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Biodiversity and Community structure of spiders in Saran, part of Indo-Gangetic Plain, India

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ABSTRACT

Present study was conducted to reveals the community structure and diversity of spider species in different habitat types (gardens, crop fields and houses) of Saran; a part of Indo – Gangetic Plain, India. This area has very rich diversity of flora and fauna due to its climatic conditions, high soil fertility and plenty of water availability. The spiders were sampled using two semi-quantitative methods and pitfall traps. A total of 1400 individual adult spiders belonging to 50 species, 29 genera and 15 families were recorded during 1st December 2013 to 28th February 2014. Spider species of houses were distinctive from other habitats it showed low spider species richness. The dominant spider families were also differs with habitat types. Araneidae, Pholcidae and Salticidae were the dominant spider families in gardens, houses and crop fields respectively. Comparison of beta diversity showed higher dissimilarity in spider communities of gardens and houses and higher similarity between spider communities of crop fields and gardens. We find that spiders are likely to be more abundant and species rich in gardens than in other habitat types. Habitat structural component had great impact on spider species richness and abundance in studied habitats.

Key words: Spiders, Indo-Gangetic Plain, Diversity, Species richness, Saran.

INTRODUCTION

Spiders belong to order Araneae, which is one of the grasping animal groups (Riechert & Lockely, 1984). Spiders can survive in most environments and are polyphagous; therefore, they have great diversity. They vary in size and colors. Spiders are grasping, carnivorous invertebrates that feed on a variety of prey, which makes them universal. They mostly feed on insects and other arthropods, for example collembolans, dipterans, homopterans and also other spiders. Spiders are abundant and their continued impact on the natural food chain can have numerous effects on insect densities (Foelix, 1996). They belong to one of the important predatory arthropods and are remarkable indicators of habitat disturbances and modifications (Moorhead & Philpott, 2013). Different spiders apply different strategies in order to catch their prey. Some spiders construct webs which play role in capturing the prey. While some spiders grasp prey by hunting, either by running and jumping on the prey or by letting the prey come to them. Spiders also act as a biological indicator for the estimation of biodiversity, management and environmental change in most terrestrial ecosystems because they are diverse, abundant and important in ecological processes and exhibit various life histories (Clausen, 1986; Churchill, 1997; Marc *et al*., 1999; Perner & Malt, 2003). Studies have shown that a hectare of tropical forest may have 300 to 800 species of spiders (Coddington & Levi, 1991). In particular, spiders can be used for management and conservation decisions in agricultural landscapes seeing as they are plentiful with a large number of species, good predictors of overall invertebrate biodiversity and available in most habitat types (Uetz, 1991; Duelli & Obrist, 1998; Willett, 2001). On the other hand, compared with insects, comparatively fewer studies were carried on dealing with the structure and development of spider communities in agro- ecosystems (Jung *et al*., 2008). Spiders are an important component of the generalist predator fauna in fields and have been intended to contribute to the biological control of pests such as aphids and leafhoppers. Studies have made known that spiders are very sensitive to any changes in the habitat structure; including habitat complexity, litter depth and microclimate characteristics (Downie *et al*., 1999; New, 1999).

Surrounded by Ganga, Gandak and Ghaghara rivers Saran region is one of the oldest populations of India. It is a part of Indo Gangetic plain. Due to the high fertility of soil for farming the plain's population density is very high. Being a part of Indo Gangetic plain this region has very rich floral and faunal diversity. Including other flora and fauna spiders are also very diverse group of organisms existing in this region. At present this region is experiencing high rate of urbanization, so it is very important to improve the knowledge on

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biodiversity of this region in order to develop proper conservation and management strategies. As spiders act as a biological controlling agent of pests and whole Indo Gangetic plains are agriculture based region, exploration and conservation of spider diversity is very necessary. However spiders study in Indo –Gangetic Plain region always remained neglected.

Our study focussed on spider species composition and spider density (a measure of abundance within a habitat) of three different habitat types in Saran division. There is no any research work related to spider has been done in this part of Indo Gangetic plain and it is completely untouched and unexplored region. In particular, we examined spider communities collected from houses, crop fields and gardens across a period of three months. Data was collected by beating method, pitfall traps and visual searching.

