

BIODIVERSITY AND HABITAT PREFERENCE OF SPIDER FAUNA IN EASTERN REGION OF RAJASTHAN AND ITS CATCHMENT AREA

¹Krishna Kant Lawania, ²Priyanka Mathur

¹Researcher, ²Head of Department
Department of Zoology
IIS University, Jaipur- 302020, Rajasthan

ABSTRACT: A pioneering study was conducted to reveal the spider diversity in the habitats of eastern region of Rajasthan, one of the most biodiversity hot spots of the India. A total of 51 species of spiders belonging to 40 genera of 17 families were collected from this area during Nov. 2012 to Dec. 2016. This represents 5% of the total families recorded in India. Guild structure analysis of the collected spiders revealed 7 feeding guilds viz., Irregular web weaver, Sheet web weaver, Funnel web weaver, Orb-web weaver, Single-line web weaver, dome shape web weaver and ambushers. The families Araneidae and Salticidae exhibited maximum species diversity. The dominant family was Araneidae with 12 species. The most striking feature of the spider fauna of eastern region of Rajasthan is the number of new records. The high species diversity of spiders in said area can be attributed to the high diversity of plants and insects. This is the first report of the spider fauna from eastern region of Rajasthan.

Keywords: Eastern region of Rajasthan, spiders, habitats, diversity, guild structure.

