International Journal of Ecology and Environmental Sciences 43 (3): 195-204, 2017
ISSN: 2320-5199 (Online)

Diversity and Distribution of Spiders in Gogi, Yadgir District: A Semi-arid Landscape in Southern India

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ABSTRACT

Anthropogenic activities such as the use of pesticides in agriculture field, intensive grazing, and human interferences can affect spider populations and assemblages. The Uranium Corporation of India Ltd (UCIL), a Government of India enterprise under the Department of Atomic Energyhas setup uranium ore mining site at Gogi, Yadgir District of Karnataka in 2012. Therefore, this study was undertaken as baseline to understand the status, population, and distribution of spiders in different ecosystems *viz.,* natural, agro, and domestic ecosystems of a semiarid region in southern India. The natural and agroecosystems were further divided into three habitats each: the natural ecosystems: grasslands, treescapes (land dominated by trees) and barren land; the agroecosystems: red gram field, rice paddy field and cotton field. Spider assemblages were sampled using pitfall traps, beating and netting for density, abundance and frequency measurements in all the selected habitats. A total of 82 spider species belonging to 19 families were found. Lycosidae was the dominant family represented by 17 species. Barren lands had the greatest spider diversity of 64 species with a density of 13 individuals m^{-2} from 15 families (Araneae) as compared with the other habitats tested. Functional groups were also studied depending upon the hunting behaviour and daily activityof the spider taxa. Majority of species were diurnal-web builders (35) and diurnal-hunter (29). However, twelve species were found to be diurnal-ambusher, five species nocturnal-hunter and one species nocturnal-web builder. By elucidating diversity of spiders in Gogi, this study enables further investigation of the contribution of ecosystem services by these invertebrates in semi-arid landscapes dominated by agricultural practices.

Key Words: Arachnida; Semiarid Ecosystem; Habitat; Ecosystems; Diversity

INTRODUCTION

Spiders are valuable indicators of the spatial heterogeneity of landscapes in terms of composition and diversity of species inanecosystem (Schmitdt et al. 2005). These invertebrates are useful predators and prey on a large number of species, and hence play a critical rolein ecosystems. In terrestrial ecosystems, spiders are the most abundant, vigorous and predators (Nyffeler 2000) and are strongly influenced by habitat types (McDonald 2007). Spiders regulate populations of insects in diverse ecosystems and play acritical role in minimizing pest populations and their impactsin landscapes dominated by agriculture (Tscharntke et al. 2007). However, land-use change, disturbance in natural habitats and increasing distance between agriculturalland and natural habitats, and high primary productivity of most agricultural landscapes are challenges to pest management using natural enemies such as spiders (Tscharntke et al. 2007; Batáry et al. 2012).

Among the 16 recognized agro-ecological zones in India, the semiarid region occupies the significant proportion of the landscape as spreads over 11 states. Despite the vitality of spiders in the provision of ecosystem services, not much was known about the diversity of spiders of India. In particular, there is a paucity of research on spiders in semiarid regions of India. The study area occurs in the Yadgir District, North Karnataka which is semiarid with an average rainfall of >650 mm spread over 50 rainy days per year. The central point of the study was Gogi village (16°43 N; 76°44 E), occurs at an elevation of 450m amsl and spread over a 30 km from its radius. The areas adjacent to Gogi include a diversity of landforms comprising a mixture of hillocks and barren and rocky outcrop environment, and villages including sparse natural vegetation (Champion and Seth 1968). The soil system of the study area is made of entisols, vertisols and inceptisols (Wani et al. 2011). Climatically, the study area is hot and dry with low rainfall and high temperatures. The mean daytime temperature of the area is 26 ºC in October to February and 39 ºC in March to October. The Uranium Corporation of India Ltd (UCIL), a Government of India enterprise under the Department of Atomic Energy has established uranium ore mining project in Gogi, Yadgir District of Karnataka (Figure 1). This study was undertaken as baseline to understand the diversity, distribution and abundance of these useful invertebrates in semiarid region which would be going through the disturbances incurred due to the development of uranium mining site. This study was carried out from February 2011 to June 2012.

