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BIODIVERSITY AND GUILD STRUCTURE OF SPIDERS IN NORTHEASTERN UTTAR PRADESH

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ABSTRACT: A total of 13,662 individuals were collected in the 4 districts of northeastern U.P., viz. Gorakhpur, Kushinagar, Maharajganj and Siddharthnagar belonging to 75 morphospecies out of which 62 were identified upto species level. The most dominant family was Araneidae (31 species) followed by Tetragnathidae, 10 species; Salticidae, 9 species; Lycosidae, 8 species; Thomisidae, Clubionidae and Theridiidae each 3 species; Oxyopidae, Pholcidae and Gnaphosidae each 2 species and Sparassidae and Hersiliidae each 1 species. Following species were most dominant in occurrence: *Tetragnatha javana* (6.41%), *Oxyopes javanus* (6.40%), *Pardosa pseudoannulata* (6.35%), *Pardosa birmanica* (6.06%), *Tetragnatha mandibulata* (5.56%), *Hippasa holmerae* (5.14%), *Tetragnatha maxillosa* (4.79%), *Hippasa partita* (4.61%), *Araneus ellipticus* (4.37%), *Camaricus formosus* (4.36%), and *Lycosa mackenziei* (4.09%). It demonstrated that 31.39% of the total collections were observed in Siddharthnagar district followed by Maharajganj (25.89%), Gorakhpur (21.97%) and Kushinagar (20.74%). Orb weavers (44.34%) formed the most dominant guild followed by ground runners (28.8%), Stalkers (16.58%), foliage runners (4.86%) and ambusers (4.76%) which were less common in the study area while very few specimens of space builders (0.67%) were caught in the study area.

KEYWORDS: Spider biodiversity, Araneidae, orb weavers, ground runners, stalkers, foliage runners, ambusers.

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1. INTRODUCTION

As a major predator group, spiders, which feed on terrestrial arthropod communities, are one of the most abundant, diversified and omnipresent populations in both natural and agricultural habitats [1-2]. Role of spiders as biocontrol agents in terrestrial ecosystems have been well documented [3-5]. Predator foraging behavior of spiders has a variety of indirect effects on other species and, ultimately, on plant communities. The current status of spiders as generalist predators could limit their biocontrol potential due to their involvement in intra-guild predation. Therefore, apart from the potential for intra-guild predation, a diversified assemblage of spiders may exert a natural biological control [5]. The current world list of spider includes 47,566 species under 4,090 genera and 117 families [6]. India has over 1,700 species belonging to 450 genera under 61 families [6]. So far, in India, state level checklists have not been compiled for all states which is crucial for the forest department to understand the wealth of biodiversity in their states [7], but there are several faunal studies in different localities of the country. Spider fauna of following protected and unprotected areas in different states of India were studied : Andman and Nicobar Islands [8-9], Andhra Pradesh [10-12], Arunachal Pradesh [13], Assam [14-15], Bihar [16], Chhattisgarh [17], Goa [18], Gujarat [19-20]), Haryana [21], Jammu and Kashmir [22], Karnataka [23-24], Kerala [25-27], Madhya Pradesh [28-31], Maharashtra [32-34], Manipur [35], Meghalaya [36-37], Mizoram [38], Odisha [39-40], Rajasthan [41], Sikkim [42], Tamil Nadu [43], Tripura [44], Uttar Pradesh [45-47], Uttarakhand [48-50], and West Bengal [51-53]. In addition, spider fauna of Indian-Trans Himalayan region [54] and Terai Conservation Area [55-56] were also studied. Spiders are the least studied or understood fauna in relation to conservation and fragmentation of habitats in northeastern part of Uttar Pradesh, India. Hence, it was felt to explore spider diversity in this region.