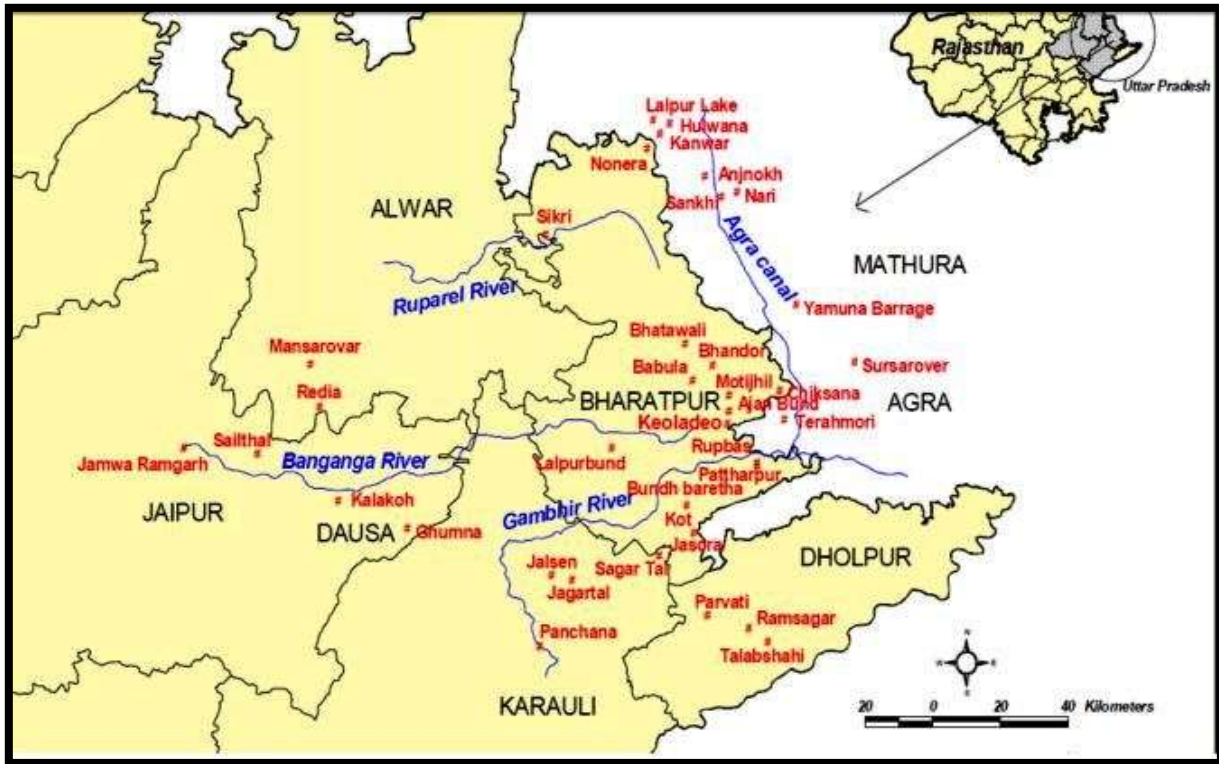
1. INTRODUCTION

In India the conservation efforts have focused on higher vertebrates and invertebrates have largely been ignored. The Arachnids are one such important group. Spider can regulate large population of insect and other invertebrate in most ecosystems (Russell-Smith, 1999). Therefore, there is a growing need to study this group. Spiders belong to order Araneae of class Arachnida (Latin arānea means spider). They are exclusively predator, with body divisible in two parts, prosoma or cephalothorax and abdomen or opisthosoma. They have eight legs attached to the cephalothorax. They possess varied distributions both in habitat, depending upon their site suitability and feeding behaviour, they are found in almost all types of ecosystems. There are mainly two major groups of spiders: old day spiders i.e. Mygalomorphs and present day spiders i.e. Araneomorphs. Spiders, having eight eyes and capacity of secreting silk and spinning web, with the help of spinnerets, make them easily distinguishable from insects. Spiders play a very important role, being a dominant predator of insects' pests. Spiders can maintain a dynamic interaction of the ecological units in a micro level food web. In Integrated crop Pest Management it can serve as an essential element. They are efficient natural controller of many insect mediated diseases like malaria, dengue etc. Spiders being ecologically important are economically beneficial also. In pharmaceutical industries spider silk and venom are now very important industrial inputs. Spider silk being proteinaceous and antibacterial in nature with very high tensile strength is not only helpful in spinning web, wrapping the prey, egg sac covering, medium of transportation or movement from one place to another but also for making surgical threads, bullet proof jackets and threads of musical instruments, while its venom is useful as antidote in many ailments. Abundance as well as diversity of spiders is a good indicator of the health of a particular ecosystem. In different bio-geographic regions of India, several European arachnologists and later by Indian Arachnologists studied spider fauna and diversity. Review of available literature reveals that Blackwall (1867); Stoliczka (1869); Karsch (1873) and Pocock (1900) were the pioneer Arachnologist of Indian spiders. They reported many species from Burma, Sri Lanka and India. Tikader (1980; 1982); Tikader and Malhotra (1980a, b) described many Indian spiders. Tikader (1980) published a book on Thomisid spiders in India, comprising two subfamilies, 25 genera and 115 species. Tikader and Biswas (1981) studied 99 species under 47 genera in 15 families from Calcutta and surrounding areas. Pocock (1900 a, b) and Tikader (1980; 1987) provided major contributions to the Indian Arachnology. Pocock (1900) described 112 species of spiders from India. His book gave the earlier list of spiders' families, in India. Tikader (1987) also studied Indian Spider and published first comprehensive list of Indian spiders, which included 43 families belonging to 249 genera 1067 species. Eastern area of Rajasthan with its varied geographic, climatic, and ecological features exhibits a rich assemblage of different types of spiders' species. However, no studies on their diversity have ever been undertaken here; with the result that many of the spider species still remain unnamed and unrecorded. Some studies taken by lawania2013(a,b,c,d,e,f).Further, environmental pollution and deforestation have led many spider species to the verge of extinction. Hence the present work is conducted with a goal to find the objectives envisaged in the proposal mentioned below.

2. MATERIAL AND METHODS

2.1 Study area- The present work has been carried out in forest and agriculture fields of Eastern region of Rajasthan (India). The Eastern region of Rajasthan (Map-1) covers mainly Bharatpur district and some micro habitat areas of Dholpur and Karoli district

(27.2170°N 77.4895°E) in Rajasthan. It was earlier known as “Braj”. This dense forest region has wide diversity of habitats ranging from marshes, grasslands, woodlands, scrublands. South-West monsoon brings rainfall during the month of June to September. The average monthly temperature is 4 °C in December and 42 °C in June. The humidity in winter season is as low as 42% in the month of February and as high as 89% in the month of August. Eastern Region of Rajasthan lies at the confluence of the Gambhir and Banganga rivers. The area lies between 27°2170 North Latitude and 77° 4895 East Longitude. It is a low lying area in the floodplains of river Banganga and Gambhir which are tributaries of river Yamuna covering an area of about 5099 sq. km. It is situated 180 km from Delhi, along the Delhi – Jaipur Highway, 50 km from Agra.



Map – 1- High value biodiversity areas (HVBA) of Eastern region of Rajasthan



Map – 2- Location Map of Eastern region of Rajasthan

2.2 Methods of collection - In total 24 study sites were chosen. Spiders were collected and counted by the two quantitative methods viz- Transect method (50 m x 10 m transects, with two transects per site) and quadrat method (20 m x 10 m quadrat, with 5-5 quadrat in per site and 10-10 quadrates in 15th & 16th sites.

