



Species diversity, abundance and habitat association of spiders with relation to their guild composition in different habitats of North Bengal Wild Animals Park (Bengal Safari)

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ABSTRACT

A field study was carried out to determine the spider population and diversity according to seasonal variation in the North Bengal Wild Animals Park, Bengal Safari. Seasonal sampling was conducted. The study was carried out using belt transects, vegetation beating, pitfall traps and leaf litter extraction. Consecutive survey for three seasons revealed occurrence of 38 species belonging to 16 families. Of these Salticids were predominant (31%) and Araneidae contributed 10% of the spider species. Shannon index, Simpson index and Evenness index were evaluated. Spiders belonging to different feeding guild and population were higher during summer season in comparison to other seasons. The study suggests influence of seasonal variations on occurrence and diversity of spiders in the study area.

Key Words: Bengal Safari, survey, spider species, seasonal variation, spider assemblages

INTRODUCTION

The greenness of the Darjeeling district of West Bengal is bestowed with great diversity of fauna owing to the existence of varied forest types and endemic vegetation existing here. The district comprises of several protected areas which serve a significant role in biodiversity conservation thereby demonstrating the human interaction with the natural world. The district is symbolized by its geological tracts comprising mainly alluvial and bhabhar formations. Ecologically suitable forest areas of the state over time have been declared as National Parks, Wild Life Sanctuaries and Reserves. With the aim of providing rewarding experience and promoting conservation of faunal resources, North Bengal Wild Animals Park has been established keeping in view of Central Zoo Authority's norms. Bengal Safari covers a small patch of Baikunthapur Forest Division amidst Sal dominated deciduous vegetation of Terai and Duars showcasing the wild beauty of Himalayan hotspot. It is a safari park which provides a glimpse of wild animals and

birds in the North Bengal plains to the public and to promote conservation of valuable faunal resources through display, preservation, exchange and rehabilitation in the wild.

Study area

The total study area of the North Bengal Wild Animals Park (Bengal Safari) is 297.00 Ha (Fig-1). This area lies between 26°47'23" N to 26° 48'39" N Latitude and 88°25'56" E to 88°27'08" E longitude. Elevation ranges between 140 to 167 m. The study area is situated in the cradle of Mahananda Wild Life Sanctuary and on the Mahananda river valley up to the elevation of 167 m with mixed and deciduous forest cover on the steep northern side, sloping down to gentle, dominated by *Shorea robusta* and grassy alluvial plains which helps in existence of a large variety of flora and fauna. The soil cover is sandy loam and the water table is about 15-25m. The annual average rainfall ranges from 2600mm to 4000mm. Bengal Safari is further subdivided into distinct zones namely- Herbivore safari (91.00 Ha), Tiger Safari Zone (20.00Ha), Leopard Safari Zone (20.00 Ha), Black Bear Safari Zone (20.00 Ha) and other enclosures comprising Gharial Pond(00.32 Ha), Crocodile Pond (00.40 Ha), Aviaries (2.00 Ha) and Trails (2.00 Ha). The study on the faunal diversity and composition of spiders was conducted in the above mentioned regions within Bengal Safari comprising various habitats.

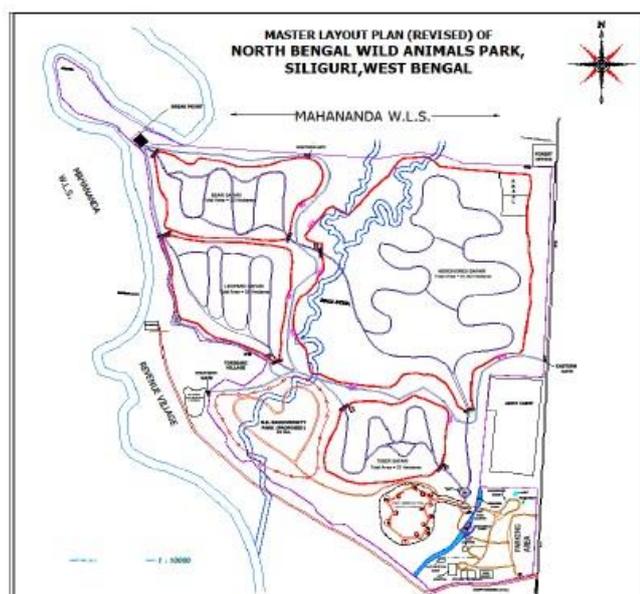


Fig-1: Layout plan of the North Bengal Wild Animals Park (Bengal Safari)

