SEASONAL ABUNDANCE AND DIVERSITY INDICES OF SPIDER'S WEB IN THE YEAR 2013 TO 2016 WITH SPECIAL REFERENCES OF WEB PATTERN AND ARCHITECTURE FROM DIFFERENT HABITATS OF EASTERN REGION OF RAJASTHAN, INDIA

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***ABSTRACT*: Spiders attract special attention to the zoologist on account of their unique weaving capability of constructing webs with geometrical precision. Web weaving habit of spiders are unique because few of others insects like (silk worm) produce silk, yet the survival value of silk spinning or web weaving has never been discovered by any observers. According to their web building 'ability, generally the spiders are considered as weavers or non-weavers Present paper describes the web architecture and patterns of spiders with respect to their diversity and distribution in the habitat of Eastern Rajasthan. There are more than 30,000 documented species of spider in the world. These species can be broken in to two categories: web builders and ground dwellers. The type of web spider spins depends entirely on the spider's way of life. The pattern and architecture of webs varies family to family. During the study 6 types of web patterns Viz. Irregular web, Sheet webs, Funnel web, Orb web, Single-line web, Dome shaped horizontal webs were identified and analyzed between July 2012 to June 2015. These webs are thought to produce patterns that resemble patterns reflected by many flowers in U.V. light. Thus insect who are searching for their favorite type of flower see the decorated web in U.V. light and fly in to the trap. Spider web can take a variety of forms, but the most common type is the Orb web. The gradations of the web patterns can be written in the following order: Orb web > Sheet web > Irregular web > Funnel web > Single line snare web > Horizontal dome shape web. The orb web and Sheet web were very commonly observed during this study. The study focused on the spider's web behavior and their survival strategy, which will help in their conservation.**

***Keywords*: Spiders (Araneae), web architecture and web patterns, conservation.**

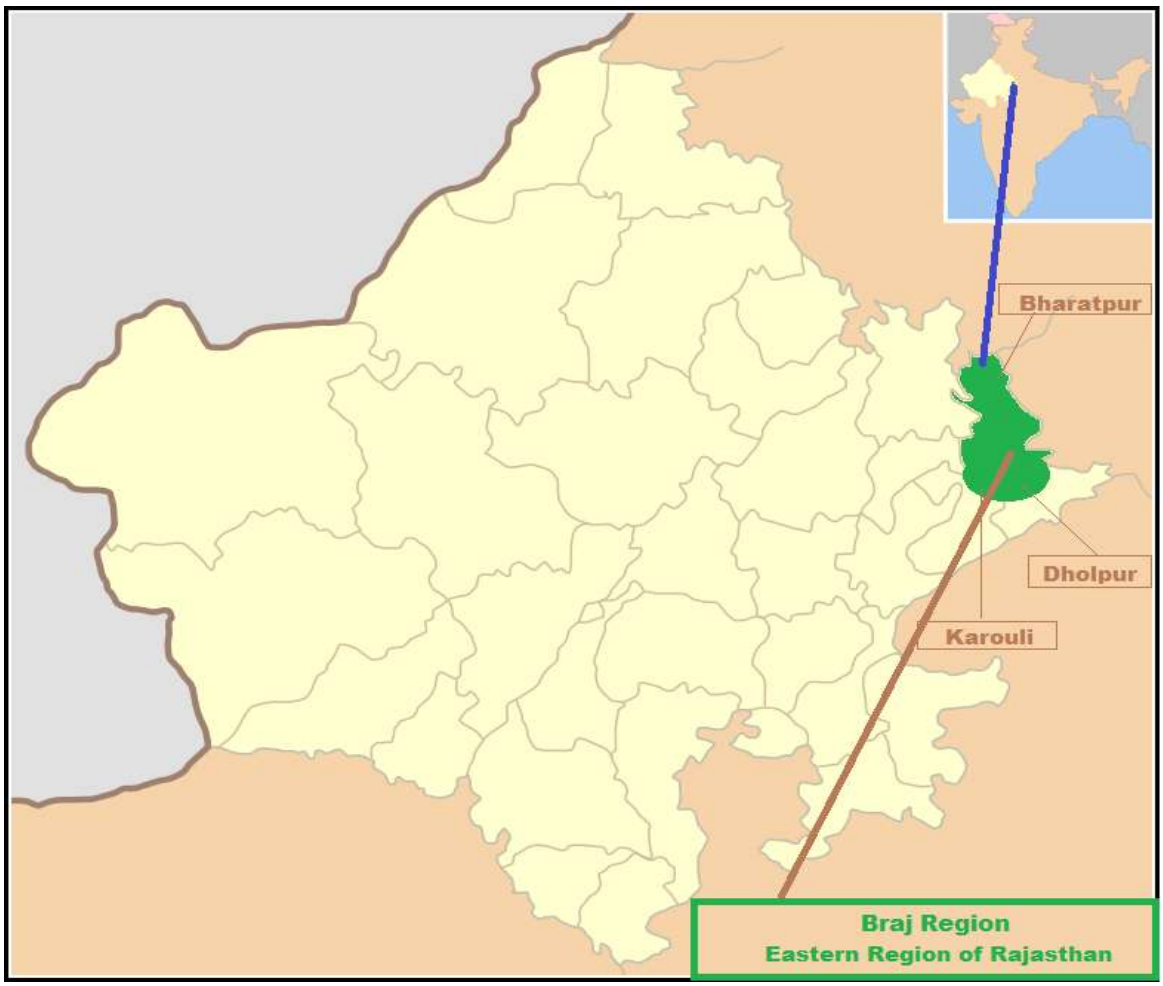
1. INTRODUCTION

Animals in various taxa build some kinds of nest. Nests are built to protect the owner from predators, moderate harsh environmental conditions, trap food for consumption or attract females to mate. Spiders also make a nest its called web. Spiders are the most diverse and abundant invertebrate predators in terrestrial ecosystems (Wise 1993; Sebastian 2009). They regulate the terrestrial arthropod population (Anonymous2000). The global list of spider fauna is approximately 39,882 species belonging to 3676 genera and 108 families (Platnick 2011). Tikader (1987) published the first comprehensive list of Indian spiders which included 1067 species belonging to 249 genera in 43 families. The parental care is the most interesting event among spiders. The eggs never lay singly, but are laid in one or more clusters and each cluster is protected by a covering of silk and the egg sac or cocoon. All spiders are carnivorous, spider mainly feed on large population of Insects and also feed on other spider. The spiders daily construct a new web with the help of energy help accumulated from the food they get. The spiders specially orb weaving spiders make their webs at night time and usually take them down in the morning Blackledge et. al.(2001; 2004). They eat the silk, leaving only the base line to rebuild on. Constructing the web uses a lot of the spider's energy does to the large amount of protein required, in the form of silk and after a time the silk will lose its stickiness and becomes inefficient at capturing prey. Eating their web is a way for the spider to recoup some of the energy used in spinning, the silk protein are thus recycled. The survey was conducted at Eastern Region of Rajasthan. Present survey is an attempt to revise and standardize spider fauna and their web weaving behavior and web patterns and architecture.