(a) Field Methods: Well standard sampling protocols were adopted for spider collection in different sites of sampling. The detailed descriptions of this collection techniques are-

(i) Sweep Netting- this method is used to collect the foliage spiders is collated by this sampling method from herbs shrubs and low level vegetation (up to 2 m in height). The sweep net consists of a 90 cm handle; 40 cm ring.

(ii) Ground Hand Collecting- Knee level spider samples collected from this collection method. This method of sampling is used to collect the spiders, in the ground, litter, in broken logs, rocks which are found to be visible.

(iii) Aerial Hand Collecting- This collection method involved the collection of species of spiders from knee level to arm length level. This method accessed free-living and web-building spiders on the stems of living or dead shrubs, high herbs, foliage and tree trunks etc.

(iv)Vegetation Beating- This method is used to access spiders living in the shrub, high herb vegetation, bushes, branches and small trees. In this method spiders were collected on a cloth (1 m by 1.2 m) by beating high herbs vegetation, dead shrubs and high herbs with a stick.

(v) Litter sampling- Specimens were collected by hand. Litter sampling involves sorting of spiders from the litter collection tray.

(vi) Pitfall sampling- Wet pitfall trap method was used to study the ground dwelling spiders. The pitfall traps consisted of a 9 cm wide by 16 cm deep plastic jar, two-third filled with 70% ethyl alcohol and a few drops of liquid soap/detergent. The pitfall traps were left open for a period of three days. The distance between two adjacent jars was 5 meter.

2.3 Post collection work:

2.3.1 Taking photographs:

After coming to the laboratory, the animals were sorted according to the family and then photographs were taken by using super-macro lens of Fuji fine pix S2950 camera model No. 1TU83456. For each spider, photographs were taken from dorsal, ventral and lateral view-after slightly narcotizing them with 70 % alcohol. A brush dipped in 70 % ethyl alcohol was touched at pedicel of spider which slowed down their movements.

2.3.2 Preserving the specimen:

After taking the habitats photographs, the legs and palps of the spiders were manipulated and made straight by dipping them in warm water to make their legs straight and after this they were transferred immediately in a petridish with 70% ethyl alcohol. Legs and palps were again made straight and properly oriented. Plastic U- pins were kept on spider legs and palps as weight, due to weight they are unable to fold back. Spider was kept properly oriented petridish and covered for 24 hours, to prevent the evaporation of alcohol.

2.3.3 Studies under stereozoom microscope:

After 24 hours of proper fixation, after this spiders specimen were stored in plastic bottles/ glass of proper size in legs spread condition, properly labelled or taken for further study. Initially the measurements of cephalothorax, abdomen, whole body (from dorsal side), leg segments and palp segments (from ventral side) were taken in mm by digital microscope.

Then the specimen was cleaned gently by brush to remove any dust particles trapped in between the body hairs. Chelicerae were made straight and then photographs of eye arrangements, cephalothorax, and abdomen were taken from dorsal side. From ventral side photographs of sternum, labium and endites (maxillae), chelicerae showing the teeth on pro and retro margins, abdomen, external epigyne, spinnerates etc. were taken. Photographs of leg segments were also taken showing trichobothria, hairs/spines, calamistrum, claws, etc. All these photographs were used for spider identification.

2.3.4 Dissection: After taking necessary photographs with MIPS (Magnus Image Processing System), the female spiders were dissected for genitalia to show internal epigyne. After its proper removal, it was made clear by using 10% KOH later it was washed with absolute alcohol and then kept it in 70% alcohol overnight. After this, photographs of internal epigyne were taken using MIPS. The same procedure is repeated for male spiders wherein preferably pedipalp of left side was made clear and transparent either removing it or in situ and then photographs were taken from its dorsal, ventral and lateral sides for proper identification of a species.

2.3.5 Identification of spiders: Up to family, genus and species level all adult specimens were identified. The identification of spiders on the basis of morphometric characters the detail structure of pedipalp of male spiders and epigyne of female.

3. RESULT AND DISCUSSION

The study was performed on 24 study sites of the said region. Spiders were collected and counted by most of the two quantitative methods viz- Transect method (with two transects per site and 50 m x 10 m transects,) and quadrat method (20 m x 10 m quadrates, with 5-5 quadrat per site and 10-10 quadrates in 15th & 16th site. These transect and quadrates were treated as our basic sampling units. Transects and quadrates were placed randomly within stratified habitat types. Sampling was carried out between July 2012 – Dec.2016. Spiders were sampled along these transects and quadrates using six sampling techniques (semi-quantitative sampling and pitfall traps). The main purpose of this sampling design was to produce a relatively complete species list and associated abundance data for a representative example of each habitat type in the region, and of the region as a whole.