2. MATERIALS AND METHODS

a. Sampling sites: The investigation was carried out for a period of five years (2013-2018). Sampling was conducted at different randomly selected sites in four district of northeastern Uttar Pradesh: 1. Siddharthnagar (27°N - 27°28' N and 82°45' E to 83°10'E and covers a total area of 2752 sq. km area, is flanked by Nepal in the north, Mahrajganj in the east, Basti and Sant Kabir Nagar on the south, and Balrampur on the west), Maharajganj (27°09' N to 83°34' E and occupies 2934.1 sq. km area; is flanked by Nepal in the north, Gorakhpur District in the south, Kushinagar District in the east and Siddharthnagar and Sant Kabir Nagar Districts in west), Gorakhpur (26°46'N to 83° 22' E and occupies 3,483.8 sq. km area is flanked by Nepal in the north, San Kabirnagar District in the south, Kushinagar District in the east and Siddharthnagar Districts in west) and Kushinagar (26°45' N and 83° 24' E, and spread over an expanse of 2873.5 sq. km area, is flanked by Mahrajganj in the west, Gorakhpur in the southwest, Deoria in the south and Bihar in the east). Study area is a part of Indo-Gangetic plain of northeastern Uttar Pradesh. The districts have a climate which is more equable than that of the adjoining districts in the west and the northern climate is

conditioned to some extent by the proximity of the hills in the north and the terai swamps. Meteorological parameters have been so distinct and have such regular impact that a year can be divided climatologically in to four seasons. The winter season from mid November to February is followed by the summer season from March to mid June. The period from mid June to the end of September is the south-west monsoon season and the October and the first half of November constitute the post-monsoon season. All the districts are well inundated by several rivers and riverines. More than 80% of the total annual rainfall is received during the crop season, July to October. Different places of these districts were chosen for sampling in different habitats.

b. Sampling

Standard sampling protocols for spider collection were adopted in different selected sampling spots. The detailed descriptions of the collection techniques [34] are as follows:

(i) Sweep Netting: The foliage spiders from low level vegetation of shrubs (up to 2 m in height) were sampled by this method. The sweep net consists of a 90 cm handle; 40 cm ring and the collection were poured on white canvas. The net was emptied at regular intervals to avoid loss and destruction of the specimen. During collection sweep net was moved back and forth to cover all ground layer herbs and shrubs till all vegetation in the sampling plots were swept thoroughly.

(ii) Ground Hand Collecting: This method of sampling is used to collect the spiders, which are found to be visible in the ground, litter, in broken logs, etc.

(iii) Aerial Hand Collecting: This method was used to collect web-building and free-living spiders on the foliage and stems of living or dead shrubs, high herbs, tree trunks etc.

(iv) Vegetation Beating: The spiders were collected by beating the vegetation with a stick and collecting the samples on a cloth. The method is used to sample spiders living in the shrub, high herb vegetation, bushes, and small trees and branches.

(v) Litter sampling: Litter sampling involved sorting of spiders from the litter collection tray.

c. Identification

The adult spiders were identified using available literatures [57-58]. Some of the immature stages could not be identified and ignored.

3. RESULTS AND DISCUSSION

A. Species composition

A total of 13,662 individuals were collected during the study period 2013-2018 belonging to 75 morphospecies out of which 62 were identified upto species level. They belong to 36 genera and 12 families (Table 1). Each mature specimen that could not be identified was included as a species but its genus was not added in the total genera. Regarding the biodiversity of the spiders in the target area, they were arbitrarily categorized into 4 kinds on the basis of percentage of their strength as: Most dominant (> 4.0%), dominant (1-4%), less dominant (0.25-1%) and rare (<0.25%). Of the total species 11 species were most dominant (accounted for 58.15% of the total population), 10 species

were dominant (accounted for 25.11% of the total population), 31 species were less dominant (accounted for 12.9% of the total population), and 23 species were rare (accounted for 3.8% of the total population). The most dominant family regarding the species diversity was Araneidae (31 species) followed by Tetragnathidae, 10 species; Salticidae, 9 species; Lycosidae, 8 species; Thomisidae, Clubionidae and Theridiidae each 3 species; Oxyopidae, Pholcidae and Gnaphosidae each 2 species and Sparassidae and Hersiliidae each 1 species (Table 1).