A few modest literatures are available about spiders of India. Some studies on taxonomy and ecology of spiders from south India and other areas of India provided the importance of these little creatures (Tikader, 1980; Tikader, 1982; Tikader, 1987; Upamanyu & Uniyal, 2008; Sebastin & Peter, 2009; Siliwal *et al*., 2005; Patil & Raghvendra, 2003; Kapoor, 2008). There is no specific study has been done on spider faunal diversity of the Indo Gangetic Plain region of India. Therefore, the objectives of the present study were two folds, first, to explore spider diversity of Saran region and second, to estimate the components of spider diversity (alpha and beta) in different habitats (gardens, houses and crop fields) of this region.

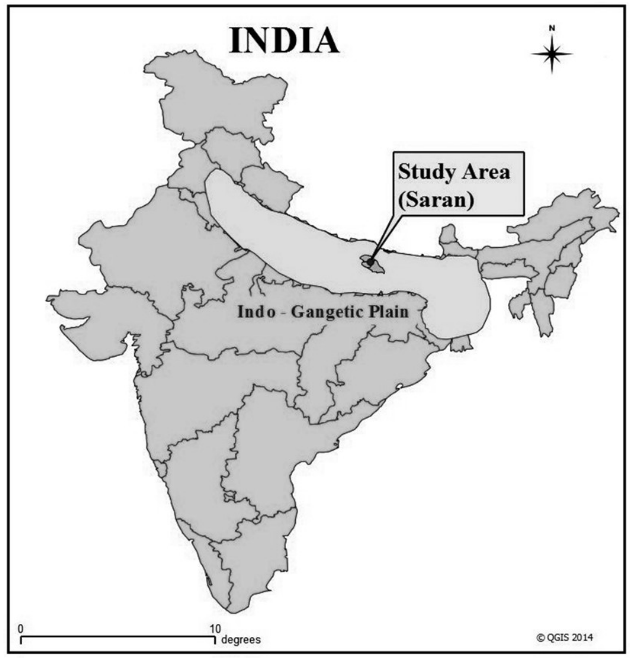

Figure 1. Schematic diagram of study area

METHODS

Study area

The study was carried out in Saran (a part of lower Gangetic biotic province). It is situated in the western part of Bihar. The global location of this region is between 25°36' to 26°39' North latitudes and 83° 54' to 85° 15' East longitudes. This division is made up of three districts namely Saran, Siwan and Gopalganj. The whole region has a varied climate. It is exceptionally hot and dry during summer and chilling cold in winter. The area receives about 500mm rainfall during monsoons, which is followed by pleasant temperature in winter. The region receives an average rainfall of about 290mm and the temperature varies from 5°C to 45°C. Saran can be divided into two geographical regions (i) Plains of alluvial soil situated at the banks of rivers, which generally affected by flood during monsoons. But so far as cultivation and agriculture is concern these areas are called the stock of food grains and (ii) Plains situated away from rivers which are not affected by flood and with full of greenery and cultivable land. The detail map of the study area is given in Figure 1. During study three habitat types were selected at different sites of whole region which are gardens, crop fields and houses.

Sampling methods

The spiders were collected from the surveyed area including habitats such as houses, crop fields and gardens (all vegetation other than crop fields) during limited duration extending from 1st December 2013 to 28th February 2014. We collected spiders by (i) Manual hand picking by visual searching as far distinct vision is possible, (ii) Beating branches of trees with a stick and collecting spiders using an inverted umbrella placed under the trees and (iii) Using pitfall traps. Pitfall traps were constructed with plastic cups (-7 cm diameter X 9 cm depth) buried in the soil and covered with a circular shaped plate placed 5cm above ground. We placed a solution of ethanol diluted in water (70% water + 30% ethanol) with a few drops of detergent to reduce surface tension, as preservative liquid. Four pitfall traps were placed in each plot with one trap at one corner. Forty pitfall traps were used in sampling with twenty traps in gardens and twenty in crop fields. These traps were left in the study area for six days in each month. In houses sampling was done only by visual searching. The trapped specimen were collected in individual vial and transported to the laboratory for identification. Habitat type and Web pattern were also recorded with each encounter.

Processing samples

We sorted specimens of spiders and identified them to family and then separated them into adults and juveniles. Juvenile specimens were discarded from the data because their identification to species level is difficult. Each adult specimen was photographed and identified to species level using existing identification keys by (Pocock, 1900; Tikader & Malhotra, 1980; Tikader, 1982; Tikader, 1987; Cushing, 2001) using microscope and ordinary hand lens wherever possible. The captured spiders were placed separately on vials with 70% ethyl alcohol. The details of spiders recorded during study are enlisted in Table 1.

