SEASONAL ABUNDANCE AND POPULATION INDICES OF SPIDER FAUNA IN *SUMMER SEASONS* OF THE YEARS 2013 TO 2016 FROM DIFFERENT HABITATS OF EASTERN REGION OF RAJASTHAN, INDIA

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***ABSTRACT*: The spiders of Eastern region of Rajasthan were studied in Summer seasons from 2013 to 2016. March, April, May and June months were included in this season. Monthly Collections were made in three year's Summer season. During the present investigation we have recorded 28 species from 25 genera 13 families from Summer Seasons of the year 2013 to 2016. Most species of spider found belonged to family Araenidae followed by Salticidae. Spiders were collected by using different methods and techniques. Higher abundance of spider was recorded during the month of March. The relative abundance of spiders in the season was in the order of: March > April > May > June. 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.**

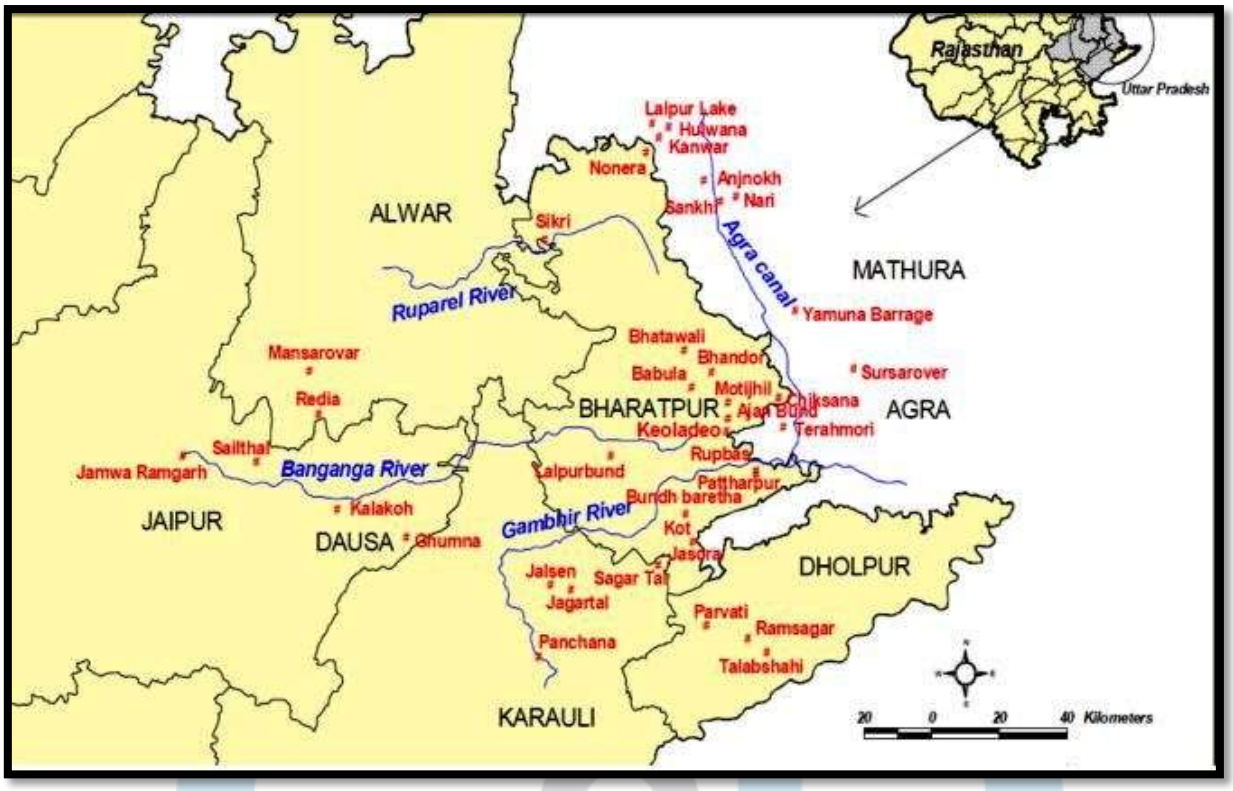
***Keywords*: Spiders, Summer, seasonal abundance, population indices.**