MATERIALS AND METHODS

Experimental Design and Sampling

This study was undertaken to understand the status, population, and distribution of spiders in different ecosystems *viz.,* natural, agro, and domestic ecosystems of a semiarid region in southern India. The natural and agroecosystems were further divided into three habitats each. The natural ecosystems were grasslands, treescapes (land dominated by trees) and barren land. The agro-ecosystems were divided into three habitats based on the type of crops grown, viz., red gram field (*Cajanus cajan*), rice paddy field (*Oryza sativa*) and cotton field (*Gossypium* sp.). In each of the habitats 10 sampling plots (5m x 5m) were laid randomly for censusing spiders. In the sampling plots pitfall traps, sweep-netand beating methods were used for collecting the spiders (Churchill and Arthur 1999).

Pitfall trap

We used cylindrical plastic containers (11 cm tall, 10 cm diameter) for use as pitfall traps. In thesetraps weused a liquid trapping medium (69 parts water, 30 parts ethyl acetate, and 1 part commercial detergent). Trapped specimens were extracted from traps after seven days for

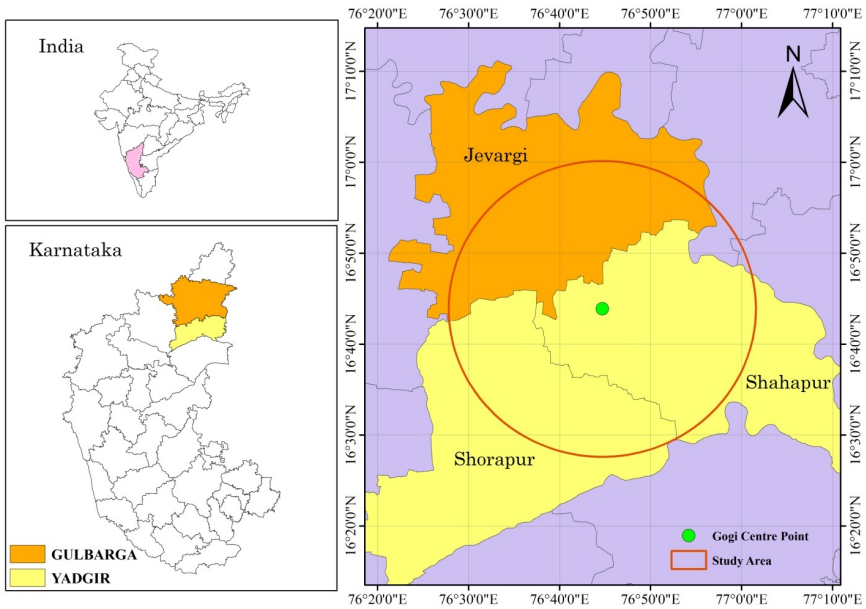

Figure 1. Geographical location of the study area

species determination (Hore and Uniyal 2008). The data from pitfall traps were used to enumerate species and relative abundance (Bury andCorn 1987).

Sweep Netting

This method was usedin areas crowded with herbs and shrubs, by sweeping insect nets through vegetation. The net was emptied after 3-4 sweeps to avoid loss and destruction of the species (Sørensen et al. 2002).

Beating

The beating/beat sheet method was used for the collection of the spiders from the upper canopies of trees that occurred in the study area. The species were collected while beating the vegetation with aheavy stick and holding acollecting umbrella underneath the vegetation (Coddington et al. 1996, Sørensen et al. 2002).

Identification of Species and Data Analysis

Specimens extracted from sweep netting and beating were transferred to cyanide jarsthat included 70% alcohol. They were shipped to Anand Agriculture University (Anand, Gujarat) for determinations, which was done using Tikader (1977, 1980, 1982, 1987), Kaston (1978), Tikader and Biswas (1981), Pocock, (1900), Siliwal (2005) and Sebastian and Peter (2009). The diversity indices were calculated using Simpson index (D; Simpson 1949) and Shannon-Wiener diversity index (H; Shannon and Waver 1949).

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

where, N = Total number of species, n= number of species in a given community

Shannon-Wiener diversity index (H)

$$H = \sum_{i=1}^{s} - (P_i * \ln P_i)$$

where, p is the proportion (n/N),
n=individuals of one particular species (n),
N = total number of individuals (N), ln is the natural log, Σ is the sum of the calculations, and s is the number of species.