Data analysis

Data analyses were performed in PAST version 3.02, a statistics package used in several fields of life sciences, earth sciences, engineering and economics (Hammer

Table 1. List of spider species and Guild structure of spiders recorded during study. Distribution according to Siliwal *et al*., 2005**.**

Family	Species	Author	Natural History and Guild Structure
Agelenidae (C. L. Koch, 1837)	*Tegenaria domestica*	Clerck, 1757	Cosmopolitan, Ambusher
Araneidae (Simon, 1895)	*Araenus diadematus*	Clerck, 1758	Cosmopolitan; Orb web spiders
	Araenus mitificus	Simon, 1886	India to Philippines, New Guinea; Orb web spiders
	Araenus spp.		
	Argiope aemula	Walckenaer, 1842	India to Philippines, New Hebrides; Orb web spiders
	Argiope anasuja	Thorell, 1887	Endemic to South Asia; Orb web spiders
	Argiope pulchella	Thorell, 1881	India to China and Java; Orb web spiders
	Cyclosa bifida	Doleschall, 1859	India to Philippines, New Guinea; Orb web spiders
	Cyrtophora spp. 1		Orb web spiders
	Cyrtophora spp. 2		Orb web spiders
	Cyrtophora spp. 3		Orb web spiders
	Cyrtophora spp. 4		Orb web spiders
	Neoscona crucifera		Orb web spiders
	Neoscona mukerjei	Tikader, 1980	Endemic to India; Orb web spiders
	Neoscona nautica	L. Koch, 1875	Cosmotropical; Orb web spiders
	Neoscona spp. 1		Orb web spiders
	Neoscona spp. 2		Orb web spiders
	Zygiella indica	Tikader and Bal, 1980	Endemic to India; Orb web spiders
Clubionidae (Wagner, 1887)	*clubiona foliata*	Keswani and Vank-hede2014	India; Foliage Runners
Hersiliidae (Thorell, 1870)	*Hersilia spp.*		Foliage Runners
Lycosidae (Sundevall, 1833)	*Pardosa spp.1*		Ground runners
	Pardosa spp.2		Ground runners
Nephilidae (Simon, 1894)	*Nephila kuhlii*	Doleschall, 1859	India to Sulawesi; Orb web spiders
	Nephila pilipes	Fabricius, 1793	China, Philippines to Australia; Orb web spiders
Oecobiidae (Blackwall, 1872)	*Oecobius spp*		Sheet web spiders
Oxyopidae (Thorell, 1870)	*Oxyopes lineatus*	Latreille, 1806	Palearctic; Stalker
	Oxyopes javanus	Thorell, 1887	India, China to Java, Philippines; Stalker
	Oxyopes spp. 1		Stalker
	Oxyopes spp. 2		Stalker
Philodromidae (Thorell, 1870)	*Philodromus spp.*		Ambusher
Pholcidae (C. L. Koch, 1851)	*Crossopriza lyoni*	Blackwall, 1867	Cosmopolitan; Cob web spider
	Pholcus phalangiodes	Fuesslin, 1775	Cosmopolitan; Cob web spider
	Pholcus podophthalmus	Simon, 1893	India, China; Cob web spider
Salticidae (Blackwall, 1841)	*Hasarius adansoni*	Audouin, 1826	Cosmopolitan, Stalker
	Helpis minitabunda	L. Koch, 1880	South Asia, Australia to New Zealand; Stalker
	Menemerus spp.		Stalker
	Myrmarachne orientales	Tikader, 1973	Southeast Asia; Stalker
	Myrmarachne pla-taleoides	O.P.-Cambridge, 1869	India, Sri Lanka, China, Southeast Asia; Stalker
	Plexippus paykulli	Audouin, 1826	Cosmopolitan; Stalker
	Plexippus petersi	Karsch, 1878	Africa to Japan, Philippines, Hawaii; Stalker
Sparassidae (Bertkau, 1872)	*Olios spp. 1*		Ground runner
	Olios spp. 2		Ground runner
	Hetropoda spp.		Ground runner
Tetragnathidae (Menge, 1866)	*Tetragnatha spp. 1*		Orb web spider
	Tetragnatha spp. 2		Orb web spider
Theridiidae (Sundevall, 1833)	*Latrodectus spp.*		Cob web Weaver
	Theridion spp.1		Cob web Weaver
	Theridion spp.2		Cob web Weaver
Thomisidae (Sundevall, 1833)	*Xysticus minutus*	Tikader, 1960	Endemic to India; Ambusher
	Misumena chrysanthemi sp. nov		Endemic to India; Ambusher

