successful group of invertebrate animals. There are currently 48,132 described spider species placed in 4,073 genera and 113 families in the world (Platnick, 2019) and there are many species yet to be discovered and described. 1686 species belonging to 438 genera and 60 families of spiders have been described in India (Adarsh and Nameer, 2015). Spiders are cosmopolitan and are found in all types of habitats and occupy almost all niches (Turnbull, 1973; Nyfeller and Benz, 1987). They play a significant role in the regulation of insects and other invertebrate populations in most ecosystems (Wise, 1993; Russell-Smith, 1999; Raghavendra, 2001).

Many threats to spider diversity have been documented. The primary threat to spiders may be due to urban development, land use management techniques, air and groundwater pollution by pesticides and fertilizers, etc. For a few species, these threats have pushed them to the threshold of extinction, attracting the attention of conservation professionals. Without the appropriate baseline information on status, distribution and abundance, it is difficult to target proper habitats for protection, develop appropriate management techniques, or consolidate the necessary resources for obtaining legal conservation status for spider diversity.

As spider's species of Assam are poorly documented so the study was carried out to document the spider diversity of Assam, which is a very elaborate work, so the diversity of spiders in Barpeta District has been taken for the study in a manner that can be replicated on other District in Assam in an attempt to assemble a comprehensive spider fauna list for the state. The study will also help to work for the conservation of the species and identify the concealed benefits of them. Efforts can also

be made to rear spiders and they can play a key role in integrated pest management as biological control for pests. The study at the ecosystem level will help to understand the role of spiders in the ecosystem. Spider surveys may provide an effective means for measuring the impact of habitat degradation or changes in land use patterns on biodiversity.

The specific objectives of the study include the collection of spiders from different habitats in selected sites of Barpeta district, Assam, India and their Identification up to species level and to study the seasonal variation of spider abundance in different habitats of Barpeta district, Assam.

2. Materials And Methods

Study area:

Fig 1: Barpeta district.

The study area considered purposively is the Barpeta district, one of the districts of the lower Brahmaputra valley of Assam, which covers an area of 3245 square kilometres. The district lies between latitude 26°5' N to 26°49' N and longitude 90°39'E to 91°17'E and is bounded by the Royal Province of Bhutan (Manas N.P) and Baksa District in North, Kamrup and Goalpara districts in the south, Nalbari district in east and Bongaigaon and Chirang district in the west.

The district is characterised by almost plain topography with the highest elevation of 200 m above mean sea level in the north, while in the south it is below 18 m above mean sea level. The district has small hillocks in the South-West-corner of the district, namely Baghbar, Fulora and Chatala overlooking the scenic and mighty Brahmaputra River. The Soil of the Barpeta District may be classified as Sandy, Sandy-loamy and alluvial soils. The tropical semi-evergreen forest covers the northern part of the district. The riverine forests are mainly found along the banks of big rivers of the district - Manas, Beki etc. Some areas are covered by mixed deciduous forests.

The climate of Barpeta is sub-tropical which remains mild and pleasant around the year. The maximum and minimum temperatures recorded for the district are 35°C and 7°C respectively. The area receives an average rainfall of 1975 mm. The air is highly humid throughout the year (ranges from 60-85%) and during the rainy season, the relative humidity is about 90 percent. The year is divided, as per Barthakur (1986) into four seasons – Monsoon (June to September), Post-monsoon (October to November), Winter (December to February) and Summer (March to May).

Study Period

The study was carried out from December 2021 to November 2022 in all four seasons of the year of the area. As many spiders exhibit diurnal activity patterns (Williams, 1962). Therefore, for sampling spiders, daytime has been considered. The sampling was made between 6 A.M. to 11 A.M. and 1 P.M. to 6 P.M. under suitable weather conditions for spider collection.

Survey plots

For the convenience of the survey of spiders in the Barpeta district of Assam, India, 10 survey plots were randomly selected. From each plot, four habitats were sampled. The four habitats that were

sampled in the district include -1. residential; 2. agricultural; 3. jungle; 4. marshy. Therefore, the total number of sites sampled was 40.

Sampling method:
A visual search sampling method (Robinson et al., 1974; Sebastian et al., 2005) was adopted in this study to sample the spider fauna from quadrates selected at random from selected study sites. The advantage of the visual search sampling method is that spiders remain undisturbed and can be censused repeatedly (Lubin, 1978). Sampling was done from the same selected study sites in all four seasons. A total of 10 hours will be spent in each site for each season, totaling 40 hours of sampling time across the four seasons. The collection was done from four quadrates (1m x 1m) placed in the respective corners of a 10m x 10m area and the area will be searched for webs and all the vegetation will be thoroughly examined from bottom to top.