MATERIALS AND METHODS

The sampling of spiders had been done by using various methods like insects, such as direct searches, pitfall traps, vegetation beating, litter shifting, sweep net (Churchill and Arthur, 1999). The applied methods of sampling were belt transects, vegetation beating, pitfall traps and leaf litter extraction. The belt transects were of 10m length and 2m width with sampling restricted to the maximum height of 1m for 30 min at each site. Vegetation beating method was employed to collect spiders living in the shrub, high herb vegetation, bushes and small trees and branches (Coddington *et al.* 1991; Coddington and Levi 1991). Spiders were collected by beating the vegetation with a stick and collecting the samples on a cloth (1m²). The spiders were preserved in different vials filled with ethyl alcohol (70%) and marked with the sample number and also mounted by adhesive on cards in dry condition. Identification of spiders was done on the basis of morphological characteristics, including eye arrangement, cephalothorax, legs and abdominal pattern. All specimens were identified using the taxonomic keys for Indian spiders given by Tikader (1987, 1982 and 1980), Platnick (2016). For taxonomic, habitat and habitat classification Patel (2003), Biswas and Biswas (1992), Siliwal *et al* (2005), Sabbastian and Peter (2009), Pocock (1899), Subramanian (1955) and Balfour and Rypstra (1998) were followed.

RESULTS

The present study in Bengal Safari represents 16 families with 32 genera and 39 species arranged on their foraging behaviour in the field (Table-1). The distribution of some families was found to be continuous (Araenidae, Salticidae, Tetragnathidae), while some had very discontinuous distribution (Fig-3). Family Salticidae (12 species) occupy maximum number of species being the most dominant family with 31% of total species (Fig-3), whereas Araneidae (4 species), Lycosidae (4 species) holds about 10% of the species, Oxyptidae (2 species), Thomisidae (2 species), Pisauridae (2 species), Therididae (2 species), Nephilidae (1 species), Sparassidae (2 species), Pholcidae (2 Species), Uloboridae (1 species) with Hersilidae (1 species), Tetragnathidae (2species), Selenopidae (1 species) and Scytodidae (1 species), Ctenidae (1 species), counts with only few species during the study (Table-1).

Table 1: Checklist of spider species surveyed in North Bengal Wild Animals Park (Bengal Safari)