Table-1- Inventory of spiders in Eastern Region

Family	Species	Common name of the spider	Ecosystem/ Habitat in which species was collected in Eastern Region of Rajasthan.			Ind. Sp. Count
			Woodland	Grassland	Wet land	
Araneidae (Clerck,1757)	(i) <i>Araneus</i> sp. (Female) (sp. nov.)	Orb- weaver spider	++	--	--	27
	(ii) <i>Argiope aemula</i> (Female) (Walckenaer, 1842)	Orb- weaver spider	++	--	--	119
	(iii) <i>Cyclosa moonduensis</i> (Female&Male) (Tikader, 1963)	Orb- weaver spider	++	--	--	78+34
	(iv) <i>Cyrtophora cicatrosa</i> (Female) (Stoliczka,1869)	Orb- weaver spider	++	++	--	82
	(v) <i>Cyrtophora citricola</i> (Female) (Forskal,1775)	Orb- weaver spider	++	++	--	93
	(vi) <i>Eriovixia excelsa</i> (Female) (Simon,1889)	Orb- weaver spider	++	--	--	23
	(vii) <i>Larinia chloris</i> (Female&Male) (Audouin, 1826)	Orb- weaver spider	++	++	++	93+37
	(viii) <i>Neoscona mokerjei</i> (Female) (Tikader, 1980)	Orb- weaver spider	++	--	--	61
	(ix) <i>Neoscona crucifera</i> (Female) (Lucas, 1839)	Orb- weaver spider	++	--	--	19
	(x) <i>Neoscona nautica</i> (Female) (C.L. Koch,1875)	Orb- weaver spider	++	--	--	15
	(xi) <i>Neoscona theisi</i> (Female) (Walckenaer,1841)	Orb- weaver spider	++	--	--	103
	(xii) <i>Zyngella indica</i> (Female) (Tikader and Bal, 1980)	Orb- weaver spider	++	--	--	43
Clubionida (Wagner, 1887)	(i) <i>Clubiona filicata</i> (Female) (O. P.-Cambridge, 1874)	sac spider	--	++	++	53
Filistatida (Ausserer, 1867)	(i) <i>Pritha</i> sp. (Male) (sp. nov.)	crevice weaver spiders	++	++	--	11
Gnaphosidae (Pocock, 1898)	(i) <i>Drassodes luridus</i> (Female) (O. P.-Cambridge,1874)	Flat-bellied ground spider	--	++	--	56
	(ii) <i>Zelotes shantae</i> . (Female) (Tikader,1982)	Flat-bellied ground spider	--	++	--	12
Hersilidae (Thorell, 1870)	(i) <i>Hersillia savingyi</i> (Female) (Lucas,1836)	Two-tailed spider	--	++	++	21
Lycosidae (sundevall, 1833)	(i) <i>Pardosa pseudoannulata</i> (Female & Male) (Bösenberg & Strand,1906)	Wolf spider	--	++	++	40+27
	(ii) <i>Wadicosa fidelis</i> (Female) (O. P. Cambridge,1872)	Wolf spider	--	++	++	16
Oxyopidae (Thorll, 1870)	(i) <i>Oxyopes biramanicus</i> (Female) (Thorell,1870)	Lynx spider	++	++	--	101
	(ii) <i>Oxyopes ck. kohensis</i> (Female) (Bodkhe & Vankhede, 2012)	Lynx spider	++	++	--	36
	(iii) <i>Oxyopes pankaji</i> (Female & Male)	Lynx spider	++	++	--	122+23