RESULTS

A total of 1060 individuals of 82 species of spiders (44 genera and 19 families) were extracted. Lycosidae was the dominant family represented by 17 species followed by Tetragnathidae (13), Araneidae (12), Theridiidae (8), Salticidae (6), Thomisidae (5), Oxyopidae (4). Philodromidae (3), Miturgidae (3) and Uloboridae (2). At the genus level the Araneidae and Theridiidae dominated in the study area with six genera each, followed by Salticidae (5), Tetragnathidae (4), Lycosidae (4), Thomisidae (4) Oxyopidae (2) and Philodromidae (2) (Table 1). Miturgidae was represented byone genus and three species. Of the 19 families obtained, nine (Uloboridae, Corinnidae, Eresidae, Filistatidae, Hersilidae, Pholcidae, Pisauridae, Scytodidae, Selenopidae, and Sparasidae) were represented by one genus and one species each. Sixty-four species were found in the natural ecosystem, 41 in agroecosystems, and 16 species in domestic (human residential) contexts. In natural and agroecosystems, 30 species of spiders were common, two were present in natural and human residential ecosystems and seven (*Pardosa birmanica, Zygeilla indica, Marapissa* sp., *Phidippus* sp., *Oxyopes* sp., *Philodromus* sp., *Hersilia savignyi*) were present in all of the three studied ecosystems of this semiarid area. However, none of the species was common between domestic (human residential) ecosystems and agro-ecosystem (Table 2).

Table 1. Recorded families, genera and species of spiders from the study area

S. No	Family	Genera	Species
1	Lycosidae	4	17
2	Tetragnathidae	4	13
3	Araneidae	6	12
4	Theridiidae	6	8
5	Salticidae	5	6
6	Thomisidae	4	5
7	Oxyopidae	2	4
8	Miturgidae	1	3
9	Philodromidae	2	3
10	Uloboridae	1	2
11	Corinnidae	1	1
12	Eresidae	1	1
13	Filistatidae	1	1
14	Hersilidae	1	1
15	Pholcidae	1	1
16	Pisauridae	1	1
17	Scytodidae	1	1
18	Selenopidae	1	1
19	Sparasidae	1	1
	Total	44	82

Table 2. Presence and absence of spiders along with their density (individuals m^{-2}) in various habitats of semiarid ecosystems