1. INTRODUCTION

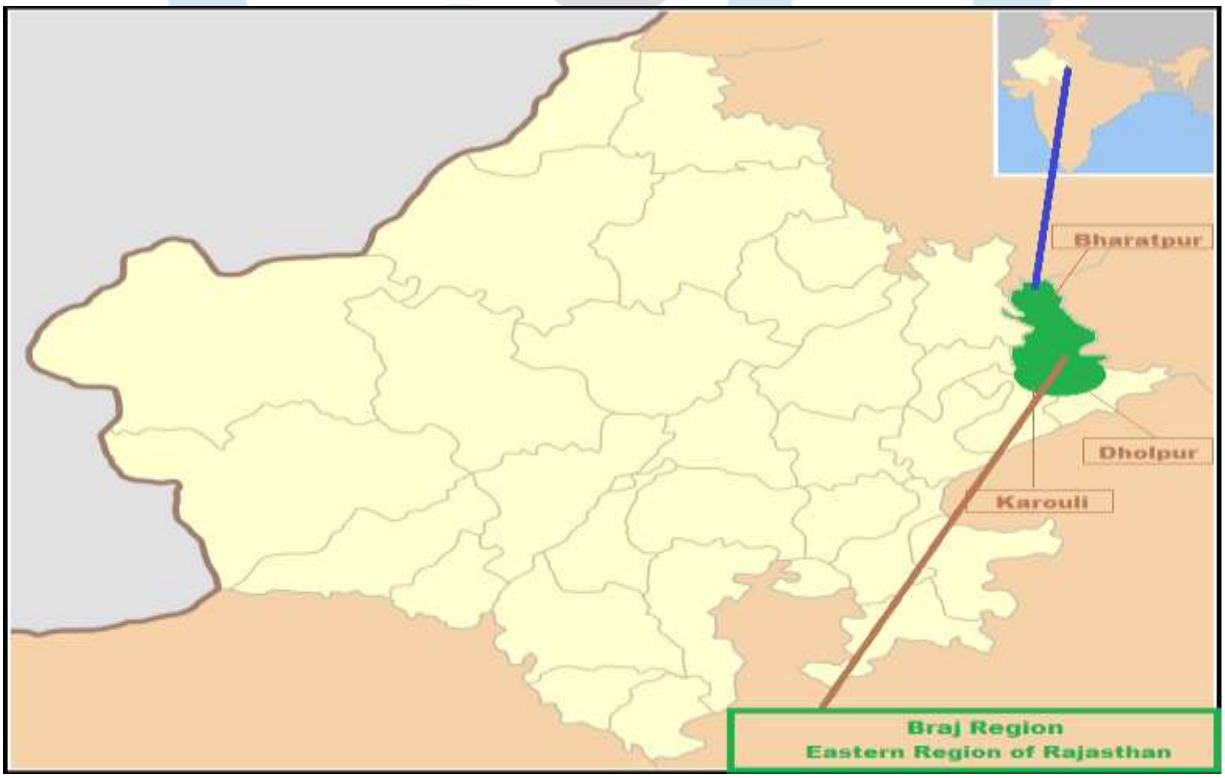
In India the conservation efforts have focused on higher vertebrates and invertebrates have largely been ignored. The Arachnids are one such important group. Spider can regulate large population of insect and other invertebrate in most ecosystems (Russell-Smith, 1999). Therefore, there is a growing need to study this group. Spiders are interesting, intelligent and elegant creatures having predatory lifestyle. Most of the spiders have cannibalistic activity during courtship behaviour. These carnivorous animals can run and jump very fast whenever required. Hence these are treated as cursorial creatures. These are pest in houses but boost the crops, by killing the harmful insects. Garden spiders are treated as friends of farmers, but farmers killing the spiders by spraying the pesticides. Spiders are an important part of food chain Dayal (1935), getting rid of unwanted insects and being food themselves for birds and other large insects and reptiles Bastawade (2002). Some of these having poisonous glands are called tarantulas. A total of 44,540 species, 3,924 genera belonging to 58 families are present in the world Platnick (2014). Pocock (1900 a, b) and Tikader (1980 a,b; 1981; 1982; 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 Lawania 2013(a,b,c,d,e,f). During the recent faunal studies in Eastern region of Rajasthan, authors could collect an interesting specimen of spiders, which are not described earlier from study area. 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 ^{o} C in December and 42 ^{o} 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 quadrate method (20 m x 10 m quadrate, with 5-5 quadrate 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 accesses 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 genetilia 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 quadrate method (20 m x 10 m quadrates, with 5-5 quadrate 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 2013 – 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- Seasonal abundance and population indices of spiders (*Randomly search method, Quadrate method, line-transect method and other methods were used for searching and collection*) in Summer seasons 2013- 2016 from different habitats in Eastern Region of Rajasthan