	(Gajbe & Gajbe,2000)					
	(iv) <i>Oxyopes</i> sp. (Female) (sp. nov.)	Lynx spider	++	++	--	6
Pholcidae (C.L. Koch,1850)	(i) <i>Artema atlanta</i> (Female) (Walckenaer, 1837)	Daddy-long-leg spider/ Cellar spider	++	--	--	104
	(ii) <i>Crossopryza lyoni</i> (Female) (Blackwall,1867)	Daddy-long-leg spider/ Cellar spider	++	--	--	92
	(iii) <i>Pholcus phalangiodes</i> (Female) (Fuesslin, 1775)	Daddy-long-leg spider/ Cellar spider	++	--	--	42
Pisauridae (Simon, 1890)	(i) <i>Hygropoda</i> sp. (Female) (sp. nov.)	Fish eating spider /Nursery web spider	--	++	++	6
	(ii) <i>Nilus albocinctus</i> (Female) (F. O. P.-Cambridge,1898)	Fish eating spider /Nursery web spider	--	++	++	69
Salticidae (Blackwall,1841)	(i) <i>Hyllus semicupreus</i> (Female) (Simon,1885)	Jumping spider	++	++	++	72
	(ii) <i>Menemerus bivittatus</i> (Female&Male)(Dufour,1831)	Jumping spider	++	++	++	69+39
	(iii) <i>Myrmarachne</i> sp. (Female) (sp. nov.)	Jumping spider	++	++	++	55
	(iv) <i>Phintella vittata</i> (Female&Male) (C. L. Koch,1846)	Jumping spider	++	++	++	76+33
	(v) <i>Plexippus paykulli</i> (Female&Male) (Audouin,1826)	Jumping spider	++	++	++	166+83
	(vi) <i>Plexippus petersi</i> (Female) (Karsch, 1878)	Jumping spider	++	++	++	87
	(vii) <i>Telamonia dimidiata</i> (Female&Male) (Simon,1899)	Jumping spider	++	++	++	110+50
	(viii) <i>Thyene imperialis</i> (Female) (Rossi,1846)	Jumping spider	++	++	++	83
Scytodidae (Blackwall,1841)	(i) <i>Scytodes fusca</i> (Female) (Walckenaer, 1837)	Spitting spiders	--	++	++	11
	(ii) <i>Scytodes thoracica</i> (Female) (Latreille, 1802)	Spitting spiders	--	++	++	13
Selenophidae (Simon, 1897)	(i) <i>Selenopes insularis</i> (Female) (Keyserling, 1881)	Wall crab spider	++	++	--	53
Sparassidae (Bertkau, 1872)	(i) <i>Olios millet</i> (Female) (Pocock,1901)	Huntsman spider	--	++	++	43
	(ii) <i>Olios obesulus</i> (Female) (Pocock,1901)	Huntsman spider	--	++	++	25
Tetragnathidae (Menge, 1866)	(i) <i>Guizygiella melanocrania</i> (Female) (Thorell, 1887)	Long-jawed spider/ Water orb weaver	++	++	++	40
	(ii) <i>Leucauge decorata</i> (Female) (Blackwall,1864)	Long-jawed spider/ Water orb weaver	++	++	++	69
	(iii) <i>Tetragnatha</i> sp. (Female) (sp. nov.)	Long-jawed spider/ Water orb weaver	++	++	++	31
Therididae (sundevall, 1833)	(i) <i>Tylorida ventralis</i> . (Female) (Thorell, 1877)	Cob web spider/ Comb footed spider	++	++	--	44
Thomisidae (sundevall, 1833)	(i) <i>Misumenops celer</i> (Female) (Hentz, 1847)	Crab spider	++	++	--	64
	(ii) <i>Philodromus</i> sp. (Female) (sp. nov.)	Crab spider	++	++	--	76
	(iii) <i>Tmarus</i> sp. (Male) (sp. nov.)	Crab spider	++	+	--	7
Uloboridae (Thorell, 1869)	(i) <i>Uloborus plumipes</i> (Female) (Lucas, 1846)	Feather legged spider/hackled-orb web spider	++	++	--	77
	(ii) <i>Uloborus</i> sp. (Female) (sp. nov.)	Feather legged spider/hackled-orb web spider	++	++	--	22

(iii) <i>Zosis genuculata</i> (Male) (Olivier,1789)	Feather legged spider/hackled-orb web spider	++	++	--	28
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Total Families- 17
Total Species- 51