Table 1. List of spiders collected in northeastern Uttar Pradesh and their relative abundance

Family/Species	Total
A. Family Araneidae Simon, 1895	2501
<i>Araneus ellipticus</i> (Tikader & Bal, 1981)	597
<i>Araneus mitificus</i> (Simon, 1886)	137
<i>Araneus</i> sp. A	29
Araneidae sp. A	26
Araneidae sp. B	111
<i>Argiope aemula</i> (Walckenaer, 1842)	56
<i>Argiope anasuja</i> Thorell, 1887	40
<i>Argiope catenulata</i> (Doleschall, 1859)	64
<i>Argiope luzona</i> (Walckenaer, 1841)	40
<i>Argiope pulchella</i> Thorell, 1881	40
<i>Cyclosa bifida</i> (Doleschall, 1859)	102
<i>Cyclosa insulana</i> (Costa)	30
<i>Cyclosa mulmeinensis</i> (Thorell, 1887)	35
<i>Cyrtophora citricola</i> (Forskål, 1775)	34
<i>Cyrtophora exanthematica</i> (Doleschall, 1859)	37
<i>Eriovixia excelsa</i> (Simon, 1889)	34
<i>Eriovixia laglaizei</i> (Simon, 1877)	60
<i>Gasteracantha diadestia</i> Thorell, 1887	38
<i>Gasteracantha hasselti</i> C. L. Koch, 1837	29
<i>Gasteracantha kuhlii</i> C.L. Koch, 1837	33
<i>Gea subarmata</i> Thorell, 1890	55
<i>Larinia kanpurae</i> Patel & Nigam, 1994	15
<i>Larinia phthisica</i> (L. Koch, 1871)	26
<i>Neoscona dhruvai</i> Patel & Nigam, 1994	34
<i>Neoscona molemensis</i> Tikader & Bal, 1981	43

Family/Species	Total
<i>Neoscona nautica</i> (L. Koch, 1875)	35
<i>Neoscona theisi</i> (Walckenaer, 1842)	528
<i>Nephila maculata</i> (Fabricius)	95
<i>Nephilengys malabarensis</i> (Walckenaer, 1842)	43
<i>Parawixia dehaanii</i> (Doleschall, 1859)	36
<i>Poltys illepidus</i> C. L. Koch, 1843	19
B. Family Clubionidae Wagner, 1887	622
<i>Clubiona drassodes</i> O. P.-Cambridge, 1874	34
<i>Clubiona japonicola</i> Boesenberg & Strand, 1906	543
<i>Clubiona</i> sp. A	45
C. Family Gnaphosidae Pocock, 1898	26
<i>Urozelotes rusticus</i> (L. Koch, 1872)	17
Gnaphosidae sp. A	9
D. Family Hersiliidae Thorell, 1870	13
<i>Hersilia clathrata</i> Thorell, 1895	13
E. Family Lycosidae Sundevall, 1833	3893
<i>Hippasa holmerae</i> Thorell, 1895	702
<i>Hippasa partita</i> (O.P.-Cambridge, 1876)	630
<i>Lycosa mackenziei</i> Gravely, 1924	559
<i>Lycosa</i> sp. A	23
<i>Pardosa birmanica</i> Simon, 1884	828
<i>Pardosa pseudoannulata</i> (Bösenberg & Strand, 1906)	853
<i>Pardosa sumatrana</i> (Thorell, 1890)	269
<i>Pardosa</i> sp. A	29
F. Family Oxyopidae Thorell, 1870	881
<i>Oxyopes javanus</i> Thorell, 1887	865
<i>Oxyopes shweta</i> Tikader, 1970	16
G. Family Pholcidae C.L. Koch, 1851	131
<i>Crossopriza lyoni</i> (Blackwall, 1867)	45
<i>Pholcus phalangioides</i> (Fuessli, 1775)	86
H. Family Salticidae Blackwall, 1841	1355
<i>Harmochirus brachiatus</i> (Thorell, 1977)	59
<i>Hasarius adansoni</i> (Audouin, 1826)	87
<i>Marengo crassipes</i> (Peckham and Peckham, 1892)	29