Family	Species (F- Female & M- Male)	Habits	Habitats	Month wise abundance in Summer season in Eastern Region of Rajasthan				Total sp. Count	Mean± S.E
				March	April	may	June		
Araneidae	1. *Argiope aemula* F	Web builder	Woodland	5	5	2	-	12	**3.0± 1.22**
	2. *Cyclosa moonduensis* F	Web builder	Woodland	7	9	2	1	19	**4.75± 1.93**
	3. *Cyclosa moonduensis* M	Web builder	Woodland	3	1	1	-	5	**1.25± 0.62**
	4. *Cyrtophora cicatrosa* F	Web builder	Woodland& Grassland	6	1	2	2	11	**2.75± 1.10**
	5. *Cyrtophora citricola* F	Web builder	Woodland& Grassland	8	4	4	5	21	**5.25± 0.94**
	6. *Larinia chloris* F	Web builder	Woodland& Grassland	4	3	5	8	20	**5.0± 1.08**
	7. *Larinia chloris* M	Web builder	Woodland& Grassland	3	4	1	2	10	**2.5± 0.64**
	8. *Neoscona theisi* F	Web builder	Woodland	5	6	4	6	21	**5.25± 0.47**
Clubionidae	9. *Clubiona filicata* F	Hunting spider	Grassland& Wetland	8	7	11	8	34	**8.5± 0.86**
Gnaphosidae	10. *Drassodes luridus* F	Hunting spider	Grassland	8	6	6	7	27	**6.75± 0.47**
Lycosidae	11. *Pardosa peudoannulat a* F	Hunting spider	Grassland& Wetland	5	8	4	2	19	**4.75± 1.25**
	12. *Pardosa peudoannulat a* M	Hunting spider	Grassland& Wetland	4	5	3	2	14	**3.5± 0.64**
Oxyopidae	13. *Oxyopes biramanicus* F	Hunting spider	Grassland & Woodland	8	6	7	5	26	**6.5± 0.64**
	14. *Oxyopes pankaji* F	Hunting spider	Grassland & Woodland	8	11	6	7	32	**8.0± 1.08**
Pholsidae	15. *Artema atlanta* F	Hunting spider	Woodland	7	9	9	5	30	**7.5± 0.95**
	16. *Crossopryza lyoni* F	Hunting spider	Woodland	6	7	7	11	31	**7.75± 1.10**
Pisauridae	17. *Nilus albocinctus* F	Hunting spider	Grassland& Wetland	4	2	4	4	14	**3.5± 0.5**
Saltisidae	18. *Hyllus semicupreus* F	Hunting spider	Grassland & Woodland	5	6	7	9	27	**6.75± 0.85**
	19. *Menemerus bivittatus* F	Hunting spider	Grassland & Woodland	8	11	6	6	31	**7.75± 1.18**
	20. *Menemerus bivittatus* M	Hunting spider	Grassland & Woodland	4	5	8	2	19	**4.75± 1.25**
	21. *Myrmarachne sp.* F	Hunting spider	Grassland & Woodland	7	6	9	5	27	**6.75± 0.85**
	22. *Phintella vittata* F	Hunting spider	Grassland & Woodland	11	7	6	8	32	**8.0± 1.08**
	23. *Phintella vittata* M	Hunting spider	Grassland & Woodland	5	3	3	2	13	**3.25± 0.62**
	24. *Plexippus paykulli* F	Hunting spider	Grassland & Woodland	16	9	12	8	45	**11.25± 1.79**