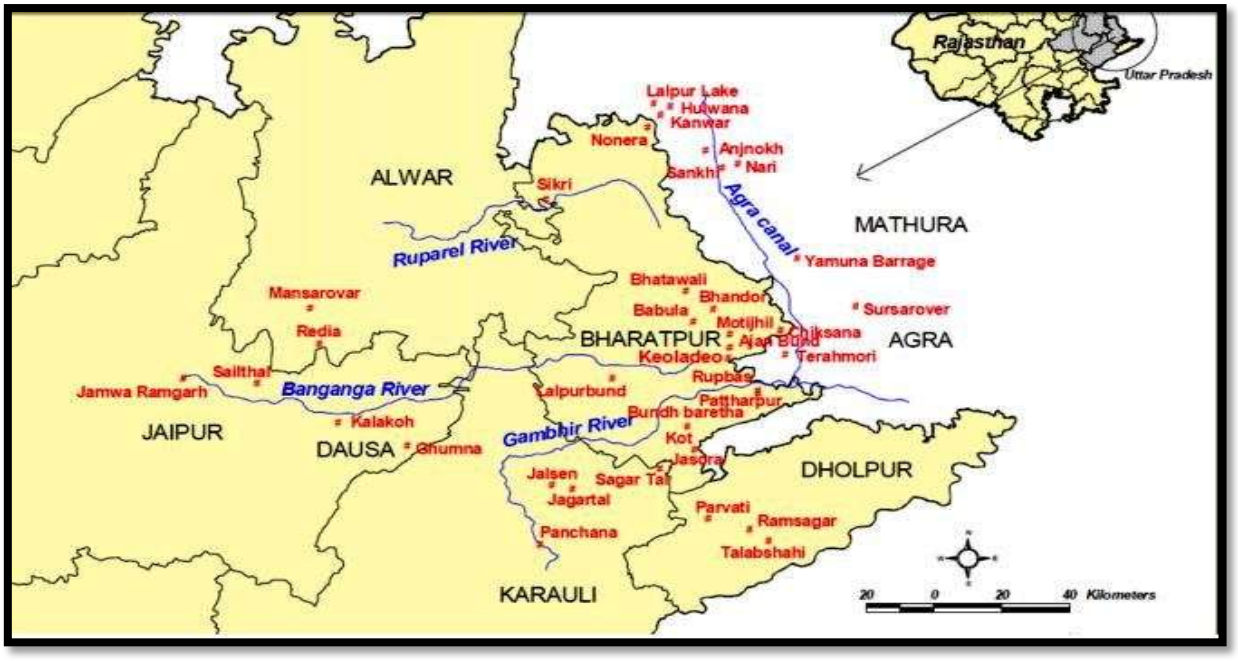
2. MATERIAL AND METHODS

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- Location Map of Eastern region of Rajasthan



Map – 2- High value biodiversity areas (HVBA) of Eastern region of Rajasthan

2.2. Methodology

Firstly the site identification is done, in this the site where the spiders and their webs are present are selected to do further study on their different web patterns.

1. Site identification - spider build webs in shrubs, trees, along rock walls, storage rooms and corners. Many spiders live in retreat area off the web. Burrowing spiders may be found under rocks, logs in debris or old litter under plants and under sheets of wood or cardboard.

2. Spider webs identification: - The different web patterns are then identified by taking their photographs and comparing them with photographs and reports on the spider's web pattern, which were done earlier.

3. Study of Spider activities and designing web patterns: - Different activities of spiders are studied which includes foraging, egg laying and ecology of the spiders, simultaneously different web patterns are also studied by taking their pictures and comparing and analyzing them with the of previous work has been done on the same and different web patterns of spiders are prepared.

4. **Photography.** To know each web pattern, photograph were taken by using super –macro lens of Canon camera.

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.

Different web architectures of different spiders

Spiders attract special attention to the zoologist on account of their unique weaving capability of constructing webs with geometrical precision. Web weaving habit of spiders are unique because few of others insects like (silk worm) produce silk, yet the survival value of silk spinning or web weaving has never been discovered by any observers. According to their web building 'ability, generally the spiders are considered as weavers or non-weavers. The weavers make the snares to trap insects for food viz. pholicidae family, while the non weavers hunt the prey by chasing viz. families' Lycosidae, Gnaphosidae, Salticidae, Oxyopidae. The spiders wait at the center or at the corner of web for capture the prey.

During the study 6 different web pattern and architectures were found in the study area. These are following types:-

(1) Irregular web (Space web):- The other name of this web is Space web. In these irregular webs, here threads are extending in all direction. Irregular web mostly built by the *Pholcus* spiders and some other spiders. These types of webs are mostly found on ceiling the roof and corner of wall. Families show the irregular type of web pattern formation like Theridiidae (*Tylorida ventralis)*, Pholcidae (*Artema Atlanta, Crossopryza lyoni, Pholcus phalangiodes*).

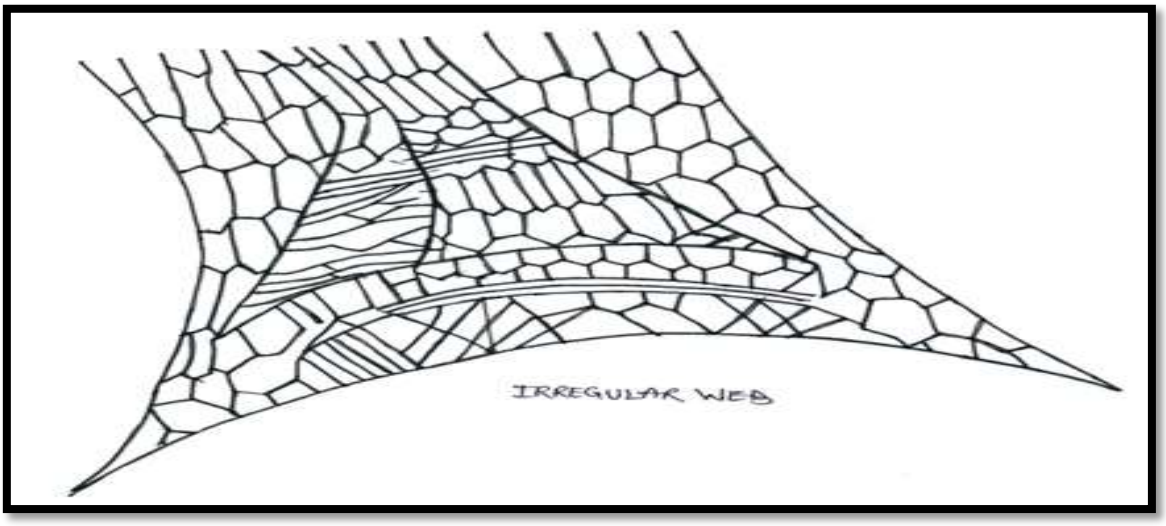
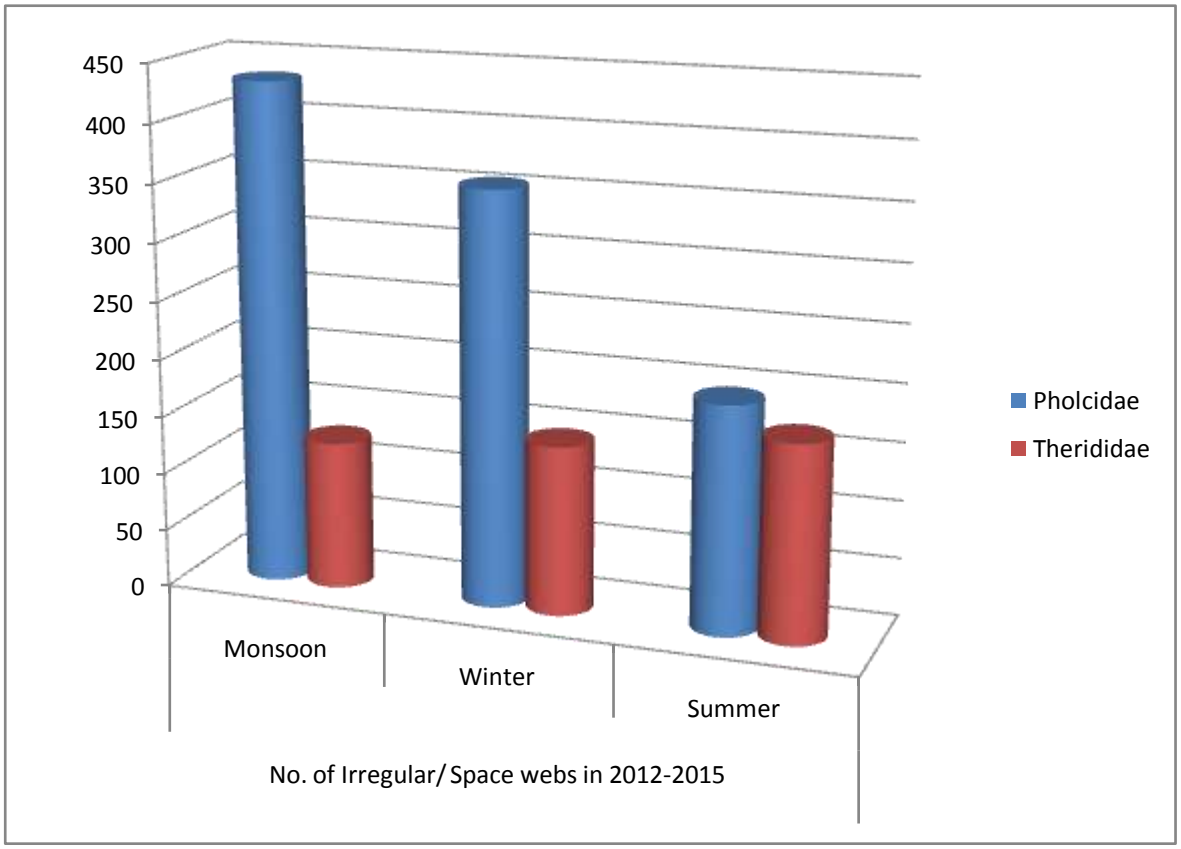