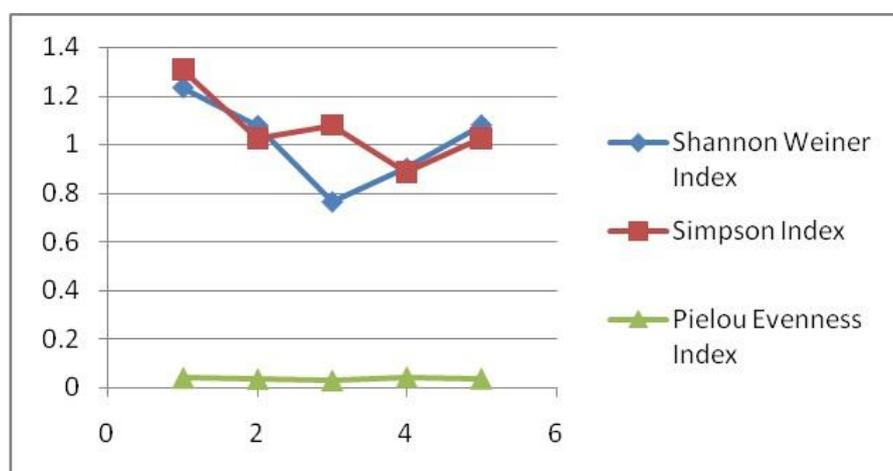
Sl. No.	Scientific Name	Family	Order
1	<i>Argiopes pulchella</i> (Thorell,1881)	Araneidae	Araneae
2	<i>Gasteracantha hasselti</i> (Koch,1837)	Araneidae	Araneae
3	<i>Gasteracantha fornicata</i> (Fabricius, 1775)	Araneidae	Araneae
4	<i>Gasteracantha kuhlii</i> (Koch,1837)	Araneidae	Araneae
5	<i>Neoscona</i> sp	Araneidae	Araneae
6	<i>Ctenus</i> sp	Ctenidae	Araneae
7	<i>Hersilia</i> sp	Hersiliidae	Araneae
8	<i>Evippa</i> sp	Lycosidae	Araneae
9	<i>Lycosa mackenziei</i> (Gravely, 1924)	Lycosidae	Araneae
10	<i>Lycosa</i> sp	Lycosidae	Araneae
11	<i>Hippasa pisaurina</i> (Pocock,1900)	Lycosidae	Araneae
12	<i>Nephila maculata</i> (Fabricius, 1793)	Nephilidae	Araneae
13	<i>Oxyopes javanus</i> (Tord Tamerlan Teodor Thorell, 1887)	Oxyopidae	Araneae
14	<i>Oxyopes birmanicus</i> (Thorell, 1887)	Oxyopidae	Araneae
15	<i>Crossopriza</i> sp	Pholcidae	Araneae
16	<i>Pholcus</i> sp	Pholcidae	Araneae
17	<i>Dolomedus tenebrosus</i> (Hentz, 1844)	Pisauridae	Araneae
18	<i>Perenethis unifasciata</i> (Chrysanthus, 1967)	Pisauridae	Araneae
19	<i>Asemonea tenuipes</i> (Pickard & Cambridge, 1869)	Salticidae	Araneae
20	<i>Siler semiglaucus</i> (Simon, 1901)	Salticidae	Araneae
21	<i>Carrhotus viduus</i> (Koch, 1846)	Salticidae	Araneae
22	<i>Hyllus</i> sp	Salticidae	Araneae
23	<i>Menemerus bivittatus</i> (Dufour, 1831)	Salticidae	Araneae
24	<i>Myrmarachne plateloides</i> (Pickard-Cambridge, 1869)	Salticidae	Araneae
25	<i>Phintella</i> sp	Salticidae	Araneae
26	<i>Phintella vittata</i> (C. L. Koch, 1846)	Salticidae	Araneae
27	<i>Plexippus paykulli</i> (Audouin1826)	Salticidae	Araneae
28	<i>Telomonina dimidiata</i> (Simom, 1899)	Salticidae	Araneae
29	<i>Selenops radiates</i> (Latrielle,1819)	Selenopidae	Araneae
30	<i>Syctodes</i> sp	Syctodidae	Araneae
31	<i>Heteropoda venatoria</i> (Linnaeus, 1767)	Sparassidae	Araneae
32	<i>Olios</i> sp	Sparassidae	Araneae
33	<i>Leucauge decorata</i> (Walckenaer, 1841)	Tetragnathidae	Araneae
34	<i>Leucauge</i> sp	Tetragnathidae	Araneae
35	<i>Latrodectus geometricus</i> (Koch, 1841)	Theridiidae	Araneae
36	<i>Theridula</i> sp	Theridiidae	Araneae
37	<i>Uloborus</i> sp	Uloboridae	Araneae
38	<i>Thomisus spectabilis</i> (Doleschall, 1859)	Thomisidae	Araneae
39	<i>Misumena decorate</i> (Tikader, 1980)	Thomisidae	Araneae

Table-2. Total number of families, genera, species and functional guilds of spiders surveyed in North Bengal Wild Animals Park (Bengal Safari)

Family	No of genus	No of Species	Feeding Guild
Araneidae	3	5	Orb Weaver
Ctenidae	1	1	Ground Runner
Hersilidae	1	1	Ambusher
Lycosidae	3	4	Ground Runner
Nephilidae	1	1	Orb weavers
Oxyopidae	1	2	Stalkers
Pholcidae	1	1	Scattered line weaver
Pisauridae	1	1	Ambushers
Salticidae	9	10	Foliage Runner
Selenopidae	1	1	Ground runner
Syctodidae	1	1	Ground runner
Sparassidae	2	2	Foliage runners
Tetragnathidae	1	2	Orb web builders
Theridiidae	2	2	Space Web builders
Uloboridae	1	1	Orb Weavers
Thomisidae	2	2	Ambusher

Table-3: Diversity indices of spider composition for different habitat transects at North Bengal Wild Animals Park (Bengal Safari)