	25. *Plexippus paykulli* M	Hunting spider	Grassland & Woodland	7	9	5	8	29	**7.25± 0.85**
	26. *Plexippus petersi* F	Hunting spider	Grassland & Woodland	8	9	4	7	28	**7.0± 1.08**
	27. *Telamonia dimidiata* F	Hunting spider	Grassland & Woodland	7	13	8	5	33	**8.25± 1.70**
	28. *Telamonia dimidiata* M	Hunting spider	Grassland & Woodland	6	3	4	4	17	**4.25± 0.62**
	29. *Thyene imperialis* F	Hunting spider	Grassland & Woodland	8	6	8	9	31	**7.75± 0.62**
Selenophidae	30. *Selenopes insularis* F	Hunting spider	Grassland & Woodland	9	13	6	4	32	**8.0± 1.95**
Sparassidae	31. *Olios millet* F	Hunting spider	Grassland & Woodland	6	5	1	-	12	**3.0± 1.47**
Tetragnathidae	32. *Leucauge decorata* F	Web builder	Woodland	2	5	1	-	8	**2.0± 1.08**
	33. *Tetragnatha sp.* F	Web builder	Woodland	2	1	-	1	4	**1.0± 0.40**
Thomisidae	34. *Philodromus sp.* F	Hunting spider	Grassland & Woodland	7	4	5	2	18	**4.5± 1.04**
Uloboridae	35. *Uloborus plumipes* F	Web builder	Woodland	5	7	1	2	15	**3.75± 1.37**
Total	**Specimen- 35** **Family- 13** **Genus- 25** **Species- 28** **Female- 28** **Male- 7**	Dominance of sp. Habits- Hunt. spider >Web builder	Dominance of habitat- Woodland>Grassland> Wetland	**222**	**216**	**172**	**157**	**767**	
				Dominance of month- March> April> May>June					

Dominance of family- Salticidae > Araneidae > Oxyopidae > Lycosidae ≈ Pholcidae ≈ Tetragnathidae > Clubionidae ≈ Gnaphosidae≈ Pisauridae ≈ Selenophidae ≈ Sparassidae ≈ Thomisidae ≈ Uloboridae