S.N.	Scientific Name	Family	Density of spiders in different habitats of ecosystems*						
			Natural ecosystems			Agroecosystems			Domestic ecosystem
			a	b	c	d	e	f	g
1	*Arctosa* sp.	Lycosidae	0	0	0.17	0	0	0	0
2	*Hippasa pisaurina*	Lycosidae	0	0	0.26	0	0	0	0
3	*Lycosa bistriata*	Lycosidae	0	0	0.12	0	0	0	0
4	*Lycosa madani*	Lycosidae	0	0	0.22	0	0	0	0
5	*lycosa pictula*	Lycosidae	0	0	0	0	0	0	0.20
6	*Lycosa prolifica*	Lycosidae	0	0	0.27	0	0	0	0
7	*Lycosa* sp.	Lycosidae	0	0	0.22	0.22	0	0	0
8	*Pardosa birmanica*	Lycosidae	0	0	0.29	0	0	0.16	0.23
9	*Pardosa altitudes*	Lycosidae	0	0	0	0	0	0	0.11
10	*Pardosa mysurensis*	Lycosidae	0.15	0	0.16	0	0	0	0
11	*Pardosa oakleti*	Lycosidae	0.11	0	0.20	0	0	0	0
12	*Pardosa pseudoannulata*	Lycosidae	0	0	0	0	0	0	0.14
13	*Pardosa pusiola*	Lycosidae	0	0	0.16	0	0	0	0
14	*Pardosa sangosa*	Lycosidae	0.13	0	0.25	0	0	0	0
15	*Pardosa shyamae*	Lycosidae	0	0	0	0	0	0	0.27
16	*Pardosa* sp.	Lycosidae	0.15	0	0.34	0	0	0	0.26
17	*Pardosa sumatrana*	Lycosidae	0.23	0	0.23	0	0	0	0
18	*Larinia* sp.	Tetragnathidae	0	0	0.22	0	0	0	0
19	*Leucauge celebesiana*	Tetragnathidae	0	0	0.19	0	0	0	0
20	*Tetragnatha fletcheri*	Tetragnathidae	0.20	0.20	0.15	0	0.28	0.2	0
21	*Tetragnatha javana*	Tetragnathidae	0	0	0.13	0	0	0	0
22	*Tetragnatha mandibulata*	Tetragnathidae	0.18	0.22	0.24	0	0.18	0.17	0
23	*Tetragnatha maxillosa*	Tetragnathidae	0.27	0.22	0.17	0	0.37	0.29	0
24	*Tetragnatha moulmeinensis*	Tetragnathidae	0.14	0.21	0.25	0	0.32	0.24	0
25	*Tetragnatha okumae*	Tetragnathidae	0	0	0	0	0	0.27	0
26	*Tetragnatha* sp.	Tetragnathidae	0.2	0.20	0.17	0.12	0.24	0.26	0
27	*Tetragnatha sutherlendi*	Tetragnathidae	0	0	0.22	0.14	0	0	0
28	*Zygeilla indica*	Tetragnathidae	0	0	0.18	0.21	0	0.21	0.19
29	*Zygeilla malanocrania*	Tetragnathidae	0	0	0	0	0.18	0	0
30	*Zygeilla* sp.	Tetragnathidae	0	0	0.22	0.24	0.12	0.36	0
31	*Araneus* sp.	Araneidae	0	0	0.15	0.25	0.21	0.3	0
32	*Argiope anasuja*	Araneidae	0	0	0.21	0	0.20	0	0
33	*Argiope minute*	Araneidae	0	0	0.17	0	0.18	0	0
34	*Argiope* sp.	Araneidae	0	0.31	0.29	0	0	0	0
35	*Cyclosa hexatuberculata*	Araneidae	0	0	0.23	0	0	0	0
36	*Cyclosa moulmeinensis*	Araneidae	0	0	0.24	0	0.12	0	0
37	*Cyrtophora cicatrosa*	Araneidae	0	0	0.27	0	0.15	0	0
38	*Gibbaranea bituberculata*	Araneidae	0	0	0.23	0	0.17	0	0
39	*Neoscona excelsus*	Araneidae	0	0.22	0.21	0	0	0	0
40	*Neoscona mukerjei*	Araneidae	0	0	0.12	0.27	0.31	0.33	0
41	*Neoscona* sp.	Araneidae	0	0	0.18	0.22	0.22	0.18	0
42	*Neoscona theisi*	Araneidae	0.25	0	0.24	0.27	0.22	0.24	0
43	*Argyrodes cyrtophore*	Theridiidae	0	0	0.09	0	0	0	0
44	*Argyrodes* sp.1	Theridiidae	0	0	0.20	0	0	0.24	0
45	*Argyrodes* sp.2	Theridiidae	0	0	0.18	0	0	0	0
46	*Theridula* sp.1	Theridiidae	0	0	0.29	0	0	0	0
47	*Theridula* sp.2	Theridiidae	0	0	0.18	0	0	0	0
48	*Theridon* sp. 1	Theridiidae	0	0	0.30	0.21	0	0	0