Collection methods
For a diversity survey, it is convenient to sample the spider fauna at different layers of each habitat separately (Russell- Smith, 1999). The collection methods (Coddington et al., 1991; Toti et al., 2000) adopted to carry out the sampling that targets the specific strata were Aerial hand collection, Ground hand collection and Beat sheet method.

1) Aerial hand collection i.e., collecting spiders found above knee level for that a sweep net was used to capture spiders seen high in the vegetation.
2) Ground hand collection i.e., collecting spiders found below knee level in the vegetation or leaf litter.
3) The beat-sheet method of collection is performed by stretching out a light-colored cloth under the tree branch or other low vegetation and grabbing the branch and shaking it vigorously. Spiders resting or nesting in this vegetation fall onto the cloth.

Preservation technique:
The spiders collected from each site were preserved in 70% ethyl alcohol. The specimens were photographed with the digital camera either in the field or as soon as they are brought to the laboratory and stored in a dark dry place.

Identification
Specimens were identified using primary taxonomic literature. The list was prepared with the help of an updated checklist.

Data analysis
Statistical data analysis was done to calculate the species richness and species diversity. To fulfil this purpose Simpson's diversity index and Shannon – Weiner's diversity index (Shannon and Wiener, 1949) methods were used.

Simpson's diversity index, $D = \frac{\sum n(n-1)}{N(N-1)}$

Where, n= Total number of organisms of a particular species.
N= The total number of organisms of all species.

Shannon–Weiner index, $H = -\sum_{i=0}^{n}[(\frac{ni}{N})\log(\frac{ni}{N})]$ or H = -Σ pi ln pi

Where i = Number of individuals belonging to the i^{th} species.
N= Total number of individuals in the sample.
pi = proportion of total sample represented by species i (To divide no. of individuals of species i by total number of samples) = ni/N

3. Results and Discussion

After one year of collections (December 2021 to November 2022), 70 species belonging to 43 genera of 15 families were collected. The list was prepared alphabetically (Table 1).

Table 1: Checklist of spiders collected from Barpeta District, Assam.

Sl no.		Species	Author
FAMILY	Araneidae Simon ,1895		
1		*Araneus inustus*	L Koch,1871

2		*Araneus mitificus*	Simon, 1886
3		*Argiope aemula*	Walckenaer, 1842
4		*Argiope anasuja*	Thorell, 1887
5		*Argiope catenulata*	Doleschall, 1859
6		*Argiope pulchella*	Thorell, 1881
7		*Cyclosa bifida*	Doleschall, 1859
8		*Cyclosa confraga*	Thorell 1892
9		*Cyclosa hexatuberculata*	Tikader, 1982
10		*Cyclosa spirifera*	Simon, 1889
11		*Cyrtophora cicatrosa*	Stoliczka, 1869
12		*Cyrtophora moluccensis*	Doleschall, 1857
13		*Gasteracantha hasselti*	C L Koch 1837
14		*Gasteracantha kuhli*	C L Koch 1837
15		*Neoscona mukerjei*	Tikader, 1980
16		*Neoscona odites*	Simon, 1906
17		*Parawixia dehaani*	Doleschall, 1859
FAMILY	Hersiliidae Thorell, 1870		
1		*Hersilia savignyi*	Lucas, 1836
FAMILY	Linyphiidae Blackwall, 1859		
1		*Linyphia striata*	Sp. nov.
FAMILY	Lycosidae Sundevall,1833		
1		*Lycosa mackenziei*	Gravely ,1924
2		*Lycosa tista*	Tikader,1970
3		*Pardosa birmanica*	Simon,1884
4		*Pardosa pseudoannulata*	Bosenberg and Strand,1906
5		*Pardosa sumatrana*	Thorell 1890
FAMILY	Nephilidae Simon,1894		
1		*Herennia multipuncta*	Doleschall, 1859
2		*Nephila kuhlii*	Doleschall, 1859
3		*Nephila pilipes*	Fabricius, 1793
FAMILY	Oxyopidae Thorell,1870		
1		*Oxyopes birmanicus*	Thorell,1887
2		*Oxyopes javanas*	Thorell,1887
3		*Oxyopes lineatus*	Latreille,1806
4		*Oxyopes shweta*	Tikader,1970
5		*Oxyopes sunandae*	Tikader,1970
FAMILY	Philodromidae Thorell,1870		
1		*Tibellus elongatus*	Tikader,1960
FAMILY	Pholcidae C L Koch,1851		
1		*Artema atlanta*	Walckenaer,1837
2		*Crossopriza lyoni*	Blackwall,1867
3		*Pholcus phalangioides*	Fuesslin,1775
4		*Smeringopus pallidus*	Blackwall,1858
5		*Uthina atrigularis*	Simon, 1901
FAMILY	Pisauridae Simon,1890		
1		*Perenethis venusta*	Koch 1878
2		*Polyboea vulpina*	Thorell 1895
3		*Thalassius albocinctus*	Doleschall,1859
FAMILY	Salticidae Blackwall, 1841		
1		*Asemonea tenuipes*	O P Cambridge, 1869
2		*Carrhotus viduus*	Koch 1846
3		*Epeus tener*	Simon,1877
4		*Hasarius adansoni*	Audouin,1826
5		*Hyllus semicupreus*	Simon, 1885
6		*Menemerus bivittatus*	Dufour, 1831
7		*Phidippus yashodharae*	Tikader,1977
8		*Plexippus paykulli*	Audouin 1826
9		*Plexippus petersi*	Karsch,1878