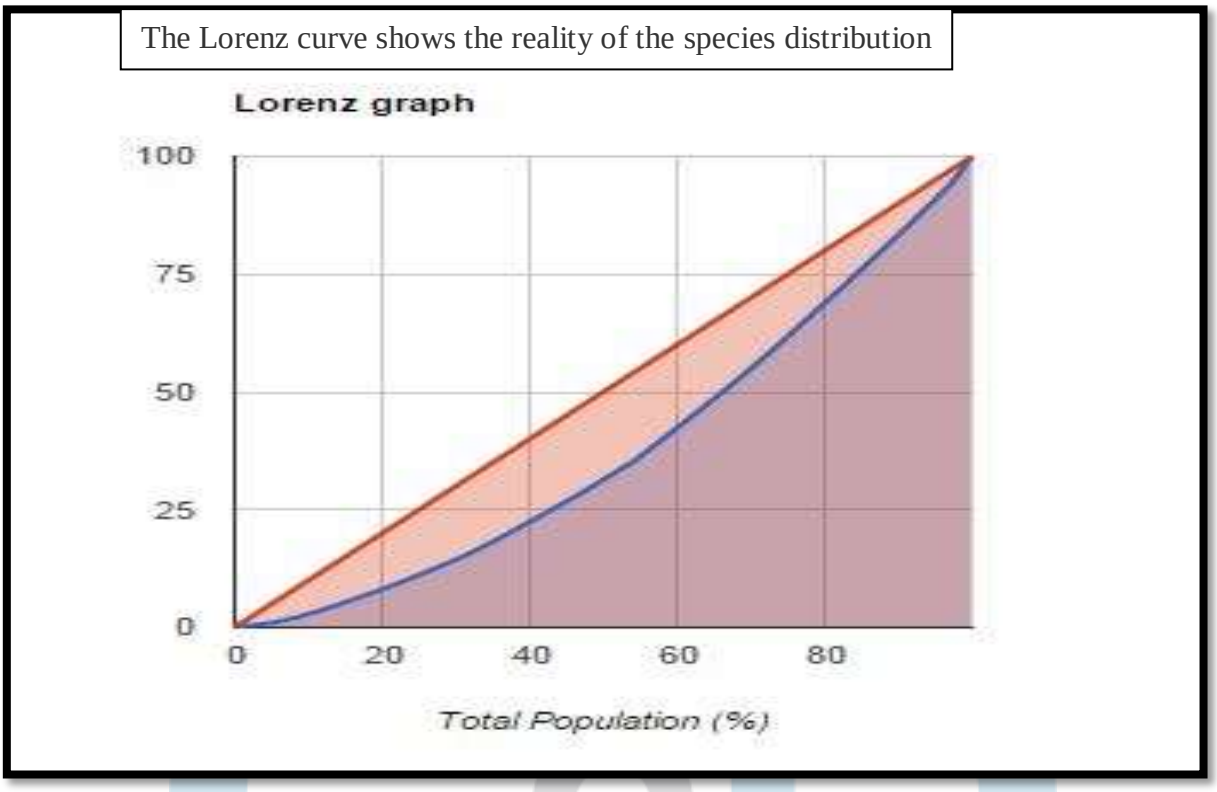
Three dominant species- *Plexippus paykulli* F > *Clubiona filicata* F > *Telamonia dimidiata* F