INDEX	Site I	Site II	Site III	SiteIV	Site V
Shannon Weiner Index	1.232	1.077	0.766	0.903	1.079
Simpson Index	1.311	1.027	1.081	0.887	1.027
Pielou Evenness Index	0.038	0.033	0.027	0.041	0.035

**Fig-2: Comparative studies of Diversity indices and evenness index**

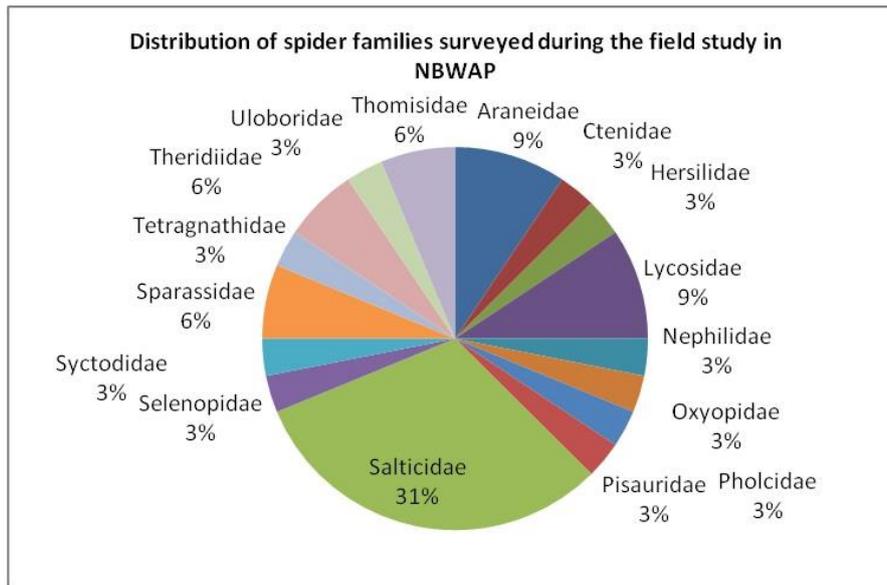


Fig-3: Distribution of spider families surveyed during the field study

The spiders were grouped into seven feeding guilds based on the foraging behaviour (Uetz *et al.* 1999) the orb weavers, stalkers, ground runners, foliage runners, sheet web builders, space web builders and ambushers. The dominant guild was of the ground runners with 26 species and is followed by orb weavers (23 species) some of these were also ground runners, stalkers (14 species), ambushers (13 species), space web builders (12 species), foliage runners (12 species) and sheet web builders (3 species) (Table-2). Most of the species shared feeding guilds depending on the vegetation cover. Most of the species were found in the winter season in comparison to those found in monsoon, summer.

Family Salticidae was counted as the dominant family for most of the months because it feeds on nymphs, larvae and insects whatever available throughout the year. Species of genus such as *Oxyopes*, *Leucage*, *Lycosa*, *Cyclosa*, *Argiope* were frequent in numbers owing to the thick herbaceous cover of the park. Spiders of family Thomisidae were mostly observed on the flowering plants, preying on the insects that accumulate on nectar containing flowers.

DISCUSSION

Spiders play a pivotal role in the functioning of ecosystem as well as in maintaining the insect density equilibrium within an area. It was found that areas with high productivity and higher number of producers exhibited high density of spiders (Oxford and Gillespie

1998). Some of the species of the family Salticidae, Thomisidae, Hersilidae, Pholcidae were abundantly distributed annually. Plant species richness and diversity appear to be a very important influencing factor for both ground-dwelling and grass-dwelling spider assemblages, vegetation is their main substrate for web building and a richly structured vegetation often ensures that a greater range of sizes and types of webs can be built (Uetz 1991).