S.N.	Scientific Name	Family	Density of spiders in different habitats of ecosystems*						
			Natural ecosystems			Agroecosystems			Domestic ecosystem
			a	b	c	d	e	f	g
49	*Theridion manjithar*	Theridiidae	0	0	0.09	0.36	0	0	0
50	*Theridion* sp. 2	Theridiidae	0	0	0.14	0	0	0	0
51	*Marapissa dhakuriensis*	Salticidae	0	0	0	0	0	0	0.13
52	*Marapissa* sp.	Salticidae	0.20	0.16	0.18	0.19	0.22	0	0.21
53	*Phidippus* sp.	Salticidae	0.21	0	0.2	0.13	0	0	0.23
54	*Plexyppus payakullii*	Salticidae	0	0	0	0	0	0	0.18
55	*Rhene* sp.	Salticidae	0	0.18	0	0	0	0	0.29
56	*Plexyppus* sp.	Salticidae	0	0	0.09	0	0	0	0
57	*Mesumenoides* sp.	Thomisidae	0	0	0	0	0	0	0.28
58	*Thanatus stripatus*	Thomisidae	0	0	0.21	0.13	0	0	0
59	*Thomisus andamanensis*	Thomisidae	0	0	0.17	0	0	0	0
60	*Thomisus pugilis*	Thomisidae	0	0	0.17	0	0	0.28	0
61	*Xysticus* sp.	Thomisidae	0	0	0.21	0	0	0	0
62	*Oxyopes ratnae*	Oxyopidae	0.13	0	0.14	0	0.20	0.16	0
63	*Oxyopes* sp.	Oxyopidae	0	0	0.18	0.23	0	0.17	0.35
64	*Peucetia* sp.	Oxyopidae	0	0	0.23	0	0	0.22	0
65	*Peucetia viridana*	Oxyopidae	0	0	0.28	0	0	0	0
66	*Philodromus shillongensis*	Philodromidae	0.17	0	0	0.14	0	0	0
67	*Philodromus* sp.	Philodromidae	0.17	0	0	0.18	0	0	0.25
68	*Tibellus* sp.	Philodromidae	0	0	0.17	0	0	0	0
69	*Cheiracanthium* sp.	Miturgidae	0.22	0	0	0	0.08	0	0
70	*Cheiracanthium saraswati*	Miturgidae	0.29	0	0	0	0.33	0	0
71	*Cheiracanthium danieli*	Miturgidae	0.27	0	0	0	0.21	0	0
72	*Uloborus krishnae*	Uloboridae	0	0	0.27	0	0	0	0
73	*Uloborus danolius*	Uloboridae	0	0	0.08	0	0	0	0
74	*Castianeria* sp.	Corinnidae	0	0	0.23	0	0	0.2	0
75	*Stegodyphus sarasinorum*	Eresidae	0	0	0.18	0	0	0	0
76	*Pritha* sp.	Filistatidae	0	0.20	0	0	0	0	0
77	*Hersilia savignyi*	Hersilidae	0	0.12	0.19	0	0.20	0.22	0.30
78	*Crossoprise lyoni*	Pholcidae	0.22	0	0.27	0	0	0.17	0
79	*Tinus* sp.	Pisauridae	0.19	0	0.14	0	0	0	0
80	*Scytodes* sp.	Scytodidae	0	0	0	0	0	0.23	0
81	*Selenops* sp.	Selenopidae	0	0	0	0	0.19	0	0
82	*Olios* sp.	Sparasidae	0	0	0.30	0	0	0	0

*(a) Grassland, (b) Treescapes (c) Barren land , (d) Red gram field, (e) Rice paddy field, (f) Cotton field, (g) Human settlements

Barren lands showed the greatest density (13 individuals m^{-2}) followed by cotton and rice paddy field (5 individuals m^{-2}), grassland and domestic (human residential); ecosystem (4.2 and 3.6 individuals m^{-2}, respectively), and the lowest density was found in treescapes (2.2 individuals m^{-2}; Figure 2).

Barren land included the greatest richness of spiders, with 64 species (36.78% of the total spiders recorded in this study) followed by rice paddy field (23 species; 13.22%), cotton field (22 species; 12.64 %), grassland (21 species; 12.07%) and red gram field (17 species; 9.77%).The lowest spider richness was in treescapes (11 species; 6.32%).In agroecosystems, spider richness was similar across different crop ecosystems, with red gram field, rice paddy field, and cotton field including 17, 23, and 22 species respectively. The

number of species from domestic ecosystems was similar to the values found in agroecosystems (Table 3).

The Simpson Indices (D) for all the studied ecosystems ranges between 0.06 and 0.01. Simpson Index (D) reveals that natural ecosystems are more diverse (0.01), followed by agricultural ecosystems (0.03) and domestic ecosystem (0.06). Among the habitats, the barren land holds high diversity (0.03) followed by grasslands, rice paddy field, cotton field (0.04), red ream field (0.06) and treescapes (0.09). Shannon-Wiener Index (H) shows less community complexity of spiders in domestic ecosystems (2.73), moderate community complexity in agricultural system (3.53) and high community complexity (4.12) in natural ecosystems (Table 3).