Family/Species	Total
<i>Myrmarachne orientales</i> Tikader, 1973	71
<i>Myrmarachne</i> sp. A	40
<i>Plexippus calcutaensis</i> (Tikader, 1974)	342
<i>Plexippus paykulli</i> (Audouin, 1826)	350
<i>Plexippus petersi</i> (Karsch, 1878)	266
<i>Stenaelurillus lesserti</i> Reimoser, 1934	111
I. Family Sparassidae Bertkau, 1872	29
<i>Heteropoda venatoria</i> (Linnaeus, 1767)	29
J. Family Tetragnathidae Menge, 1866	3501
<i>Leucauge celebesiana</i> (Walckenaer, 1842)	252
<i>Leucauge decorata</i> (Blackwall, 1864)	535
<i>Tetragnatha ceylonica</i> Cambridge	190
<i>Tetragnatha javana</i> (Thorell, 1890)	855
<i>Tetragnatha mandibulata</i> Walckenaer, 1842	725
<i>Tetragnatha maxillosa</i> Thorell, 1895	654
<i>Tetragnatha</i> sp. A	41
<i>Tetragnatha</i> sp. B	68
<i>Tetragnatha</i> sp. C	103
Tetragnathidae sp. A	78
K. Family Theridiidae Sundevall,	60
<i>Dipoenura fimbriata</i> (Simon, 1909)	21
<i>Molione triacantha</i> (Thorell, 1892)	20
<i>Thwaitesia margaritifera</i> (O.P. Cambridge, 1881)	19
L. Family Thomisidae Sundevall, 1833	650
<i>Camaricus formosus</i> Thorell, 1887	596
<i>Mastira moneka</i> (Tikader, 1963)	22
Thomisidae sp. A	32
Grand Total	13662

Following species were most dominant in occurrence: *Tetragnatha javana* (Thorell, 1890) (6.41%), *Oxyopes javanus* Thorell, 1887 (6.40%), *Pardosa pseudoannulata* (Bösenberg & Strand, 1906) (6.35%), *Pardosa birmanica* Simon, 1884 (6.06%), *Tetragnatha mandibulata* Walckenaer, 1842 (5.56%), *Hippasa holmerae* Thorell, 1895 (5.14%), *Tetragnatha maxillosa* Thorell, 1895 (4.79%), *Hippasa partita* (O.P.-Cambridge, 1876) (4.61%), *Araneus ellipticus* (Tikader & Bal, 1981)

(4.37%), *Camaricus formosus* Thorell, 1887 (4.36%), and *Lycosa mackenziei* Gravely, 1924 (4.09%). All these collectively constitute about 58.15% of the individuals collected from the target area of northeastern Uttar Pradesh. Dominant and less dominant species were 41 and constitute 36.07% of the collected individuals. Rare occurring species accounts only 3.78% of the total collected individuals. Of the total catch, 25.4% were juveniles (3470 individuals) and sex ratio (proportion of males in the population) was 0.67, i.e. 67% of the adults were males (9154 individuals). The family Hersiliidae and Sparassidae are composed of single species each. Family Lycosidae and Tetragnathidae accounted for the largest population of the species of spiders, each representing 28.60% and 26.04% of all the species, respectively, followed by Araneidae (18.31%) and Salticidae (10.06%). The above 4 families constituted 83.00% of the total catchments (13,662 individuals). The rest of the six families are poorly represented (Table 2).

Table 2. District wise distribution of number of spiders collected in the northeastern Uttar Pradesh.