Fig. - 1- Irregular web of spiders of Theridiidae family

Table-1- Number and percentage of Irregular web of different families in different seasons of 2013-2016.

Family	No. of Irregular/ Space webs in 2013-2016			Percentage of Irregular/ Space webs in 2013-2016		
	Monsoon	Winter	Summer	Monsoon	Winter	Summer
Pholcidae	433	356	196	77.19%	70.92%	53.56%
Theridiidae	128	146	170	22.81%	29.08%	46.44%
Total	561	502	366	100%	100%	100%



Graph 1- Number and percentage of Irregular web of different families in different seasons of 2013-2016

(2) **Sheet web/ Tangle web: -** Sheet web/ Tangle web: - A sheet web is flat with main lines running down the center. Sometimes it's called a triangular web. The spider shakes it when any insect lands on sheet web, causing the insect to struggle and get caught in the strands. This type of web pattern formation shows by some Families like Lyniphidae *and* Filistatidae (*Pritha sp.*).

Principal part of the web of a more or less closely woven sheet extended in a single plane and consisting of threads extending in all direction in that plane. These webs are found on two adjacent walls. Linyphiidae family shows the sheet type of web formation.

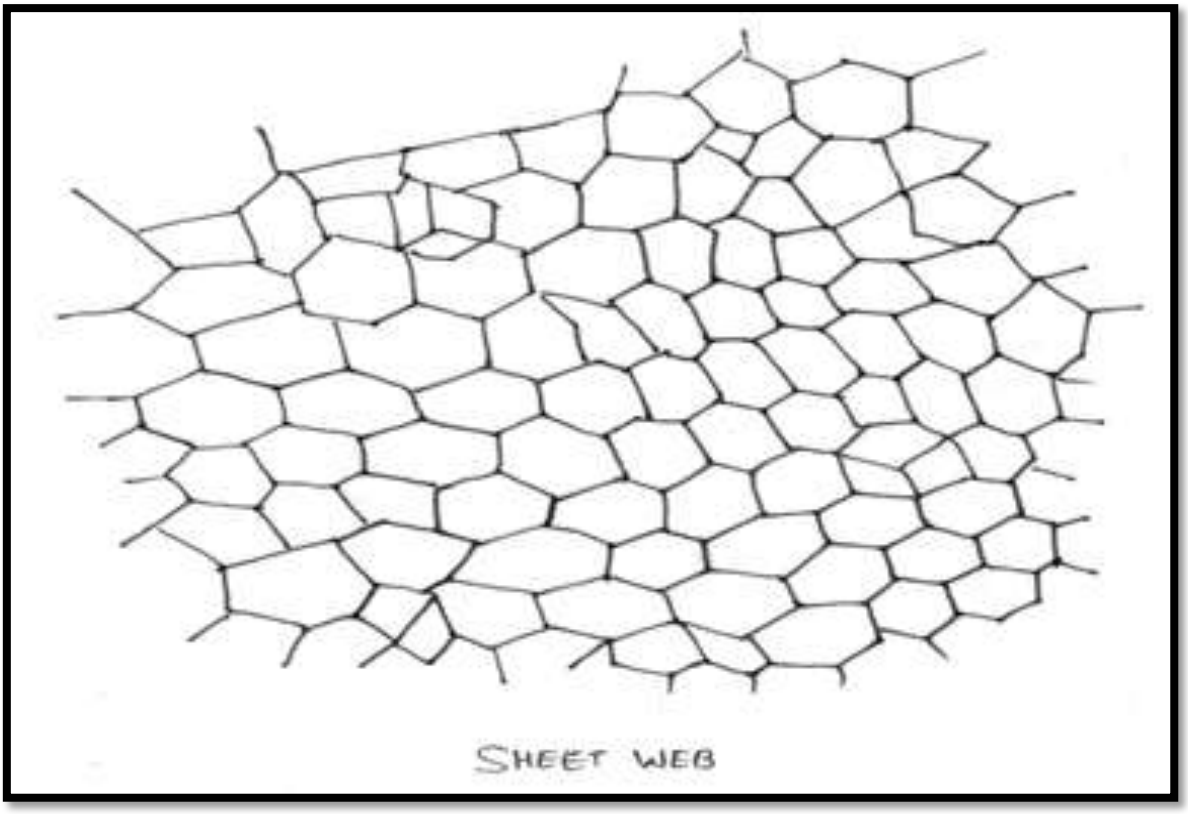
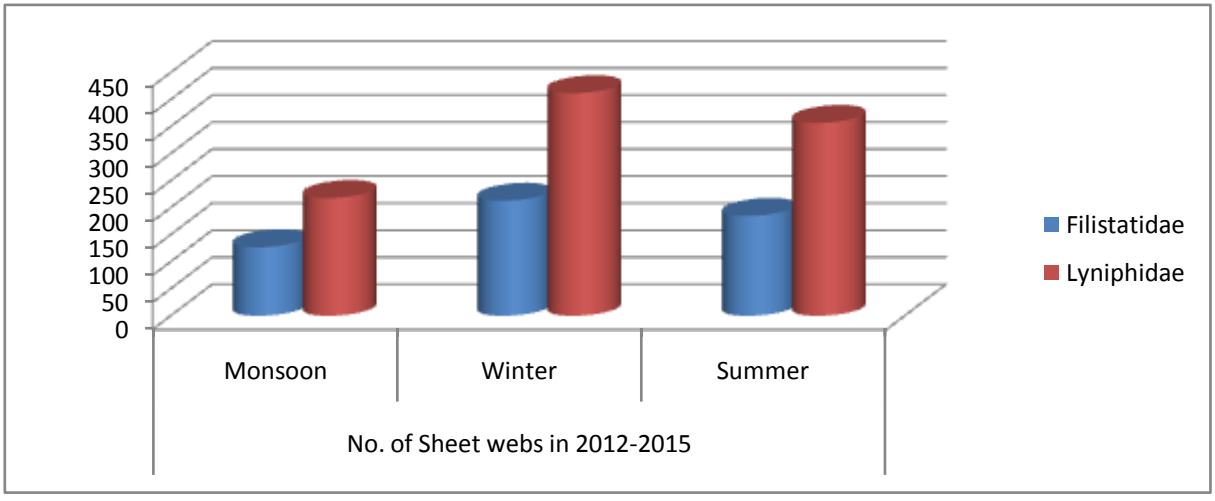


Fig.- 2- Sheet web of spiders of Lyniphidae family

Table-2- Number and percentage of Sheet web of different families in different seasons of 2013-2016.