Total Genus- 40
F (Female)- 48, M (Male)- 11

Dominance of Habitat - Woodland> Grassland> Wetland

Dominance of sp. Habits- Hunting spider >Web builder

Dominance of seasons- Monsoon> Winter> Summer

Dominance of family-

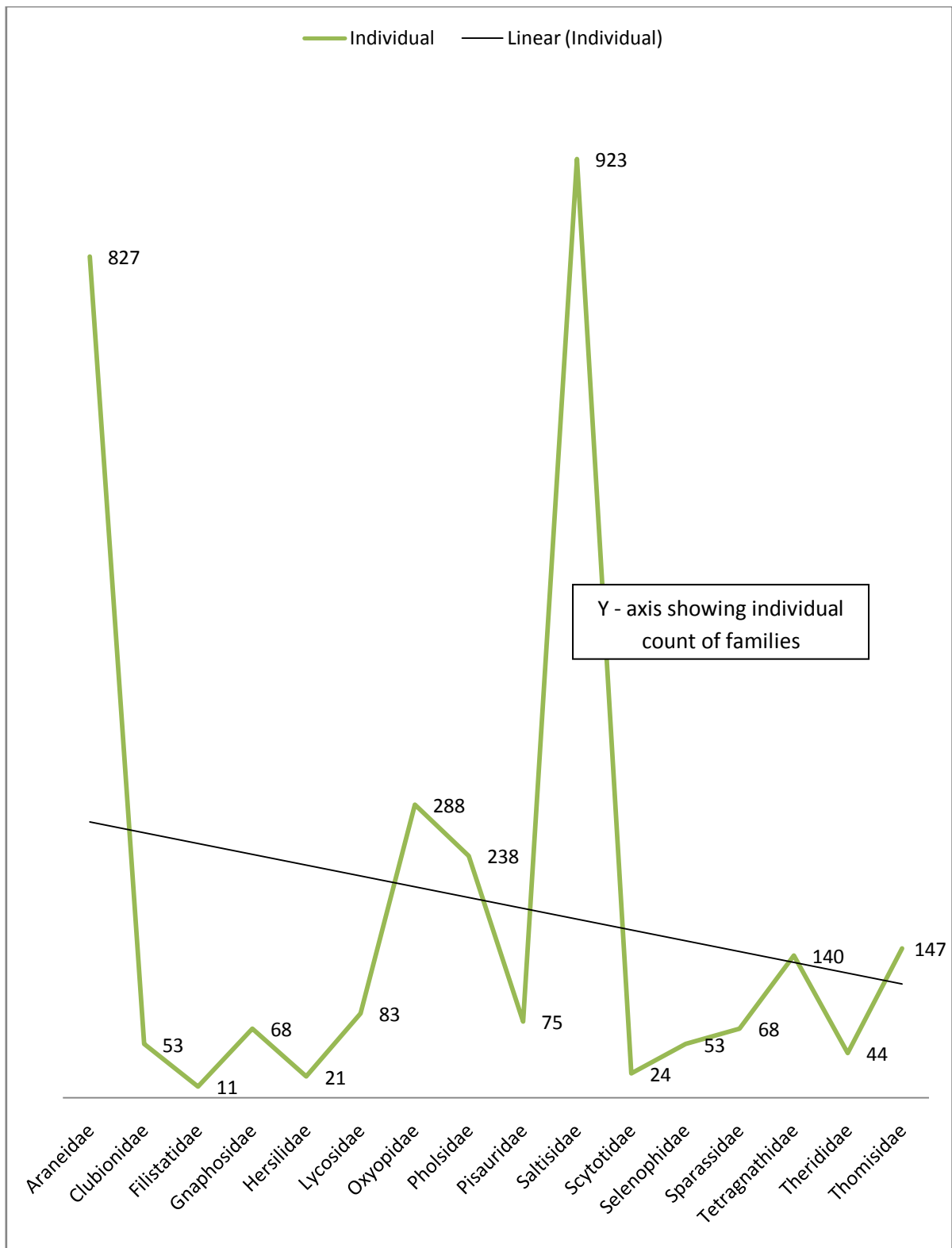
Araneidae > Salticidae > Oxyopidae > Lycosidae ≈ Pholcidae ≈ Tetragnathidae ≈ Thomisidae ≈ Uloboridae > Gnaphosidae ≈ Pisauridae ≈ Scytodidae ≈ Sparassidae > Clubionidae ≈ Filistatidae ≈ Hersilidae ≈ Selenophidae ≈ Therididae

Three dominant species- *Plexippus paykulli* F > *Oxyopes pankaji* F > *Argiope aemula*