et al., 2001). Spider communities were analysed by using diversity indices Shannon diversity, Simpson index, Buzas and Gibson's evenness, Brillouin's index, Menhinick's richness index, Margalef's richness index, Equitability, Fisher's alpha Berger-Parker dominance and Chao 1 estimator) and β diversity. Dominance = 1 - Simpson index. It varies between 0 (when all taxa are evenly present) to 1 (when community is dominated completely by one taxon). And it is defined as:

$$D = \sum_i \left(\frac{n_i}{n}\right)^2$$

where n_i is the number of individuals of taxon *i.*

Shannon – Wiener index is a diversity index, which considers the number of individuals as well as number of taxa. It varies from 0 for communities with only a single taxon to high values for communities with many taxa, each with few individuals. It is defined as:

$H = -\sum p_i \log (p_i)$

where $p_i = \frac{n_i}{\sum n}$ and n is the number of individuals of species *i.*

Simpson index (–D) = 1-$\sum (p_i \times p_i)$.

Buzas and Gibson's evenness (E) = $\frac{e^H}{S}$

where e^H is the Shannon – Wiener index and S is the number of species.

Menhinick's richness index is defined as $\frac{S}{\sqrt{n}}$.

Margalef's richness index = $\frac{(S-1)}{\ln(n)}$

where S is the number of taxa, and n is the number of individuals.

Brillouin's index is defined as:

$$HB = \frac{\ln(n!) - \sum_i \ln(n_i)}{n}$$

where $n!$ Means the factorial of $n = 1\times2\times3\times4\times\ldots\ldots.n$. n = total number of individuals in the sample, n_i = number of individuals of species *i.*

Fisher's alpha - a diversity index, defined completely by the formula:

$$S = a \times \ln \left(\frac{1+n}{a}\right)$$

where S is number of taxa, n is number of individuals and a is the Fisher's alpha.

Equitability (J) measures the evenness with which individuals are divided among the taxa present. It is defined as:

$$J = \frac{[-\sum p_i \log (p_i)]}{\log (S)}$$

Berger-Parker dominance (d): Only calculates the proportion of the most common species in a sample. It is formulated as:

$$d = \frac{n_{max}}{n}$$

where n_{max} = abundance of most common species.

Chao1: An estimate of total species richness.

$$Chao1 = S + \frac{F_1(F_1-1)}{2(F_2+1)}$$

where F_1 is the number of singleton species and F_2 the number of doubleton species. One way analysis of variance (ANOVA) was performed to determine differences in spider biodiversity between different habitat types.

Beta diversity between communities was calculated by using Wilson & Shmida beta diversity measure (β_t). The value of β_t varies from 0 (similarity) to1 (dissimilarity).

$$\beta_t = \frac{g(H) + l(H)}{2\alpha}$$

where g = cumulative gain in species, H = range of habitat gradient, l = cumulative loss in species and $\bar{\alpha}$ = average number of species found within the quadrats. This index does not consider sample size and is independent from alpha diversity (Wilson & Shmida, 1984). The calculation was estimated by using rows (samples) of presence-absence (0/1) data, (Koleff *et al*., 2003), with species in columns. The beta diversity module in PAST software is used to estimate β diversity.

RESULTS

***General community patterns*:**

During the study a total of 2150 individuals were collected out of which 750 (34.88%) were unidentified juveniles and 1400 (65.12%) were adults. Out of total adult specimen collected 51 species were identified belonging to 29 genera and 15 families (Table 1). A total of forty nine species of twenty seven genera in the gardens, nineteen species of fourteen genera in the houses and thirty nine species of twenty two genera were collected during study. A list of spider species collected from different habitats is tabulated in Table 2. The most abundant families were Salticidae, Araneidae and Pholcidae (Figure 2). The most diverse family was Araneidae with 17 species. The dominant spider family was different between the three habitat types. In gardens the most abundant family was Araneidae, in houses the most abundant family was Pholcidae and in crop fields the most abundant family was Salticidae. Species *Crossopriza lyoni, Oecobius spp* and *Pholcus phalangiodes* constituted more than 66% of the total spiders collected from houses. Only seven families from the recorded fifteen families were found in all studied habitats viz. Agelenidae, Araneidae, Clubionidae, Lycosidae, Salticidae, Sparassidae and Theridiidae.