Family	Number of species	Number of individuals collected				Total
		Kushinagar	Gorakhpur	Maharajganj	Siddharthnagar	
Araneidae	31	446	483	686	886	2501
Clubionidae	3	126	158	151	187	622
Gnaphosidae	2	3	0	8	15	26
Hersiliidae	1	0	0	0	13	13
Lycosidae	8	902	850	970	1171	3893
Oxyopidae	2	189	213	231	248	881
Pholcidae	2	23	30	44	34	131
Salticidae	9	206	274	393	482	1355
Sparassidae	1	10	19	0	0	29
Tetragnathidae	10	776	818	860	1047	3501
Theridiidae	3	2	5	11	42	60
Thomisidae	3	151	152	183	164	650
Number of individuals	Total	2834	3002	3537	4289	13662
	in %	20.74	21.97	25.89	31.39	31.39

B. Species diversity in different districts

Four districts of northeastern Uttar Pradesh, viz. Gorakhpur (160 sites), Kushinagar (146 sites), Maharajganj (137 sites) and Siddharthnagar (168 sites) were surveyed and spiders were collected from several locations in different niches/habitats including forest trees, kitchen garden, shrubs on roadside, human dwellings, agricultural and horticultural crops, etc. Districtwise distribution of the collected spiders was displayed in Table 2 and Fig. 1A-B, 2A-B. It demonstrated that 31.39% of the total collections were observed in Siddharthnagar district followed by Maharajganj (25.89%),

Gorakhpur (21.97%) and Kushinagar (20.74%). Three families were not recorded from each district. Gnaphosidae was not recorded in Gorakhpur, Hersiliidae was recorded only in Siddharthnagar, and Sparassidae was reported only in Kushinagar and Gorakhpur.