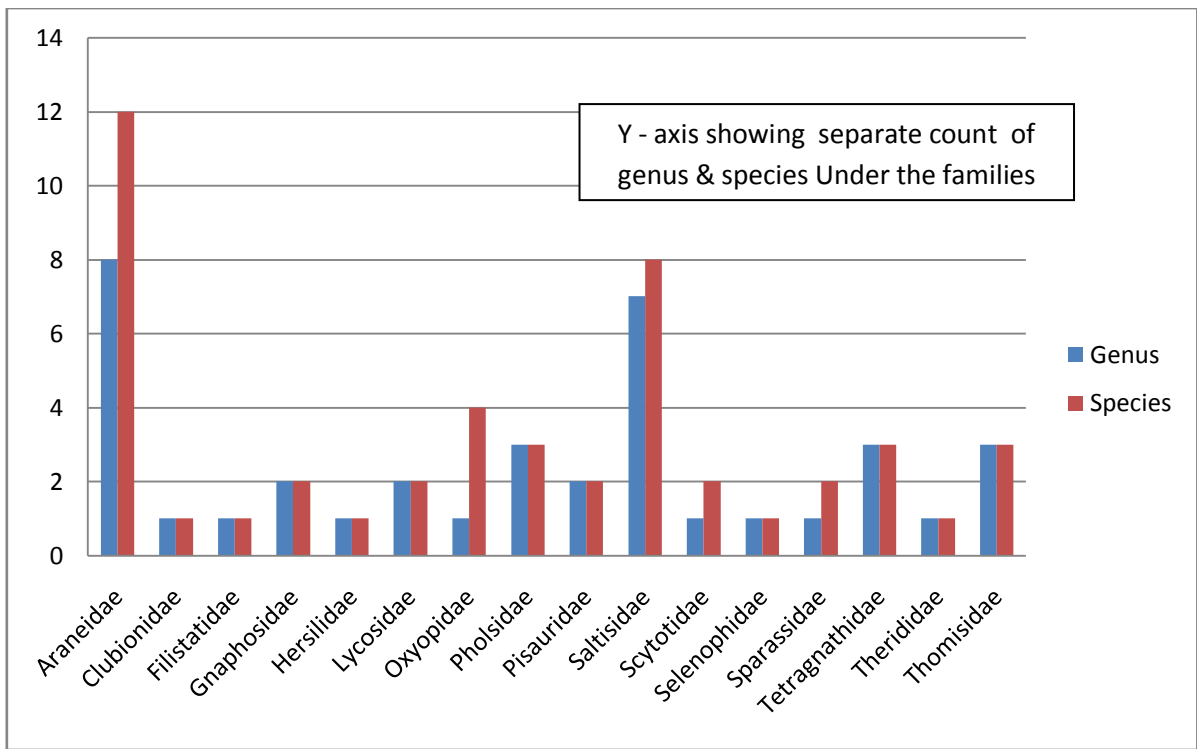
Three rare species- *Oxyopes sp.* F < *Tmarus sp.* M < *Scytodes fusca* F

Table- 3- Consolidated numerical data of spider diversity of Eastern Region of Rajasthan.