Family	No. of Sheet webs in 2013-2016			Percentage of Sheet webs in 2013-2016		
	Monsoon	Winter	Summer	Monsoon	Winter	Summer
Filistatidae	127	213	185	36.82%	34.08%	34.14%
Lyniphidae	218	412	357	63.18%	65.92%	65.86%
Total	345	625	542	100%	100%	100%



Graph 2- Number and percentage of Sheet web of different families in different seasons of 2013-2016

(3) **Funnel web: -** A funnel web is built in the grassland and woodland areas. The spider hides in the small end and rushes out and grabs the insects as they come down the web. Spider (Funnel web weaver) is agroup of spiders that make funnel-shaped webs, which the use to trap insects. They are among the most abundant and conspicuous spiders in temperate grassland area. They are also known as grass spiders. Worldwide there are about 700 known species of funnel web spiders. The principal part of a funnel web is sheet like in structure, but webs of this type different from sheet web in having a tube extending from one edge these found near water cooler. Families like Agelenidae and Lyniphidae show funnel type of web pattern formation.

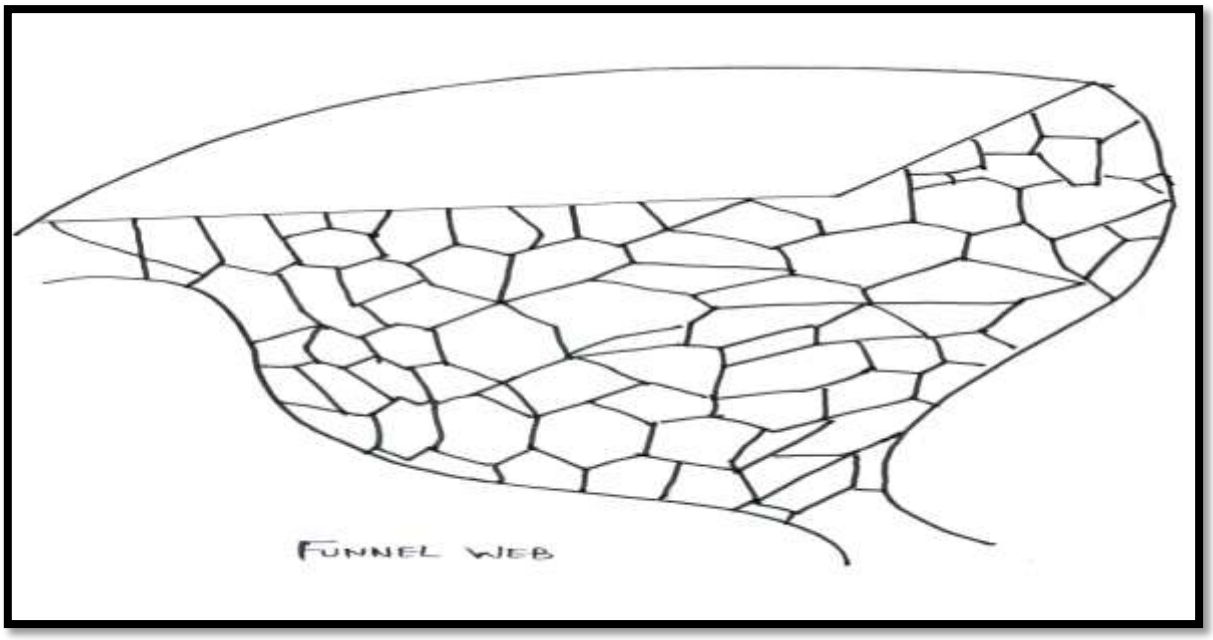
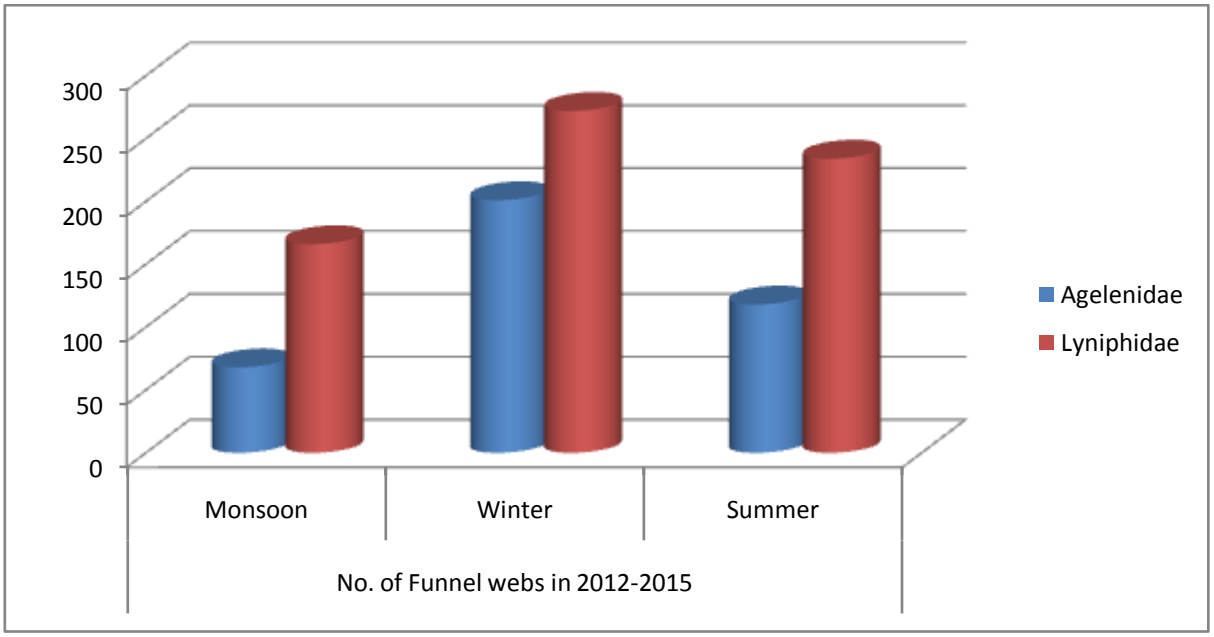


Fig. – 3 - Funnel web of spiders of Lycosidae Family

Table-3- Number and percentage of Funnel webs of different families in different seasons of 2013-2016.