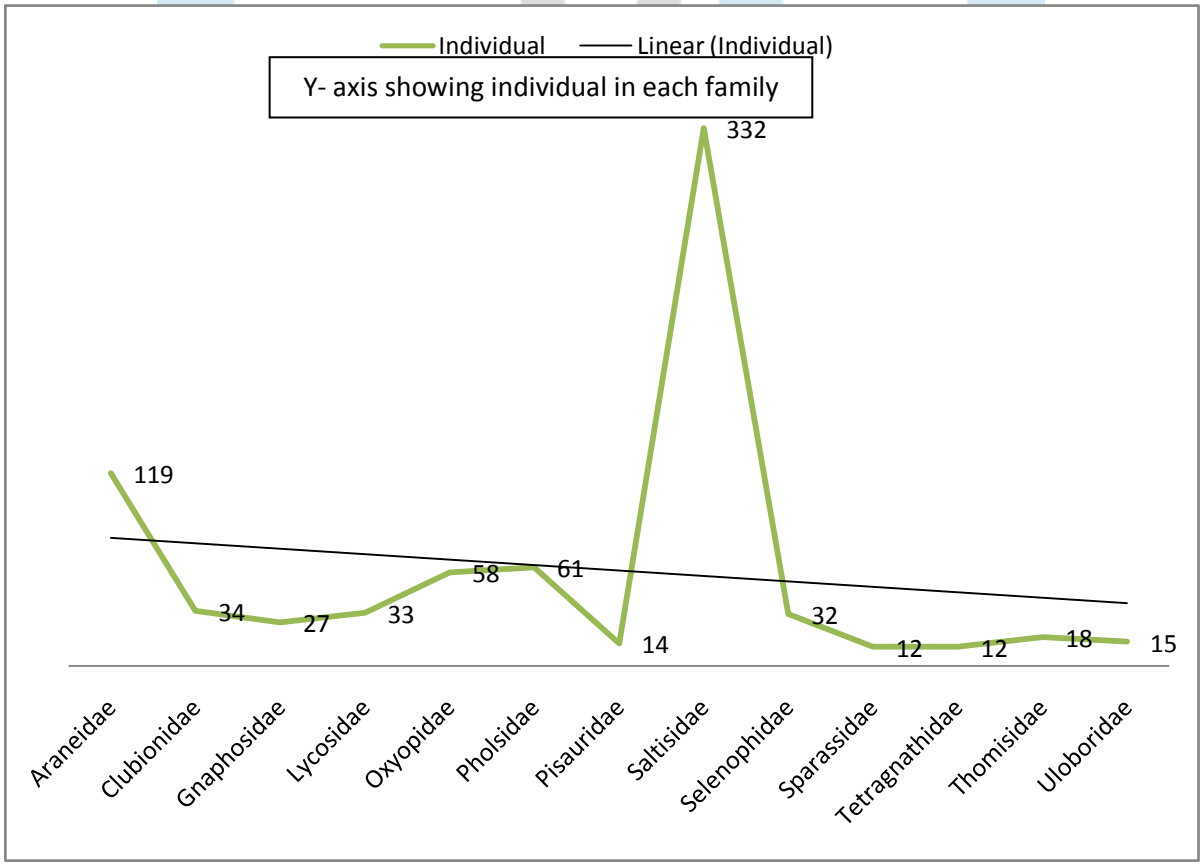
Three rare species- *Tetragnatha sp.* F < *Cyclosa moonduensis* M < *Leucauge decorata* F

Table-2- Representing diversity indices of spiders in The Summer seasons of the years of 2013-2016 in Eastern Region of Rajasthan

Diversity Indices	Formula for calculation	Diversity indices of spider fauna in Monsoon seasons of the years of 2013-2016 from Eastern Region of Rajasthan
Total no. of spider	-	**767**
Total no. of species	-	**35**
Average population size	-	**21.91**
Simpson Index	$\frac{\sum_i n_i(n_i-1)}{N(N-1)}$	**0.03272**
Simpson Index Approximation	$\frac{\sum_i n_i^2}{N^2}$	0.03398
Reciprocal Simpson Index	$\frac{1}{\left(\frac{\sum_i n_i^2}{N^2}\right)}$	30.56
Alternate Reciprocal Simpson Index	$\frac{1}{\left(\frac{\sum_i n_i(n_i-1)}{N(N-1)}\right)}$	29.43
Dominance index	$1-\left(\frac{\sum_i n_i(n_i-1)}{N(N-1)}\right)$	**0.9673**
Dominance index		0.966