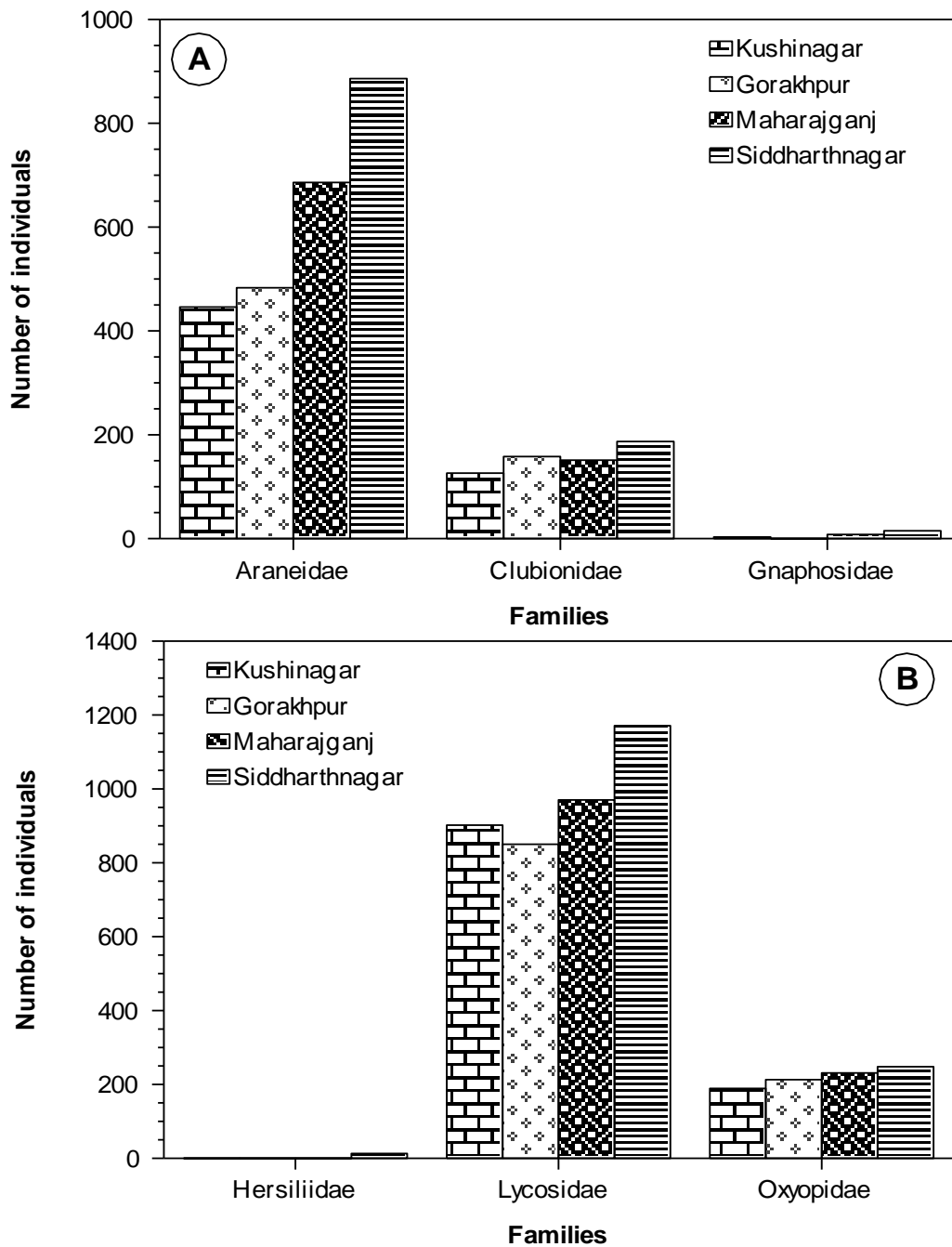


Fig. 1: A-B. Districtwise distribution of number of spiders collected in the northeastern Uttar Pradesh.