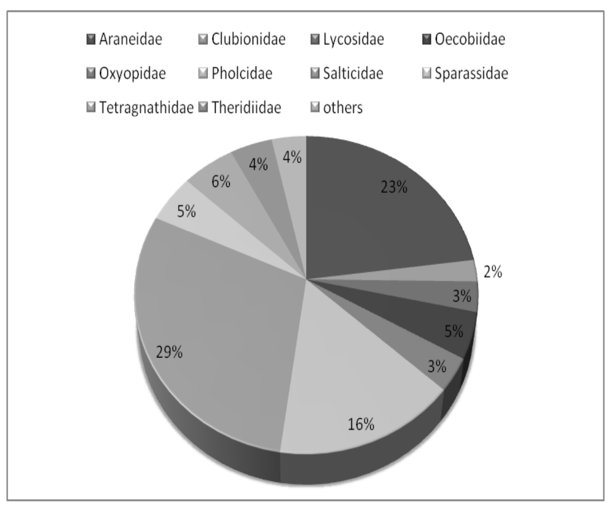

Figure 2. Relative abundance of different spider families recorded during whole study.

Table 2. List of spider species recorded in each habitat types during study in Saran. [Habitats are abbreviated as follows CF– Crop fields, H– Houses and G– Gardens]

Species	Family	CF	H	G
Araenus diadematus	Araneidae	8	0	21
Araenus mitificus	Araneidae	3	0	7
Araenus spp.	Araneidae	2	0	17
Argiope aemula	Araneidae	4	0	7
Argiope anasuja	Araneidae	8	0	9
Argiope pulchella	Araneidae	1	0	12
clubiona foliata	Clubionidae	12	7	12
Crossopriza lyoni	Pholcidae	0	117	0
Cyclosa bifida	Araneidae	9	0	12
Cyrtophora spp. 1	Araneidae	22	0	48
Cyrtophora spp. 2	Araneidae	0	0	6
Cyrtophora spp. 3	Araneidae	0	0	1
Cyrtophora spp. 4	Araneidae	0	0	2
Hasarius adansoni	Salticidae	21	9	17
Helpis minitabunda	Salticidae	8	0	4
Hersilia spp.	Hersiliidae	0	0	7
Hetropoda spp.	Sparassidae	6	5	8
Latrodectus spp.	Theridiidae	4	23	10
Leucauge decorata	Tetragnathidae	7	0	25
Menemerus spp.	Salticidae	16	8	9
Misumena chrysanthemi sp. nov	Thomisidae	0	0	3
Myrmarachne orientales	Salticidae	14	0	18
Myrmarachne plataleoides	Salticidae	4	0	19
Neoscona crucifera	Araneidae	5	2	11
Neoscona mukerjei	Araneidae	11	4	13
Neoscona nautica	Araneidae	6	0	12
Neoscona spp. 1	Araneidae	7	0	15
Neoscona spp. 2	Araneidae	5	3	17
Nephila kuhlii	Nephilidae	0	0	8
Nephila pilipes	Nephilidae	0	0	2
Oecobius spp	Oecobiidae	0	66	0
Olios spp. 1	Sparassidae	9	0	13
Olios spp. 2	Sparassidae	10	0	19
Oxyopes lineatus	Oxyopidae	4	0	9
Oxyopes javanus	Oxyopidae	5	0	7
Oxyopes spp. 1	Oxyopidae	5	0	8
Oxyopes spp.2	Oxyopidae	3	0	7
Pardosa spp.1	Lycosidae	12	1	4
Pardosa spp.2	Lycosidae	10	1	15
Philodromus spp.	Philodromidae	11	0	4
Pholcus phalangiodes	Pholcidae	0	62	29
Pholcus podophthalmus	Pholcidae	0	0	13
Plexippus paykulli	Salticidae	42	19	71
Plexippus petersi	Salticidae	41	23	69
Tegenaria domestica	Agelenidae	6	1	3
Tetragnatha spp. 1	Tetragnathidae	1	0	8
Tetragnatha spp. 2	Tetragnathidae	4	0	31
Theridion spp.1	Theridiidae	4	9	3
Theridion spp.2	Theridiidae	2	4	2
Xysticus minutus	Thomisidae	0	0	5
Zygiella indica	Araneidae	4	2	6