Approximation	$1-\left(\frac{\sum_i n_i^2}{N^2}\right)$	
Shannon Index	$-\sum_i\left(\frac{n_i}{N}\cdot\log_2\left(\frac{n_i}{N}\right)\right)$	**4.982**
Shannon Index	$-\sum_i\left(\frac{n_i}{N}\cdot\ln\left(\frac{n_i}{N}\right)\right)$	3.453
Shannon Index	$\sum_i\left(\frac{n_i}{N}\cdot\log_{10}\left(\frac{n_i}{N}\right)\right)$	-1.50
Berger-Parker Dominance	$\frac{n_{max}}{N}$	0.05867
Inverted Berger-Parker Dominance Index	$\frac{N}{n_{max}}$	17.04
Margalef Richness Index	$\frac{S-1}{\ln N}$	**5.119**
Menhinick Index	$\frac{S}{\sqrt{\sum_i n_i}}$	1.264
Renyi Entropy/ Hill Numbers (r=0,1,2,∞)	$\frac{1}{1-r}\cdot\ln\left(\sum_i p_i^r\right)$	35, 31.6, 29.43, ≈∞
In ( ) of Hill Numbers (0,1,2,∞)	-	3.555, 3.453, 3.382, ≈ - ∞
Buzas and Gibson's Index	$\frac{e^{-\sum_i\left(\frac{n_i}{N}\cdot\ln\left(\frac{n_i}{N}\right)\right)}}{S}$	0.9028
Gini Coeffificient	-	18.47
Equitability Index	$-\frac{\sum_i\left(\frac{n_i}{N}\cdot\ln\left(\frac{n_i}{N}\right)\right)}{\ln N}$	0.9712
Absolute Beta Value	$((S_0-c)-(S_1-c)...)$	34
Whittaker's Index	(S/alpha)	1
Alternate Whittaker's Index	Index (S/alpha-1)	0
Sorensen's Similarity Index	-	1
Sorensen's Similarity Index (%)	-	100%
Jaccard Index	-	-1
Jaccard Index (%)	-	-100%
Routledge beta-R Index	-	11.67
Mountford Index	-	-006061
Mountford Index (%)	-	-6.061%
Bray Curtis Dissimilarity	-	0
Number of Common species	-	35
Absolute gamma	$(S_0+S_1...-c)$	0





Graph 1&2- Lorenz and linear graph showing diversity richness in Summer season in the year 2013-2016
Note- Lorenz graph representing cumulative % population of Spiders

In the present study the seasonal abundance of spiders was studied. 13 families 25 genera and 28 species were recorded in

Summer season. These results indicated that spider's diversity in Eastern region of Rajasthan is mostly dependant on the presence of food and pest species in the said area. Due to presence of ample food and pest diversity the summer season represented high diversity of spider in this region. In the present investigation, the important observation is hunters or and ground dweller spiders dominated the study area over the web builders irrespective of the said area. This could possibly be due to the agricultural practices used in different crop fields. During the crop season, workers work in the field and their movements disturb the web. Therefore, only those web constructing spiders were recorded, which could construct their webs in a limited space and secondly most of them are nocturnal.

Species richness was estimated in Summer Season. Similarity of spider species among different seasons was examined using the diversity indices including, Simpson index, Shannon – weiner index and Margalef richness index. The diversity, richness, and evenness indices for spiders were calculated using the Biodiversity calculator (www. Alyoung.com/labs/biodiversity calculator_html). Diversity indices were calculated and are shown in table- 2. The dominance index (1-Simpson index) calculated for Summer season is 0.9673 and the Shannon index as 4.982. The Simpson was calculated for all Summer seasons were 0.03272 and Margalef richness index is the (5.119) for spider diversity in Summer season.

4. CONCLUSION

During the Present investigation we have recorded 28 species from 25 genera and 13 families from selected habitats from Eastern region of Rajasthan, during the Summer seasons of the year 2013 to 2016. Diversity wise spider species recorded in the present investigation are in the order as- Salticidae > Araneidae > Oxyopidae > Lycosidae ≈ Pholcidae ≈ Tetragnathidae > Clubionidae ≈ Gnaphosidae≈ Pisauridae ≈ Selenophidae ≈ Sparassidae ≈ Thomisidae ≈ Uloboridae. During the study we have recorded some observation about their feeding habits. Jumping spiders are found to rely much more on sight. Web builders from Araneidae and Tetragnathidae have advantages of catching pray in the web. All the observation included that they are keeping the insect population in control and thus helping human being from getting protected from vector borne diseases.

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