The family level composition of spiders in various habitats, revealed maximum number 15 in barren land, 10 in cotton field, 9 in grassland, 8 in red gram field, 7 each in domestic and rice paddy field and least (5) in treescapes Among the 9 families of spiders represented in grasslands. The two families Lycosidae and Tetragnathidae were dominant (23.81% of recorded species) followed by Miturgidae (14.29%) and Philodromidae (9.52%). Tetragnathidae was the dominant family in treescapes represented by 45.45% of the species. In barren lands of the 15 families, the Lycosidae has high dominance (20.31%) followed by Araneidae (18.75%), Tetragnathidae (17.19%) and Theridiidae (12.50%). Among the 8 families of spiders in red gram field, Tetragnathidae and Araneidae were equally dominant

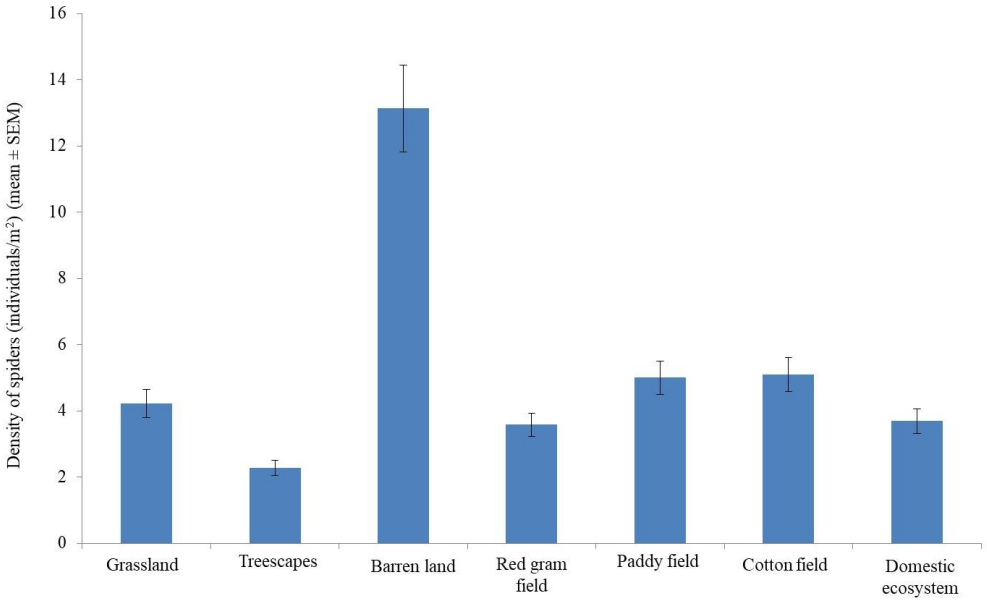

Figure 2. Density of spiders in various habitats of the studied ecosystems. Standard error of means (SEM) is also shown with the bars

Table3. Diversity, composition of spider species, their families in different ecosystems of study region

HABITATS OF SPIDERS	Families	Total species	%	Simpson Index (D)	Shannon-Wiener Index (H)
Natural ecosystem				**0.01**	**4.12**
(a) Grassland	9	21	12.07	0.04	3.01
(b) Treescapes	5	11	6.32	0.09	2.37
(c) Barren land	15	64	36.78	0.03	4.10
Agriculture ecosystem				**0.03**	**3.53**
(d) Red gram field	8	17	9.77	0.06	2.79
(e) Rice paddy field	7	23	13.22	0.04	3.08
(f) Cotton field	10	22	12.64	0.04	3.06
Domestic ecosystem	**7**	**16**	**9.20**	**0.06**	**2.73**

Table 4. Family composition, species richness within families (N) and relative dominance of families (%) in different habitats nested within different ecosystems of the study area