Based on foraging behavior the collected spiders were divided into seven functional ecological guilds. Among these seven types of functional group the Stalkers were the most abundant and comprised more than 33% of individuals from recorded spiders (Figure 3). Spiders of the families Salticidae, and Oxyopidae fall under this category. However, the most diverse guild was Orb web weavers which constitute 22 species of spider. Spiders of family Araneidae, Nephilidae and Tetragnathidae come under this category. Other recorded ecological guilds were cob web weaver (20%) formed of families Pholcidae and Theridiidae, ground runners (8%) which includes families Lycosidae and Sparassidae, sheet web weavers (5%) formed of family Oecobiidae, foliage runners (3%) which includes families Clubionidae and Hersiliidae and ambushers (2%) which includes families Agelenidae, Philodromidae and Thomisidae.

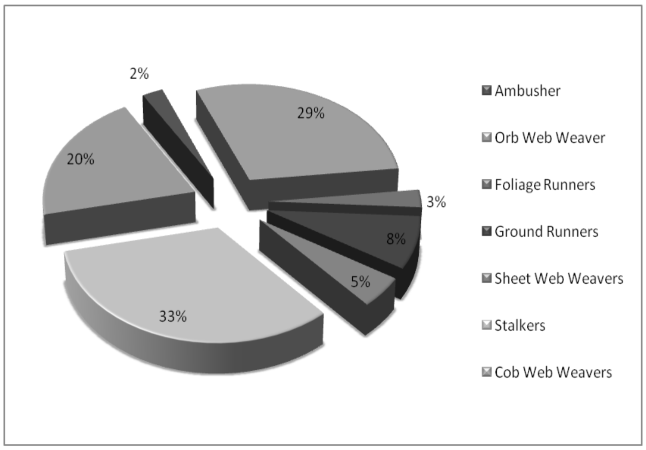

Figure 3. Percentage guild structure of spiders recorded during whole study.

***Biodiversity*:** Table 3 shows the values of alpha diversity indices for spider communities in the considered habitat types. Spider diversity was different among different habitat types for all species. The diversity, richness, evenness and dominance index values of all three habitats were analyzed using ANOVA. One way ANOVA showed that the differences in the Simpson index ($F = 40.3$, df = 3.427, $p = 0.004$), Shannon index ($F = 157.6$ df = 3.854, $p < 0.001$), Buzas and Gibson's evenness ($F = 21.72$, df = 3.943, $p = 0.007$), Brillouin index ($F = 153.4$, df = 3.854, $p < 0.001$), equitability index ($F = 27.37$, df = 3.715, $p = 0.005$) Berger-Parker dominance index ($F = 22.61$, df = 3.639, $p = 0.008$) and Chao-1 ($F = 26.78$, df = 3.805, $p = 0.005$) showed significant variation among habitats. But the diversity index Fisher's alpha and richness indices Margalef and Menhinick's index did not show significant variation among all habitats. The pairwise comparison of Shannon diversity index showed that the diversity showed greater significant variation between gardens and houses (ANOVA: $F = 359.9$, df = 3.372, $p < 0.0001$) than crop fields and gardens (ANOVA: $F = 215.7$, df = 3.884, $p = 0.0001$), but not significant difference between crop fields and houses (ANOVA: $F = 9.54$, df = 3.71, $p = 0.04$).

Figure 4 shows the comparison of Shannon Weiner diversity index of spider communities and dominant families Araneidae and Salticidae between the three studied habitats. A significant difference was found between habitat types for Shannon diversity index in Araneidae (ANOVA: $F = 30.70$, df = 3.629, $p = 0.005$). No significant difference was found between habitat types in Salticidae (ANOVA: $F = 11.12$, df = 3.984, $p = 0.02$). Beta diversity between spider communities showed higher dissimilarity in spider communities of gardens and houses than crop fields and houses (Figure 5). Spider