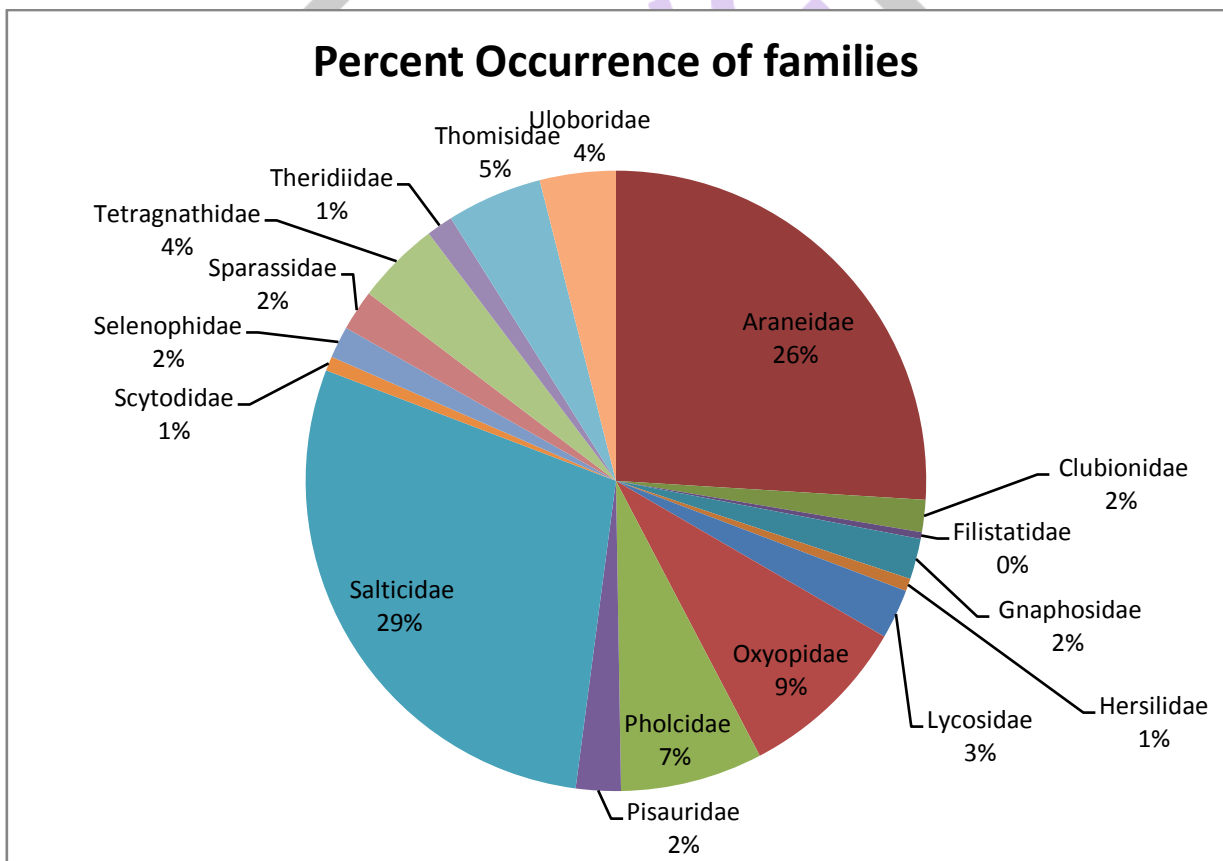
Family	Number of			Percent Occurrence
	Genus	Species	Individual	
1. Araneidae	8	12	827	26%
2. Clubionidae	1	1	53	1.68%
3. Filistatidae	1	1	11	0.35%
4. Gnaphosidae	2	2	68	2.12%
5. Hersilidae	1	1	21	0.66%
6. Lycosidae	2	2	83	2.59%
7. Oxyopidae	1	4	288	8.97%
8. Pholcidae	3	3	238	7.42%
9. Pisauridae	2	2	75	2.34%
10. Salticidae	7	8	923	28.75%
11. Scytodidae	1	2	24	0.75%
12. Selenophidae	1	1	53	1.66%
13. Sparassidae	1	2	68	2.12%
14. Tetragnathidae	3	3	140	4.37%
15. Theridiidae	1	1	44	1.38%
16. Thomisidae	3	3	147	4.98%
17. Uloboridae	2	3	127	3.96%
Total	40	51	3211	100%



Graph-1- Showing individual count in each family.



Graph-2- Representing Genus & species count in each family



Graph-3- Percent occurrence of spider's family in the study area.

Habitats of Eastern region of Rajasthan (India) in season Monsoon, winter and Summer, were surveyed during July 2012 to Dec. 2016. During the present investigation we have recorded 51 species from 40 genera and 17 families from selected habitats (table-1). Spiders were collected by using visual search and pitfall trap methods, beating and sweeping methods were also used. Among all the species collected from all the habitats hunters / ground dwellers dominated to web builders.

The relative abundance of spiders in the collection was in the order of –

Araneidae > Saltisidae > Oxyopidae > Lycosidae ≈ Pholidae ≈ Tetragnathidae ≈ Thomisidae ≈ Uloboridae > Gnaphosidae ≈ Pisauridae ≈ Scytotidae ≈ Sparassidae > Clubionidae ≈ Filistatidae ≈ Hersiliidae ≈ Selenophidae ≈ Therididae

Out of the 17 families recorded from the three seasons, spider from Araneidae, Lycosidae, Saltisidae, Thomisidae, Sparassidae and Tetragnathidae are dominant and together from more than 80 % of the predator population preying on the pests. At the species level *Plexippus payankulli* and *Oxyopes pankaji* was most common spider species observe in all the season from study area. Surprisingly no presence of Liniphid spiders from the study area is observed through they are represented in large number not only in India but throughout the world (Platnick 2011, 2013). Out of 51 species recorded 41 species are females of which no males are recorded. 2 species are males of which no females are recorded. During the study period 8 species are recorded both male and female. About 9 species could not be identified species level that included 9 mature specimens. This indicates that large number of spider species may be new to this area and hence detail studies are needed.

4. CONCLUSION

Eastern region of Rajasthan and its catchment area is rich in spider diversity. This region also exhibits good number of spider and remarkable diversity in guilds of spider fauna. This study serves as a baseline for future study of spiders in this habitat. But further study is required to confer. This was conducted from July 2012 to Dec. 2016. So seasonal variation in diversity and abundance of spider fauna was also studied. It is emphasizes the need for conservation of this ecosystem by characterizing species diversity and highlighting rare and endemic species in this ecosystem.

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