Family	No. of Funnel webs in 2013-2016			Percentage of Funnel webs in 2013-2016		
	Monsoon	Winter	Summer	Monsoon	Winter	Summer
Agelenidae	68	201	118	29.06%	42.50%	33.53%
Lyniphidae	166	272	234	70.94%	57.50%	66.47%
Total	234	473	352	100%	100%	100%



Graph 4- Number and percentage of funnel web of different families in different seasons of 2013-2016

(4) **Orb webs:** An orb web is shaped like a circle. An orb-web the characteristics feature is that the center portion, the part laying within the supporting frame work, the web of Aranidae consist of a series of radiating lines an excellent illustration of orb web.

A spider (family Araneidae) is typical orb-weaver, the most common group of builders of spiral wheel-shaped web weaver, this web often found in gardens, forests and fields. Spiders common name is reerred from the round shape of this typical web, and the taxon was formerly also referred to as the Orbiculariae.

Orb-weavers have eight similar eyes, hairy or spiny legs, and no stridulating organs. The Araneidae family is cosmopolitan, including many well-known large or brightly colored garden spiders. The 3,006 species in 168 genera worldwide make Araneidae the third-largest family ofspiders known (behind Salticidae and Linyphiidae). The orb-weavers include over 10,000 species and make up about 25% of spider diversity.

However, orb-webs are also produced by members of other families. The large golden orb-weavers (Nephilidae) and the long-jawed orb weavers (Tetragnathidae) were formerly included in the Araneidae; they are indeed closely related to them, being part of super family Araneoidea. Their webs are similar to those of the typical orb-weavers, but tend to be less sophisticated and often have an irregular instead of a neat spiral arrangement of the prey-capturing threads. The cribellate or hackled orb-weavers (Uloboridae) belong to a distinct superfamily of the suborder Araneomorphae; their webs are often very sophisticated, but Uloboridae use neither venom to kill their prey, nor sticky threads in their web, and probably evolved the orb structure independently. Uloboridae are cribellate, and their threads can be recognized by the fuzzy and dull appearance, which captures prey by a velcro-like mechanism.

This type of web were recorded in four different families -

(a) Wheel-shaped orb webs- (Family- Aranidae)

(b) Large golden orb-web (Family- Nephilidae)

(c) Long-jawed orb weavers (Family- Tetragnathidae)

(d) Cribellate or hackled orb-web (Family- Uloboridae)

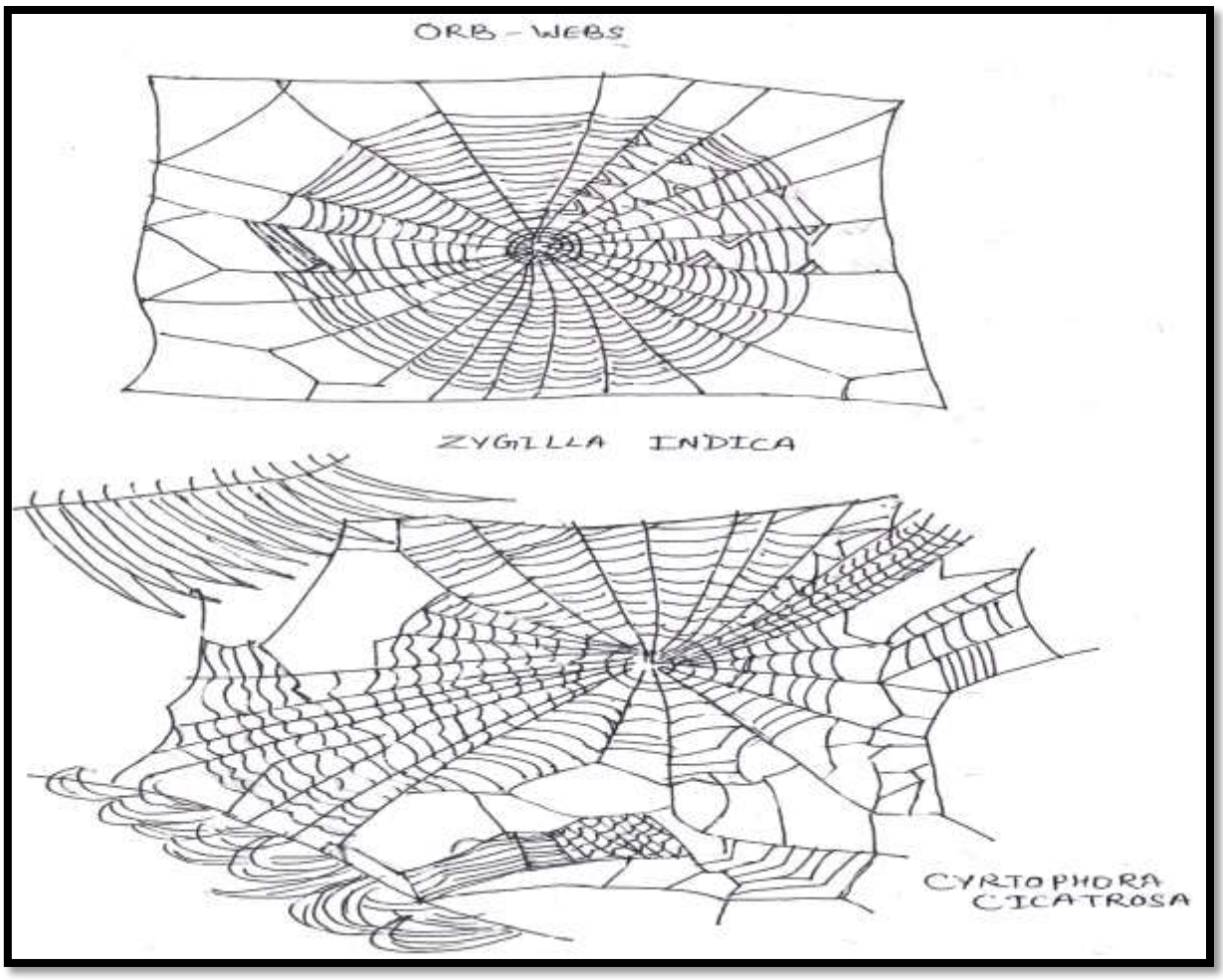
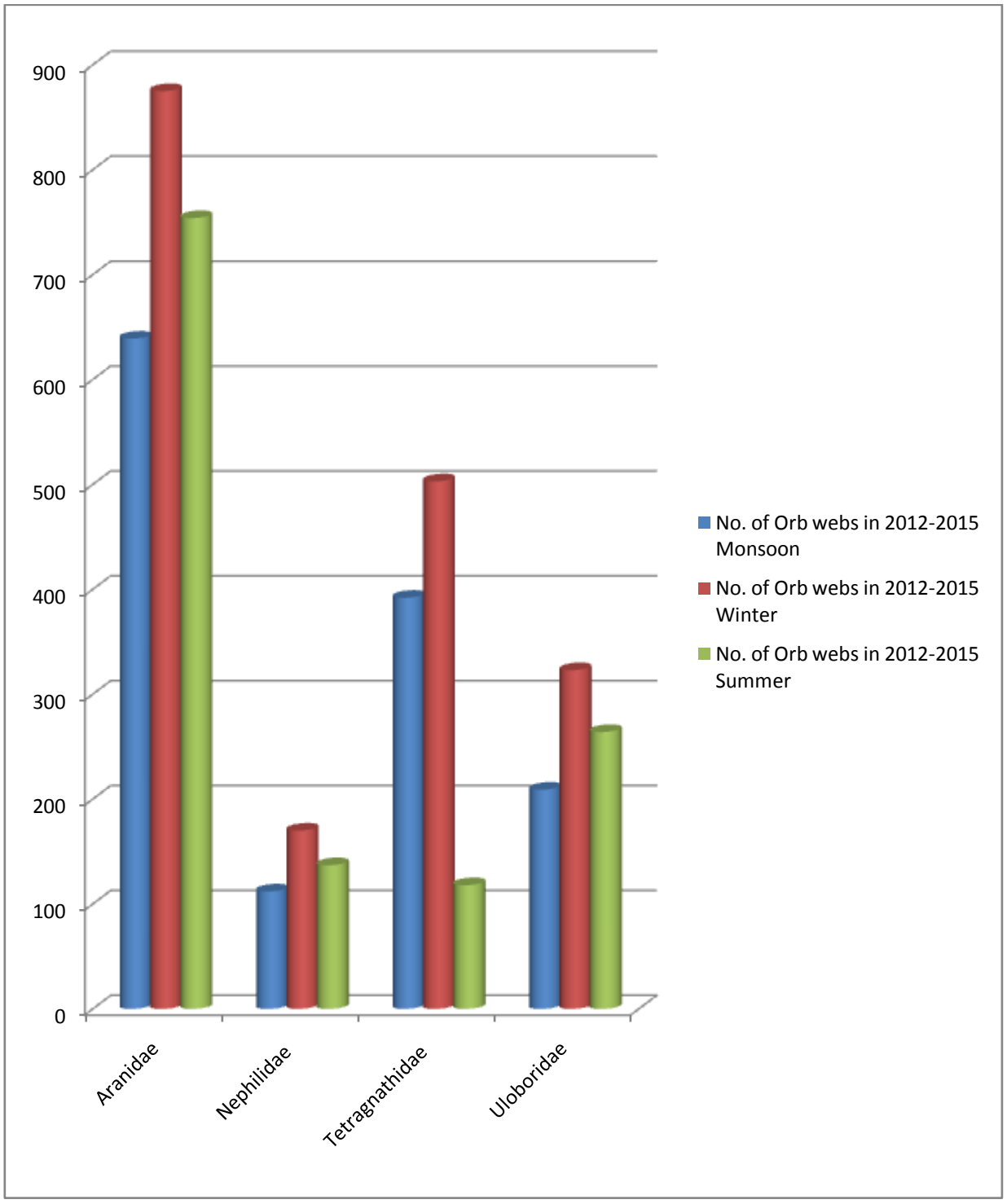