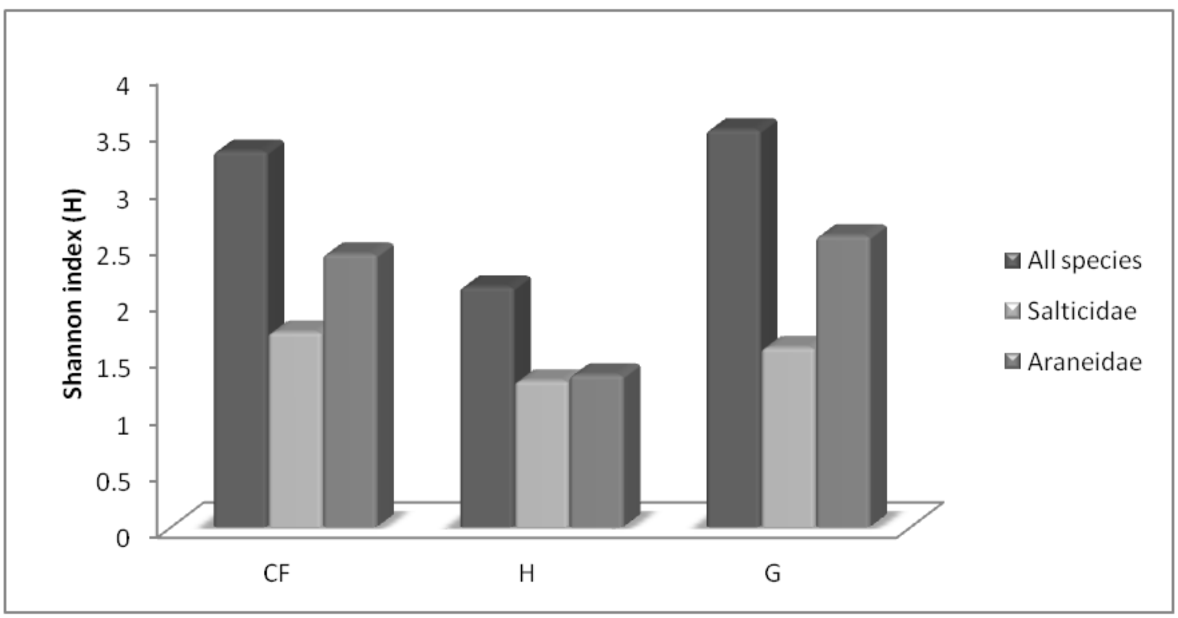

Figure 4. Biodiversity of all recorded spider species and Family Araneidae and Salticidae in three habitats (mean±S.E.). CF= Crop fields, H= Houses and G= Gardens.

Table 3. Diversity indices of spider assemblage calculated according to types of habitats in Saran. CF– crop fields, H– houses, G– gardens.

	CF	Lower	Upper	H	Lower	Upper	G	Lower	Upper
Taxa_S	39	38	39	19	18	19	49	49	49
Individuals	356	356	356	366	366	366	678	678	678
Dominance_D	0.05012	0.04482	0.06121	0.1766	0.1559	0.2022	0.04257	0.03898	0.04927
Simpson_1-D	0.9499	0.9388	0.9552	0.8234	0.7978	0.8441	0.9574	0.9507	0.961
Shannon_H	3.318	3.189	3.36	2.119	2.006	2.218	3.508	3.413	3.542
Evenness_e^H/S	0.7079	0.6241	0.739	0.4381	0.3924	0.4844	0.6811	0.6197	0.7045
Brillouin	3.124	3.003	3.165	2.029	1.919	2.125	3.366	3.275	3.399
Menhinick	2.067	2.014	2.067	0.9931	0.9409	0.9931	1.882	1.882	1.882
Margalef	6.468	6.298	6.468	3.049	2.88	3.049	7.363	7.363	7.363
Equitability_J	0.9057	0.8713	0.9173	0.7197	0.6819	0.7536	0.9013	0.8771	0.91
Fisher_alpha	11.17	10.77	11.17	4.254	3.969	4.254	12.12	12.12	12.12
Berger-Parker	0.118	0.1011	0.1545	0.3197	0.2732	0.3661	0.1047	0.09292	0.1298
Chao-1	39.33	38.75	45	20	19	29	49	49	54

communities of crop fields and gardens showed greater similarity than other habitats.

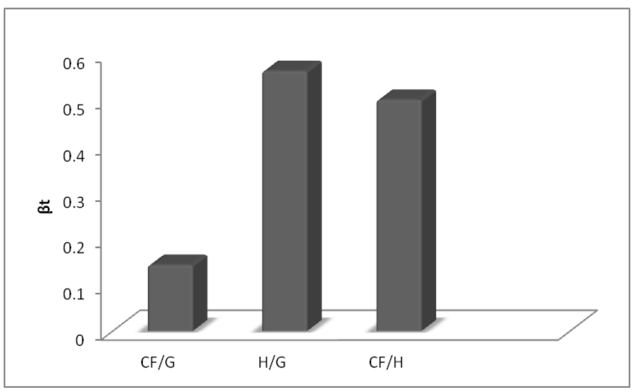

Figure 5. Comparison of beta diversity (β_t) of spider species in three different types of habitats in Saran (CF– crop fields, G– gardens, H– houses)