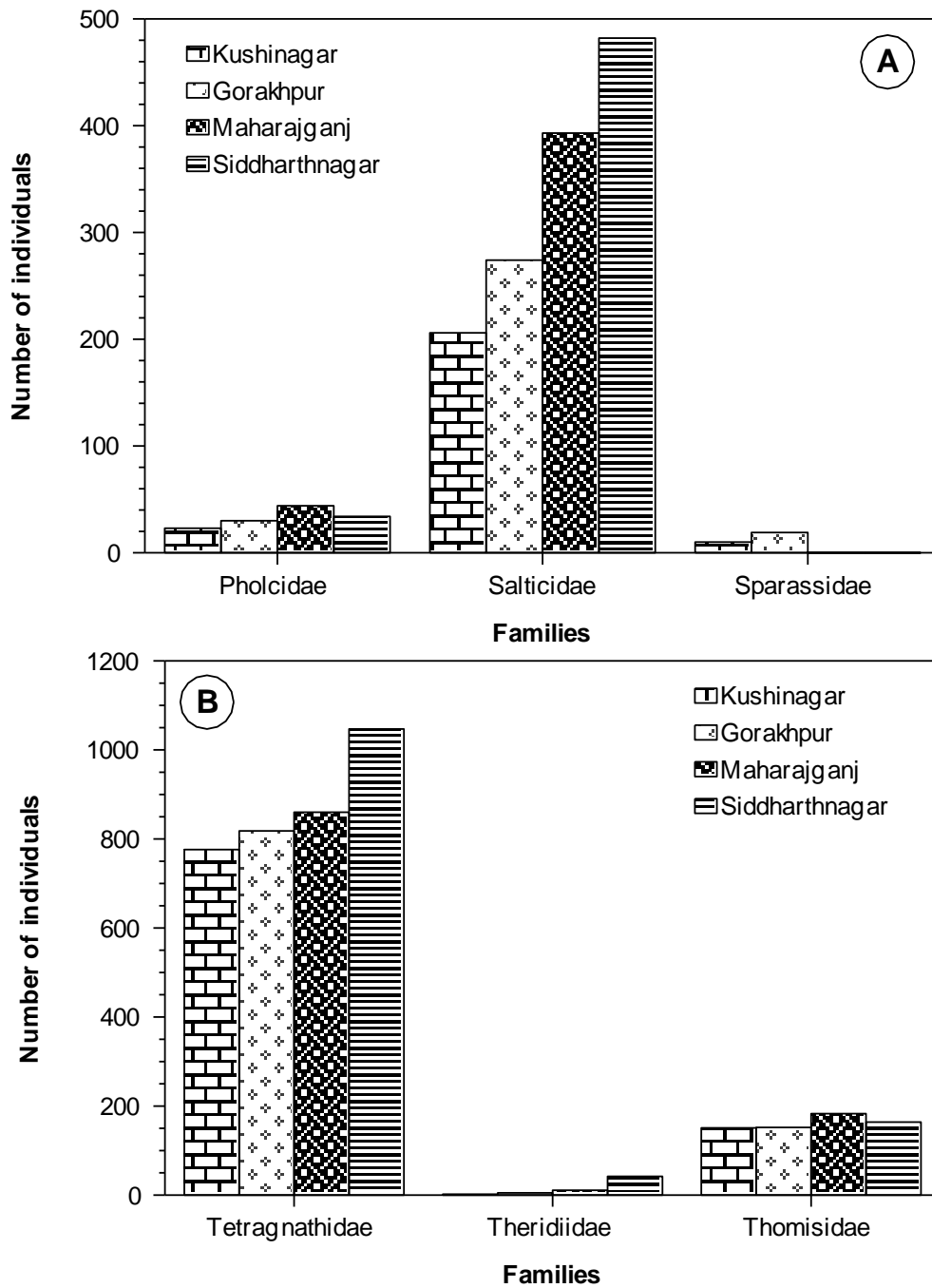


Fig.2: A-B. Districtwise distribution of number of spiders collected in the northeastern Uttar Pradesh.

C. Foraging guilds

The collected spiders were grouped into 6 foraging guilds [46, 59]. These guilds are :

(a) Orb web weavers: The typical orb-weaver spiders are the most common group of builders of spiral wheel-shaped webs often found in gardens, fields and forests. Their common name is taken from the round shape of this typical web, example, most of the members of Araneidae and Tetragnathidae.

(b) Stalkers: Stalkers or jumping spiders are active hunters often seen during the day walking up

and down walls in houses as well as in the fields. They hunt small arthropods by stalking them slowly and finally jumping on them. Most of the members of Oxyopidae and Salticidae in constitute this foraging guild.

(c) Ground runners: Ground runner spiders do spin silk, but they do not trap prey within their webs as they do not construct any kind of web. Rather, they hunt and chase prey along the ground. The members of the family Gnaphosidae comes under this guild.

(d) Foliage runners: The name indicate such group of spiders spent most of their times running on the foliage of the crops, for example, the members of Clubionidae and Sparassidae.

(e) Space builders: The space builders construct webs but the web has no adhesive properties like orb web but the irregular structure traps insects, making escape difficult. The spider quickly envelops its prey with silk and then inflicts the fatal bite. The prey may be eaten immediately or stored for later. The members of the family Pholcidae are example of this category.

(f) Ambushers: The spiders belonging to the family Thomisidae do not build webs to trap their prey, but they ambush unsuspecting insects that come within contact, grasping them with their strong, spiky, curved front legs, similar to Venus flytrap plant. Out of 13662 spiders collected, orb weavers (6058 individuals, 44.34%) formed the most dominant guild followed by ground runners (3934 individuals, 28.8%). Stalkers (2265 individuals, 16.58%), foliage runners (664 individuals, 4.86%) and ambusers (650 individuals, 4.76%) which were less common in the study area while very few specimens of space builders (91 individuals, 0.67%) were caught in the study area (Table 3).

Table 3. Districtwise foraging guilds of spiders collected in the study area.