10		*Telamonia dimidiate*	Simon,1899
FAMILY	Sparassidae Bertkau 1872		
1		*Heteropoda leprosa*	Simon 1884
2		*Heteropoda nilgirina*	Pocock,1901
3		*Heteropoda venatoria*	Linnaeus,1767
4		*Olios millet*	Pocock,1901
FAMILY	Tetragnathidae Menge,1866		
1		*Leucauge decorate*	Blackwall,1864
2		*Leucauge tessellate*	Thorell,1887
3		*Tetragnatha andamanensis*	Tikader,1977
4		*Tetragnatha javana*	Thorell,1890
5		*Tetragnatha mandibulata*	Walckenaer,1842
FAMILY	Theridiidae Sundevall,1833		
1		*Argyrodes andamanensis*	Tikader,1977
2		*Argyrodes argentatus*	OP Cambridge 1880
3		*Argyrodes flavescens*	OP Cambridge 1880
4		*Argyrodes gazedes*	Tikader,1970
5		*Chrysso angula*	Tikader,1970
6		*Theridion manjithar*	Tikader,1970
FAMILY	Thomisidae Sundevall,1833		
1		*Camaricus formosus*	Thorell,1887
2		*Misumena chrysanthemi*	Sp.nov.
3		*Thomisus lobosus*	Tikader,196
FAMILY	Uloboridae Thorell,1869F		
1		*Uloborus danolius*	Tikader,1969

Genera like *Araneus, Argiope, Cyclosa, Cyrtophora ,Gasteracantha, Neoscona, Parawixia* (Fam: Araneidae); *Hersilia* (Fam: Hersiliidae); *Linyphia* (Fam: Linyphiidae*); Lycosa, Pardosa* (Fam: Lycosidae); *Herennia, Nephila* (Fam: Nephilidae); *Oxyopes* (Fam: Oxyopidae);*Tibellus* (Fam: Philodromidae); *Artema , Pholcus, Smeringopus, Uthina, Crossopriza* (Fam: Pholcidae); *Perenethis, Thalassius, Polyboea* (Fam: Pisauridae); *Asemonea, Carrhotus, Epeus, Hasarius, Hyllus , Menemerus, Phidippus, Plexippus, Telamonia* (Fam: Salticidae); *Olios, Heteropoda* (Fam: Sparassidae); *Tetragnatha, Leucauge* (Fam: Tetragnathidae); *Argyrodes, Chrysso, Theridion,* (Fam: Theridiidae); *Camaricus, Misumena* (Fam: Thomicidae); *Uloborus* (Fam: Uloboridae) were recorded in the area. Families consisting of hunting and wandering spiders like Salticidae (10 spp.), Lycosidae (5 spp.), Oxyopidae (5 spp.), Sparassidae (4 spp.), Pisauridae (3 spp.), Thomisidae (3 spp.), Philodromidae (1 spp.) and Hersilidae (1 spp.) represent 44 % of the total spider fauna. Web-building families like Araneidae (17 spp.), Theridiidae (6 spp.), Tetragnathidae (5 spp.), Pholcidae (5 spp.), Nephilidae (3 spp.), Linyphiidae (1 spp.) and Uloboridae (1 spp.) contribute 56 % of total spider fauna found of the area.

The percentage distribution of spider species concerning four collecting seasons in periodicity of occurrence shows that the percentage abundance of spider species in the post-monsoon season is 98.6% which is the highest, followed by the summer season is 92.8%. The abundance of spider species is incredibly less i.e., 32.8% in the winter season (Table 2). This result reveals that spiders are inactive throughout the winter season but very active in post-monsoon, as mentioned by Kato et al. (1995) that climatic changes through seasons would influence the abundance of spiders. Chetia and Kalita (2012) reported that the majority of the vital factors are the availability of food (small insects) and environmental changes that play a major role in the distribution of spiders in different geographic sites. They reported many spider species from warmer regions as compared to cold regions. It may be a result of the different seasonal preferences of different spider species.