DISCUSSION

Of about 1520 spider species belonging to 377 genera and 60 families reported from India (Sebastian & Peter, 2009), 50 species belonging to 28 genera and 15 families have been recorded from this region. It represents 25% of the total families of spiders reported in India. It can be implicit that rich floral and faunal diversity in Gangetic plains is the key to provide diverse microhabitat for different species. In present study the observed diversity showed very significant differences between habitats. The variations among spider species according to habitats are due to their different hunting strategies, web types and feeding habits. The structure of vegetations also influences the diversity of spiders. Hawksworth *et al*., (1995) has showed that there is a link exists between species diversity and the structural complexity of habitats. In addition, higher diversity in the gardens supports the intermediate disturbance hypothesis (IDH), according to which diversity will be highest under intermediate levels of disturbance (Connell, 1978). Many factors are likely to influence spider species diversity at both local and landscape scales, including vegetation structure and complexity, predation, intra and interspecific competition, availability of prey, productivity and environmental stability (Greenstone, 1984; Marc *et al*., 1999; Pinkus-Rendón *et al*., 2006; Riechert & Gilliespie, 1986; Shochat *et al*., 2004; Turnbull, 1973; Uetz, 1979). These factors can influence spider assemblage by altering humidity, prey activity – density, temperature, and richness of prey (Bultman & Uetz, 1982, Samu *et al*., 1999). Spider communities may also influence indirectly by Structural heterogeneity that has positive effect on prey densities, such as herbivorous invertebrates (Nentwig, 1980). Structural complexity provided by habitats also offer more attachment points for web (Uetz, 1991) and it may be the possible cause of finding more orb web weavers in gardens than other habitats. The value of diversity indices of different habitats showed a consistent pattern of decreased diversity in the houses than gardens and crop fields. It might be due to lack of vegetation in houses and higher level of disturbance received by houses than other habitats. In addition the spider community of houses was dominated by some species like *Crossopriza lyoni, Pholcus phalangiodes* and *Oecobius spp.* Hence it was assumed to support a less diverse spider community.

Families Theridiidae and Salticidae did not distinguish habitats and their spider species were recorded in all habitats. It showed that Salticids and theridiids spiders have a broad habitat range and are very active. Seven of the ten species of these families were found in all habitats, which results in almost similar spider communities among habitats. Our results point out that the dominant spider species may act as a potential biological indicator for comparative study of spider assemblage among habitats for fast biodiversity assessment and environmental monitoring.

Beta diversity varies among habitats. Higher similarity between spider communities of crop-fields and gardens indicates that these habitats provides nearly similar environment for spider assemblage. However, vegetation structure and complexity of these habitats are very different from each other. Also, gardens have greater number of spider species and individual spiders. Considering both points, we argue that habitat complexity has influence on species richness possibly because availability of niches increases with habitat complexity and climatic condition determine which spider species can live in certain habitat but not their numbers (Jiménez -Valverde & Lobo, 2007).

Some spider families like Araneidae, Tetragnathidae, Nephilidae, Oxyopidae and Salticidae are excellent predators in crop fields and vegetable gardens and maintain ecological balance by reducing pest population. So their conservation and augmentation in the fields should be encouraged as it helps farmers to simple and efficient method of pest control without using any harmful chemical pesticides. Some research works on spider are done in some part of south India (Sudhikumar *et al*., 2005) and northeast region (Chetia *et al*., 2012). But unlike other regions of India, there is no previous work available for this region to compare the spider diversity. This study is the first attempt in this region of India.

CONCLUSION

Present study describes the variations of spiders diversity in different habitats mainly houses, crop fields and gardens of Saran, an area of Indo – Gangetic Plain. We find that spiders are likely to be more abundant and species rich in gardens than in other habitat types and species composition strongly varied in the different habitats. Our results indicate that habitat structural component had a high impact on spider species richness and abundance in three studied habitats. Additionally, disturbance level within habitats also seems to contribute a significant role in composition of spider diversity. Taking account the abundance of Salticids spiders in all types of habitat we may conclude that family Salticidae is the most successful spider family as it is flourished in all habitats. More sampling and data on spider taxonomy and the precise functional role of spiders in agro-ecosystem of IGP are needed, particularly regarding their capability to act as top-down predators for biological pest control.

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