Foraging Guild	Districts				Total	In %
	Kushinagar	Gorakhpur	Maharajganj	Siddharthnagar		
Orb web weaver	1231	1314	1580	1933	6058	44.34
Ground runner	905	850	978	1201	3934	28.80
Stalker	395	487	634	749	2265	16.58
Foliage runner	136	177	151	200	664	4.86
Ambusher	151	152	183	164	650	4.76
Space web builder	25	13	11	42	91	0.67

Twelve spider families were recorded from the four districts of northeastern Uttar Pradesh which represent about one-fifth of the families reported from the country [6]. The number of families found here is lower than the number recorded in other parts of the country [60] or for other biomes surveyed in India [14, 17, 24, 27, 28, 30, 32-34, 50, 61-65]. The numbers of taxa recorded are generally lower than those reported for other surveys in different regions of the country. Lycosidae was the most dominant family followed by Tetragnathidae like other studies [26, 46, 66]. Tetragnathidae was observed as dominant families followed by Linyphiidae and Lycosidae [60].

The dominance of these spiders might be expected as this wet habitat provides congenial conditions for these families [26]. The phenological patterns of lycosid populations in the fields were similar to other studies [67-69]. Regarding the foraging guilds, orb web weavers (44.34%) dominate followed by ground runners (28.8), stalkers (16.5%), foliage runner (4.86%), ambushers (4.76%) and lastly space builders (0.67%). The dominance of orb weavers may be explained on the account of habitats such as rice fields, forests and bushes on roadside. The small shrubs and grasslands provide good habitats for ground runners. Space builders (Pholcidae) are house dwelling and hence, diversity is limited. Although collection effort of present study was extensive yet families Corinnidae, Ctenidae, Eresidae, Eutrichuridae, Filistatidae, Linyphiidae, Miturgidae, Uloboridae and others recorded from south India were not represented in the present study. The crop phenology and irrigation method and patterns and habitats were similar at all collection sites in the present study. In addition, the difference in quantity and quality of spider fauna is also 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 [70-72]. Hence, the number of families represented and total species reported from different regions of the country can not be compared. The most common explanation for the observed pattern of the spider guild structure includes its structural diversity, microenvironment, or the level of disturbance. Complex habitat maintains diverse spider assemblage [73]. The structural complexity results in an increase abundance and diversity of food for spiders, which promote rapid population growth, leading to elevated spider densities [74]. It has been found that arable fields are regularly recolonized from the perennial habitats [75]. Perennial habitats such as field boundaries may provide food, refuge and over wintering sites for many invertebrate species including many natural enemies of major crop pests, thus act as a source of dispersal to arable fields, which are frequently disturbed by different management practices [76]. Conventional management practices such as tillage, burning and insecticide application have numerous indirect effects on the spider population. Insecticides can reduce populations of phytophagous insects, which result in less available prey for spiders [77]. The importance of rain fall in the regional spider diversity has already been established [78]. In the tropics, a continuum of species with extended seasonal ranges has been found [79], which would give rise to variable samples at different times of the year. Most spiders are limited to a certain extent by environmental conditions. 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 [46]. This was the second attempt to document spider fauna in this part of the state after Singh and Singh [46], however, they studied the spider biodiversity only in riceland habitats. Siddharthnagar district was never surveyed for spider fauna. The diversity both at ecosystem and microhabitat level supports considerably large number of spiders in these districts. Since the study area is a human dominated landscape, they are facing

threats like habitat loss, pollution and changes in land use pattern. Appropriate conservation strategies should be developed and implemented to conserve the faunal and floral diversity of this region.

4. CONCLUSION

Four districts of northeastern U.P., viz. Gorakhpur, Kushinagar, Maharajganj and Siddharthnagar were surveyed to observe the spider biodiversity. Total 62 species were observed. The most dominant family was Araneidae followed by Tetragnathidae, Salticidae, Lycosidae, Thomisidae, Clubionidae and Theridiidae. Regarding the guild structure, orb weavers formed the most dominant guild followed by ground runners, Stalkers, foliage runners and ambushers.

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CONFLICT OF INTEREST

No conflict of interest exists.

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