Fig.- 4- Orb web of spiders of Aranidae Family

Table-4- Number and percentage of Orb webs of different families in different seasons of 2013-2016

Family	No. of Orb webs in 2013-2016			Percentage of Orb webs in 2013-2016		
	Monsoon	Winter	Summer	Monsoon	Winter	Summer
Aranidae	639	875	754	47.26%	46.77%	59.23%
Nephilidae	112	170	137	8.29%	9.09%	10.77%
Tetragnathidae	392	503	118	29.00%	26.88%	9.27%
Uloboridae	209	323	264	15.45%	17.26%	20.73%
Total	1352	1871	1273	100%	100%	100%



Graph 4- Number and percentage of Orb web of different families in different seasons of 2013-2016

(5) The single - line snare:-

There is a single horizontal line, attached at both ends to branches that stretch about four feet across open spaces in the forest.

Some species of families like Theridiidae, Uloboridae shows single-line snare type of web pattern formation.

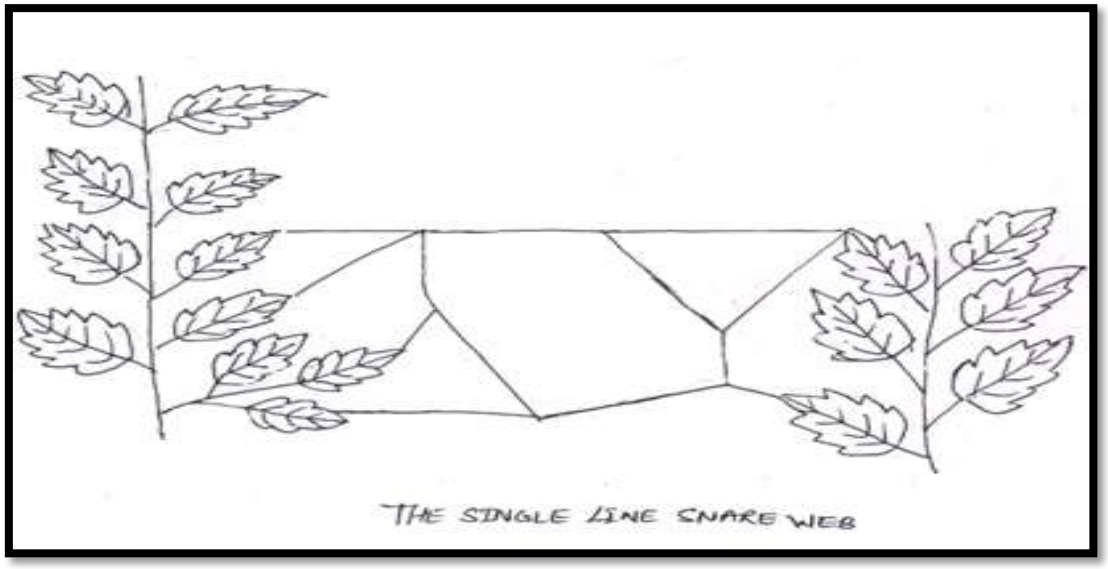
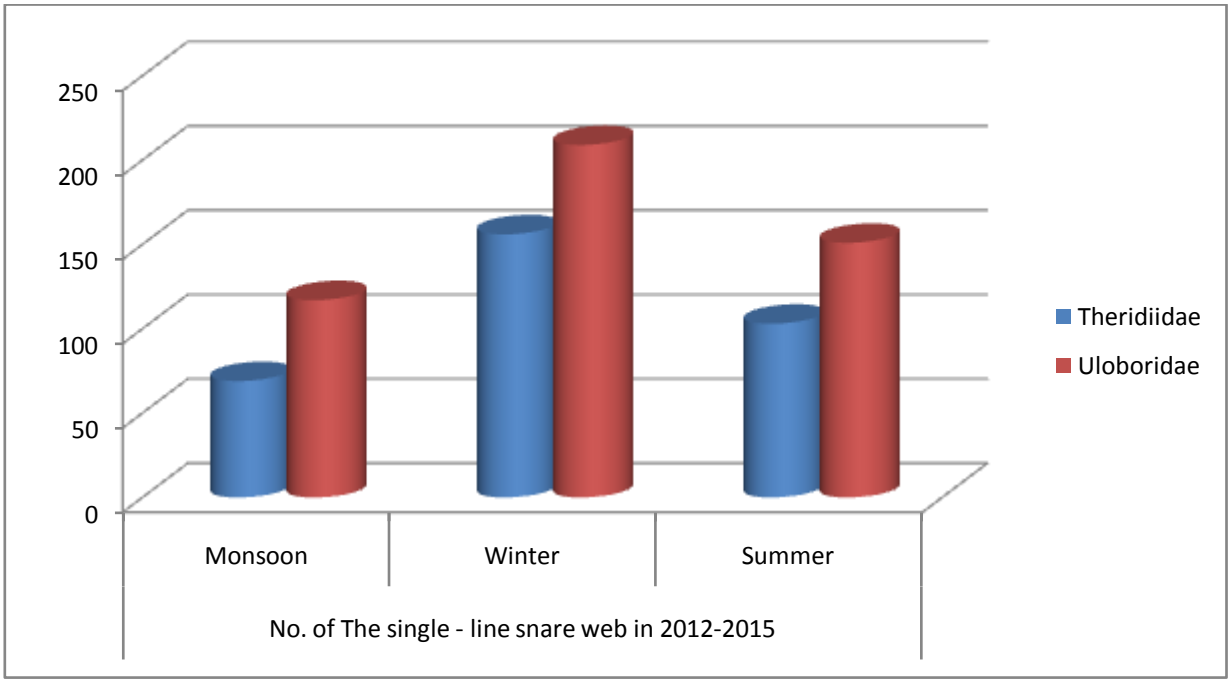


Fig.- 5 - Single line snare web of spiders of Uloboridae family

Table-5- Number and percentage of Single line- snare webs of different families in different seasons of 2013-2016.