The vegetation of this region comprises of mixed deciduous forest comprising trees such as *Shorea robusta*, *Lagerstroemia hirsuta*, *Lagerstroemia parviflora*, *Schima wallichii*, *Alstonia scholaris*. Shrubby vegetation comprises *Chromolaena odorata*, *Clerodendrum infortunatum*, *Coffea bengalensis*, *Catunaregam spinosa*, *Abrus pulchellus*, *Croton caudatus*, *Caesalpinia cucullata*, Herbaceous layer comprises *Ageratum houstonianum*, *Ageratum conyzoides*, *Oplismenus burmannii*, *Axonopus compressus*, *Leucas indica* etc. The density and occurrence of spiders was proportional to the daytime temperature of the study area. It was observed that the density of forest floor was richer during the summer season due to presence of humid weather and higher prey base. The occurrence of spiders during initial onset of monsoon was abundant due to the growth of new plants, thick herb cover. The depth of the litter on the forest floor significantly affected the density of spiders as litter cover depth ranged from 0.5 – 5.95 cm during the months of November-March, higher density of spiders were observed in forest floor having higher depth in the litter cover.



PHOTOPLATE 1: Spiders recorded in different habitats of Bengal Safari (NBWAP)

1) *Plexippus paykulli*; 2) *Gasteracantha hasselti*; 3) *Syctodes* sp; 4) *Oxyopes javanus*; 5) *Evippa* sp; 6) *Lycosa*; 7) *Phintella* sp; 8) *Siler semiglaucus*; 9) *Phintella* sp; 10) *Gasteracantha kuhlii*; 11) *Pisaura* sp; 12) *Leucage decorate*; 13) *Argiope pulchella*; 14) *Pholcus* sp; 15) *Gasteracantha fornicate*; 16) *Lycosa* sp; 17) *Telemonia dimidata*; 18) *Oxyopes biramnicus*; 19) *Hersilia* sp; 20) *Nephila pilipes*; 21) *Asomonea tenuips*; 22) *Menemerus bivittatus*; 23) *Phintella vittata*; 24) *Thomisus* sp; 25) *Heteropoda venatoria*; 26) *Crossopriza* sp; 27) *Hyllus* sp; 28) *Misumena decorate*; 29) *Carrhotus viduus*; 30) *Perenethis* sp; 31) *Leucage* sp; ; 32) *Thomisus spectabilis*; 34) *Myrmarachne plateloides*

Thus changes in the spider composition and abundance are proportional to the seasonal environmental changes. Availability of several microhabitats amidst the dense forest cover results in higher diversity of spider species assemblage and composition in the study area as it serves as a cover for escape from predators and prey availability is fulfilled. Other favourable factors are availability of heterogeneous niches, optimal forest litter, minimal anthropogenic disturbance in biodiversity rich zones, genetic variations and balanced prey-predator dynamics within the study area. Thus further investigation of environmental changes and microhabitat availability would bring substantial outcomes regarding spider diversity and abundance in this region.

The species richness in five sampling sites of the study area showed considerable variation and higher richness as recorded during the three seasons (Fig-2). The species diversity index of different sampling sites was ranged from 0.766 to 1.232 (Table-2). In this study maximum diversity index was recorded higher in Site I ($\bar{H}=1.232$) within the herbivore safari as compared with Site II ($\bar{H}=1.077$) within the Bear & Leopard Safari area, Site III ($\bar{H}=0.766$) within the Park playground Area, Site IV ($\bar{H}=0.903$) Tiger Safari area, Site V ($\bar{H}=1.079$) alongside the aviary trails. This is confirmed by Simpson's index of species diversity and abundance (SI=1.311, SII= 1.027 and SIII= 1.081, SIV=0.887, SV=1.027) (Table-3). The evenness index of three sampling stations (SI=0.038, SII= 0.033, SIII = 0.027, SIV =0.041 and SV=0.035) indicates uneven distribution of spider fauna in this study area (Table-3). Shannon-Weiner and Simpson's index indicated that Herbivore Area with thick vegetation cover comprising dominant deciduous trees, herb layer and dense forest floor is richest and more diversified. This may be due to the higher availability of suitable microhabitats, thick canopies, presence of higher organic load and high prey base, less anthropogenic disturbances.

CONCLUSION

The above mentioned field survey suggests that diversity in vegetation structure is proportional to the occurrence of spider species as it provides several types of niches for spiders to carry out biological as well as ecological activities. Overall, our results indicated that occurrence of uneven spider species composition is due to the different vegetation layers within the study sites

such as forest floor comprised more species as compared to herbaceous layer. Hence it can be concluded that forest floor vegetation cover in the habitat is significant as different vegetation patches can provide habitat for very different spider assemblages and thus contribute to the overall spider diversity.

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Competing interests

Authors have declared that no competing interests exist.

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