Table 2: Percentage distribution of spider species with collecting seasons in periodicity of occurrence.

Sl. No.	Collecting Seasons	No. of families	% of family	No. of species	% of species	No. of Observed individuals	% of individuals
1	Monsoon	10	66.7	27	38.5	250	19.6
2	Post-Monsoon	15	100	69	98.6	537	42.1

3	Winter	9	60	23	32.8	167	13.08
4	Summer	13	86.7	65	92.8	322	25.23
TOTAL		-	-	-	-	1276	100

The study of spider fauna with three collection methods shows that about 75.71% of total species were collected by the beating method. The number of individuals was collected more by Beating than by aerial or ground methods. It may be for their abundance in the vegetation of jungle areas. (Table 3).

Table 3: Study of spider fauna in relation to collection methods.

Collecting Methods	No. of sample units	No. of adults	% of total adults	No. of species	% of total species
Aerial	40	383	30.02	47	67.14
Ground	40	319	25	42	60
Beating	40	574	44.98	53	75.71
Total	40	1276	100	70	-

Species diversity of spider in different seasons were examined using the diversity indices including, Simpson's index and Shannon – Weiner index. The Shannon-wiener index value increases with biodiversity. In contrast, the Simpson index measures the relative abundance of species, with a higher value indicating high dominance/low biodiversity.

The Shannon-Weiner index for the sampled site in post-monsoon, summer, monsoon and winter seasons are 1.83718, 0.43196, 0.16804 and 0.01331 respectively. The Shannon index increases as both the richness and the evenness of the community increase. The Shannon index, H, increases with increasing numbers of species. So, the Shannon-Weiner index is more in the post-monsoon season and less in the winter season. It can be interpreted that the number of species is more in the post-monsoon season, whereas it is relatively decreasing in summer, monsoon and winter. The Shannon Weiner index for the winter season is significant ($p < 0.05$), but insignificant for all other seasons ($p > 0.1$).

The Simpson's dominance index for the sampled site in post-monsoon, summer, monsoon and winter seasons are 0.01297, 0.01778, 0.01449 and 0.01573 respectively. The Simpson's index, D is a measure of dominance, so as D increases, diversity (in the sense of evenness) decreases. The Simpson's dominance index shows that the value of D is higher in summer, followed by winter and monsoon, and less in the post-monsoon season. So, it can be interpreted that the diversity of spider is more in post-monsoon season, but the relative abundance of spiders is almost the same. Thus, the Simpson's index is significant ($p < 0.05$) in the study of spiders in different seasons in the sample sites.

Mukherjee et al. (2010) indicated that late spring had higher numbers of spiders than early summer and autumn. He indicated that the populations of spiders showed stable numbers throughout summer and a smaller increase in the autumn as a general trend. On the contrary of that, Hussein (1999) found that the highest diversity (9 species) was recorded in summer, while the lowest values, 3 species, were registered in winter. Deshmukh and Raut (2014) reported the Shannon index and Simpson index as 1.06 and 0.103 respectively in Salbardi forest (Satpura range) Maharastra.

The difference in quantity and quality of spider fauna is related to the time of the collection and method of sampling. There are many environmental factors like seasonality, spatial heterogeneity, competition, predation, habitat type, environmental stability and productivity that can affect species diversity (Riechert, Bishop 1990). We found overall significant differences in the diversity, evenness and richness between the seasons. The results indicate that all the seasons show different species composition. It might be expected that climatic changes through seasons would influence the abundance of spiders (Kato et al. 1995). Studies by Russell-Smith (2002) established the importance of rainfall in regional spider diversity. In general, different species have varying humidity and temperature preferences and are limited to those seasons which offer a microclimate within the range of their physiological tolerances. So, the difference in species diversity between the seasons is likely to be due to the difference in the amount of rainfall and temperature in the seasons. The difference in

the seasonal abundance of spiders may be due to the variation in patterns of activity of individual spiders and the phenology of the total spider community (Corey et al. 1998).

4. Conclusion

The present study brings out only a portion of the diversity of the spider wealth that remains concealed in the landscape of Assam (Barpeta district). The further prospective study will indeed raise the number of spider species exponentially. There is a need to realize the importance of our biological wealth and continue the research and document them. Governments and our Forest Departments must take constructive steps to protect and conserve smaller animals like spiders along with larger animals. As an inhabitant of the Barpeta district, the study is done in the area of Barpeta district, but it is the representation of the state of Assam and further research is needed to be planned in the other district of Assam.

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