Family	No. of The single - line snare web in 2013-2016			Percentage of The single - line snare web in 2013-2016		
	Monsoon	Winter	Summer	Monsoon	Winter	Summer
Theridiidae	69	156	103	37.10%	42.74%	40.56%
Uloboridae	117	209	151	62.90%	57.26%	59.44%
Total	186	365	254	100%	100%	100%



Graph 5- Number and percentage of single line snare web of different families in different seasons of 2013-2016

(6) **Horizontal dome shaped web:-**

Some garden spiders like *Cyrtophora Cicatrosa and Cyrtophora* cicatrosa weaves a horizontal dome shape web with many radial and spiral and them raises its center to form a dome, spider builds a flat mesh under this dome. It was found on Cycas plant. Lyniphidae and Aranidae families also build three-dimensional horizontal dome shape webs which work differently from flat orb webs. Orb webs depend on sticky silk to entangle the prey which flies horizontally into the invisible trap. In three-dimensional webs, the silk is not sticky, in which flying insects are knocked down by the vertical silk lines onto the horizontal platform, the spider then runs out of its hiding place to grab them. Another type the Tent Spiders has various ingenious hiding places. The horizontal platform is often dome shaped. Which are not rebuilt regularly and can last for a long time (several weeks). The study suggests that orb webs are not waterproof (water droplets remain on the web) while three-dimensional webs are, and may thus be more durable in wet habitats.

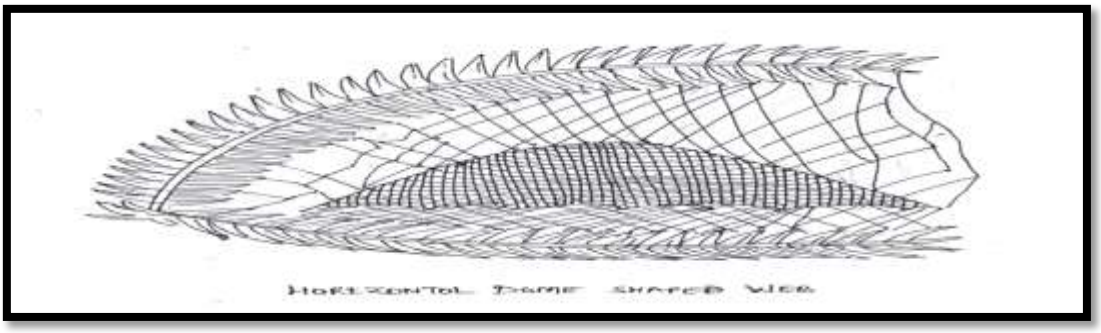
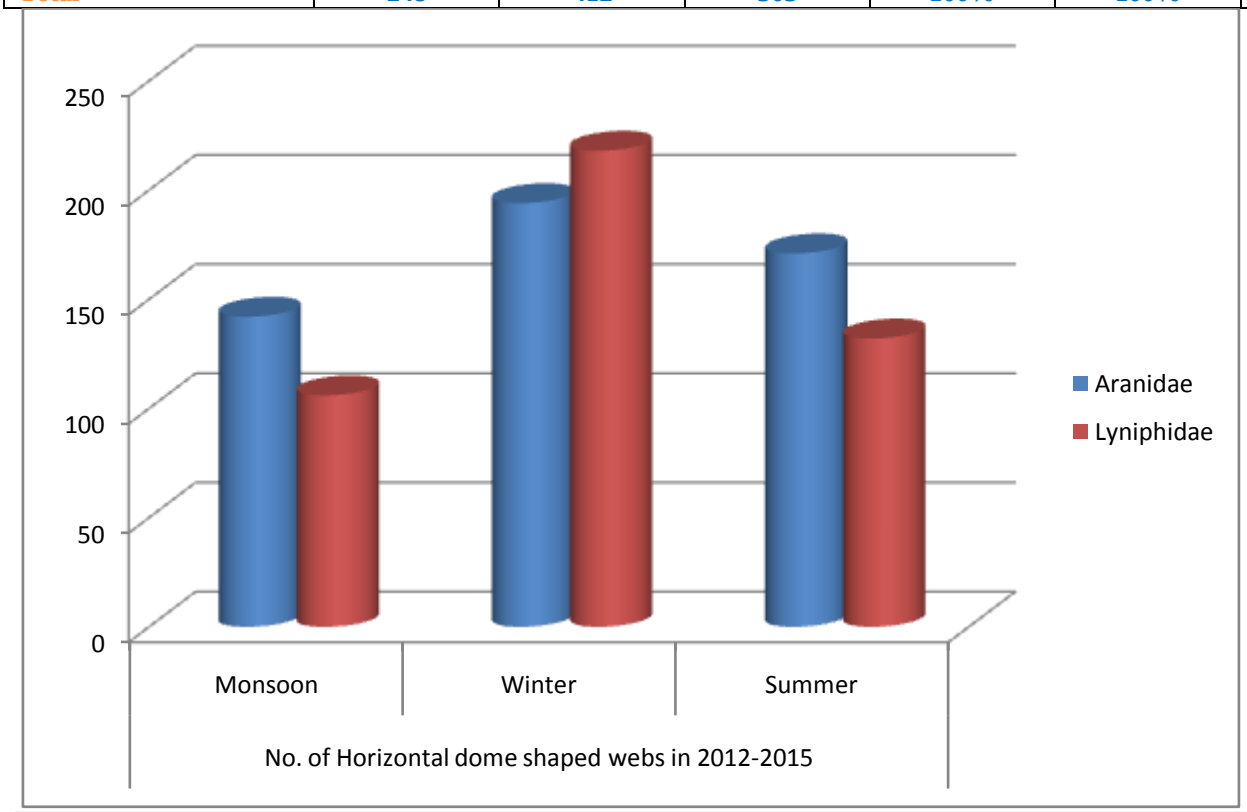


Fig.- 6 - Horizontal dome shape web of *Cyrtophora* genus of Family Aranidae

Table-6- Number and percentage of Horizontal dome shaped webs of different families in different seasons of 2013-2016.

Family	No. of Horizontal dome shaped webs in 2013-2016			Percentage of Horizontal dome shaped webs in 2013-2016		
	Monsoon	Winter	Summer	Monsoon	Winter	Summer
Aranidae	142	194	171	57.26%	47.09%	56.44%
Lyniphidae	106	218	132	42.74%	52.91%	43.56%
Total	248	412	303	100%	100%	100%



Graph 6- Number and percentage of Dome shape horizontal web of different families in different seasons of 2013-2016

Table- 7- Month wise abundance of spiders web (*Randomly search method, Quadrate method, line-transect method and other methods were used for searching and collection*) in the year 2013- 2014 from different habitats in Eastern Region of Rajasthan.