Family	Grasslands		Treescapes		Barren lands		Redgram Field		Rice Paddy Field		Cotton Field		Human settlement	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Lycosidae	5	23.81			13	20.31	1	5.88			1	4.55	6	37.50
Tetragnathidae	5	23.81	5	45.45	11	17.19	4	23.53	7	30.43	8	36.36	1	6.25
Araneidae	1	4.76	2	18.18	12	18.75	4	23.53	9	39.13	4	18.18		
Theridiidae					8	12.50	2	11.76			1	4.55		
Salticidae	2	9.52	2	18.18	3	4.69	2	11.76	1	4.34			5	31.25
Thomisidae					4	6.25	1	5.88			1	4.55	1	6.25
Oxyopidae	1	4.76			4	6.25	1	5.88	1	4.34	3	13.64	1	6.25
Miturgidae	3	14.29							3	13.04				
Philodromidae	2	9.52			1	1.56	2	11.76					1	6.25
Uloboridae					2	3.13								
Corinnidae					1	1.56					1	4.55		
Eresidae					1	1.56								
Filistatidae			1	9.09										
Hersilidae			1	9.09	1	1.56			1	4.34	1	4.55	1	6.25
Pholcidae	1	4.76			1	1.56					1	4.55		
Pisauridae	1	4.76			1	1.56								
Scytodidae											1	4.55		
Selenopidae									1	4.34				
Sparasidae					1	1.56								
Total Species	21	100	11	100	64	100	17	100	23	100	22	100	16	100
Families	9		5		15		8		7		10		7	

* N -Number of Species

(23.53%) followed by Theridiidae, Salticidae and Philodromidae (11.76%). In rice paddy field 39.13% of the species were Araneidae, while and next most dominant family was Tetragnathidae (30.43%). In cotton field the most and second-most dominant families were Tetragnathidae (36.36%) and Araneidae (18.18%) respectively. The Lycosidae was the dominant family in domestic ecosystems (37.50%) followed by Salticidae (31.25%). The family Lycosidae was also the dominant family in grasslands and barren lands (Table 4).

The genera of spiders were further classified into functional groups based on hunting behavior (hunter, web builder, ambusher) and daily activity (diurnal and nocturnal) (Table 5). Among the species, 92.7% were diurnal while 7.3% were nocturnal. Six species of four families namely Miturgidae, Filistatidae, Selenopida, Sparasidae were found to be nocturnal in nature. Out of these species, three species belonged to genus *Cheiracanthium* (Miturgidae) and one species each from the genera *Pritha* (Filistatidae), *Selenops* (Selenopida) and *Olio* (Sparasidae). Hunting behaviour indicates that 43% species belonging to six families were web builders followed by hunters (41.46%) from 8 families and ambusher (14.63%) from five families (Table 5).

DISCUSSION

The objective of the study was to measure the species richness in various habitats of three major ecosystems in the semiarid area of Gogi (Yadgir District, Karnataka) in 2011-2012. Pitfall trap, net collection and beating methods were chosen considering the nature and complexity of various habitats in the semiarid landscape. Several researchers have studied the spider diversity in semiarid regions of India. Siliwal et al. (2003) reported 116 species of spiders belonging to 66 genera and 25 families in Purna Wildlife Sanctuary of Gujarat and Araneidae family was found dominating. However, in our study region Lycosidae was a dominant family. Patel

Table 5. Hunting behaviour and daily activity of recorded spider genera

S.N.	Family	Genus	No.of species	Hunting behavior	Daily Activity
1	Lycosidae	*Arctosa*	1	Hunter	Diurnal
2		*Hippasa*	1	Hunter	Diurnal
3		*Lycosa*	5	Hunter	Diurnal
4		*Pardosa*	10	Hunter	Diurnal
5	Tetragnathidae	*Larinia*	1	Web builder	Diurnal
6		*Leucauge*	1	Web builder	Diurnal
7		*Tetragnatha*	8	Web builder	Diurnal
8		*Zygiella*	3	Web builder	Diurnal
9	Araneidae	*Araneus*	1	Web builder	Diurnal
10		*Argiope*	3	Web builder	Diurnal
11		*Cyclosa*	2	Web builder	Diurnal
12		*Cyrtophora*	1	Web builder	Diurnal
13		*Gibbaranea*	1	Web builder	Diurnal
14		*Neoscona*	4	Web builder	Diurnal
15	Theridiidae	*Argyrodes*	3	Web builder	Diurnal
16		*Theridula*	2	Web builder	Diurnal
17		*Theridion*	3	Web builder	Diurnal
18	Salticidae	*Marapissa*	2	Hunter	Diurnal
19		*Phidippus*	1	Hunter	Diurnal
20		*Plexyppus*	2	Hunter	Diurnal
21		*Rhene*	1	Hunter	Diurnal
22	Thomisidae	*Mesumenoides*	1	Ambusher	Diurnal
23		*Thanatus*	1	Ambusher	Diurnal
24		*Thomisus*	2	Ambusher	Diurnal
25		*Xysticus*	1	Ambusher	Diurnal
26	Oxyopidae	*Oxyopes*	2	Hunter	Diurnal
27		*Peucetia*	2	Hunter	Diurnal
28	Philodromidae	*Philodromus*	2	Ambusher	Diurnal
29		*Tibellus*	1	Ambusher	Diurnal
30	Miturgidae	*Cheiracanthium*	3	Hunter	Nocturnal
31	Uloboridae	*Uloborus*	2	Ambusher	Diurnal
32	Corinnidae	*Castianeria*	1	Hunter	Diurnal
33	Eresidae	*Stegodyphus*	1	web builder	Diurnal
34	Filistatidae	*Pritha*	1	Web builder	Nocturnal
35	Hersilidae	*Hersilia*	1	Ambusher	Diurnal
36	Pholcidae	*Crossoprise*	1	Web builder	Diurnal
37	Pisauridae	*Tinus*	1	Ambusher	Diurnal
38	Scytodidae	*Scytodes*	1	Hunter	Diurnal
39	Selenopidae	*Selenops*	1	Hunter	Nocturnal
40	Sparasidae	*Olios*	1	Hunter	Nocturnal

(2003) studied the spiders of Vansda National Park, Gujarat and reported 124 species of spiders belonging to 67 genera and 22 families. Deshmukh et al. (2014) have recorded 104 spider species belonging to 52 genera and 18 families from Salbardi forest (Satpura Range), Maharashtra, India and found Salticidae a dominant family. Archana (2011) and Lawania et al. (2013) studied spiders of Toranmal Sanctuary, Maharashtra, India and Deeg (Bharatpur, Rajasthan), respectively and found family Araneidae to dominate in the agricultural fields. We also found Araneidae to be the dominant family in the agroecosystem. Saini et al. (2012) reported maximum species richness of spiders in woodland due to dense canopy and availability of more prey. Our study also recorded the highest spider species richness in natural ecosystems, followed by agroecosystems, and this may reflect the degree of disturbance in these eco-system types.

Among the habitats, the highest numberof spiders were found in barren lands followed by the rice paddy field, cotton field and red gram field. The grasslands of natural ecosystems had a similar diversity to the various land use types in agroecosystems. Grasslands have high disturbance levels due to grazing and collection of fodder for livestock and therefore, represent low species rich-ness. Few species were found in treescapes. The tree species in the study area undergo high biotic pressure for fulfilling the requirement of fuel, edible, fodder and miscellaneous purpose (Nautiyal et al. 2015), hence influence the species occurrence. Agriculture intensification has resulted in losses of natural and semi-natural habitats and their associated floral and faunal diversity (Moser et al. 2002, Biaggini et al. 2007). Decline in invertebrate populations have been empirically linked toreductions in landscape heterogeneity and significant use of insecticides by several researchers (Biaggini et al. 2007, Finch et al. 2007). Our study shows that invertebrate diversity could be valuable indicators of landscape degradation, and that the spiders has significant value as indicator taxa, given the ecological roles they play in diverse landscapes. Apart from providing baseline information on spiders, this study enables further investigation of the contribution to ecosystem services by these invertebrates in semiarid landscapes dominated by agriculture.

ACKNOWLEDGEMENTS

This study was conducted at the Institute for Social and Economic Change, Bangalore, India. We are thankful to the Department of Atomic Energy, Board of Research in Nuclear Sciences, Bhabha Atomic Research Centre for funding the research project titled ‘‘Baseline Study of Flora and Fauna at the Proposed Uranium Mining Site At Gogi, Gulbarga District (Karnataka)’. We thank Late

Prof. B.H. Patel, Patel Society, Anand, Gujarat for helping us in the identification of spider species.

Author Contributions

Sunil Nautiyal, Y.D. Imran Khan and K. Bhaskar have done the field work and studied various habitats for spider diversity. Sunil Nautiyal, H. Kaechele, YD Imran Khan analysed the data statistically, tabulated the results, and wrote the manuscript.

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Received 18 May 2017
Accepted 12 August 2017