Types of webs	Families	Month wise abundance of webs in the year of 2013-14 in Eastern Region of Rajasthan												Sp. wise total Count of web	Total
		JL	A	S	O	N	D	JN	F	MA	A	MY	JU		
		Monsoon				Winter				Summer					
Irregular Web	Pholcidae	44	52	18	30	40	59	32	29	17	16	21	21	**379**	**536**
	Theridiidae	14	21	9	10	11	9	8	14	16	9	19	17	**157**	
Sheet web	Filistatidae	13	14	9	13	19	12	18	22	26	14	11	27	**198**	**627**
	Linyphidae	28	23	14	17	42	61	33	32	49	53	34	43	**429**	
Funnel Web	Agelenidae	11	4	6	6	19	11	20	11	15	11	19	17	**150**	**437**
	Linyphidae	19	17	19	16	38	31	28	30	23	21	28	17	**287**	
Orb web	Aranidae	54	75	38	52	83	71	68	59	68	64	85	36	**753**	**1557**
	Nephilidae	6	4	3	6	11	7	8	13	21	16	14	6	**115**	
	Tetragnathidae	56	16	34	32	50	53	48	52	14	13	10	19	**397**	
	Uloboridae	22	18	20	23	36	26	14	36	24	25	28	20	**292**	
Single-line Web	Aranidae	3	6	4	6	20	19	12	27	7	9	10	3	**126**	**308**
	Linyphidae	14	8	17	19	17	17	18	17	13	16	14	12	**182**	
Horizontal Dome-shapeWeb	Theridiidae	18	13	9	13	17	16	17	18	19	24	16	14	**194**	**357**
	Uloboridae	11	9	7	4	27	20	12	24	13	16	9	11	**163**	

Table- 8- Month wise abundance of spiders web (*Randomly search method, Quadrate method, line-transect method and other methods were used for searching and collection*) in the year 2014- 2015 from different habitats in Eastern Region of Rajasthan.

Types of webs	Families	Month wise abundance of webs in the year of 2014-15 in Eastern Region of Rajasthan												Sp. wise total Count of web	Total
		JL	A	S	O	N	D	JN	F	MA	A	MY	JU		
		Monsoon				Winter				Summer					
Irregular Web	Pholcidae	30	19	28	37	30	36	19	33	28	33	11	18	**322**	**485**
	Theridiidae	11	19	7	6	13	9	8	20	22	17	14	17	**163**	
Sheet web	Filistatidae	10	8	13	11	22	19	22	25	23	18	19	21	**211**	**477**
	Linyphidae	22	19	18	20	17	10	14	27	29	21	39	30	**266**	
Funnel Web	Agelenidae	7	3	4	8	13	16	9	17	10	8	13	8	**116**	**371**
	Linyphidae	14	18	12	11	27	22	28	13	29	30	32	19	**255**	

Orb web	**Aranidae**	73	83	44	95	75	75	102	51	109	93	73	123	**996**	**1899**
	Nephilidae	19	14	16	7	16	19	14	9	10	25	14	16	**179**	
	Tetragnathidae	33	39	54	42	59	25	52	45	11	6	13	9	**388**	
	Uloboridae	18	23	20	15	31	18	28	65	34	30	14	40	**336**	
Single-line Web	**Aranidae**	7	7	11	4	13	14	14	11	14	16	12	14	**137**	**328**
	Linyphidae	13	7	11	8	23	20	17	22	19	17	9	25	**191**	
Horizontal Dome-shape web	**Theridiidae**	16	14	21	7	23	19	16	20	16	31	9	11	**203**	**385**
	Uloboridae	9	10	11	9	20	23	17	19	16	11	18	19	**182**	

Table-9- Month wise abundance of spiders web (*Randomly search method, Quadrate method, line-transect method and other methods were used for searching and collection*) in the year 2015- 2016 from different habitats in Eastern Region of Rajasthan.

Types of webs	**Families**	**Month wise abundance of webs in the year of 2015-16 in Eastern Region of Rajasthan**										**Sp. wise total Count of web**	**Total**
		JL	**A**	**S**	**O**	**N**	**D**	**JN**	**F**	**MA**	**A**		
		Monsoon				**Winter**				**Summer**			
Irregular web	**Pholcidae**	36	40	16	52	19	23	8	28	16	15	**253**	**377**
	Theridiidae	8	5	11	7	11	14	19	10	16	23	**124**	
Sheet web	**Filistatidae**	18	14	11	15	19	15	13	7	19	7	**138**	**440**
	Linyphidae	19	20	11	17	44	36	54	42	40	19	**302**	
Funnel web	**Agelenidae**	3	4	6	6	23	24	17	21	11	5	**120**	**250**
	Linyphidae	12	8	10	10	13	19	7	16	12	23	**130**	
Orb web	**Aranidae**	37	33	25	30	78	82	72	38	50	53	**498**	**1046**
	Nephilidae	13	9	9	6	18	16	14	25	9	6	**125**	
	Tetragnathidae	27	23	12	24	36	30	27	26	13	10	**228**	
	Uloboridae	19	17	13	12	24	21	18	22	25	24	**195**	
Single-line web	**Aranidae**	6	8	5	2	6	7	9	4	10	9	**66**	**170**
	Linyphidae	6	5	4	5	16	14	9	19	15	11	**104**	
Horizontal Dome-shape web	**Theridiidae**	8	6	4	13	12	16	13	7	19	12	**110**	**216**
	Uloboridae	11	8	7	5	14	16	14	12	10	9	**106**	

Table- 10- Total web counts of webs in spiders families

Family	Irregular web			Sheet web			Funnel web			Orb web			Single-line web			Horizontal dome shaped web		
	M	W	S	M	W	S	M	W	S	M	W	S	M	W	S	M	W	S
1. Agelenidae							68	201	118									
2. Aranidae										639	875	754				142	194	171
3. Filistatidae				127	213	185												
4. Linyphidae				218	412	357	166	272	234							106	218	132
5. Nephilidae										112	170	137						
6. Tetragnathidae										392	503	118						
7. Pholcidae	433	356	196															
8. Theridiidae	128	146	170										69	156	103			
9. Uloboridae										209	323	264	117	209	151			
Season wise total count of web	561	502	366	345	625	542	234	473	352	1352	1871	1273	186	365	254	248	412	303
Total	1429			1512			1059			4496			805			963		

Dominance of web-

Orb web > Sheet web > Irregular web > Funnel web > Single line snare web > Horizontal dome shape web

In the present study the seasonal abundance of spider's web was studied. We studied web pattern and architecture of 9 families in the study area. During the study six types of web pattern formation are identified and analyzed by comparing with the studies and reports related to the same topic. Web formation by the spiders was also been studied during this study. The dominance of Web pattern was this manner- Orb web > Sheet web > Irregular web > Funnel web > Single line snare web > Horizontal dome shape web. The orb web and Sheet web were very commonly observed during this study.

These results indicated that web's diversity in Eastern Region of Rajasthan is mostly dependant on the presence of food and paste species in the said area. Due to presence of ample food and paste diversity the Monsoon season represented high diversity of spider's web 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 webs. Therefore, only those web constructing spiders were reported, which could construct their webs in a limited space and secondly most of them are nocturnal. During evening, they construct the web, prey whole the night on the pests caught in the web and by dawn, they eat their webs (*Neoscona*). Among web builder, *Argiope* and *Cyclosa* dominated all the three seasons. Cyclosa is thus the most successful web builder as they require a small space to construct mostly the basal webs. The webs built by the spiders are used mainly for three purposes: for capturing the prey, for egg laying and their development, and for defence.

Average population of spider webs in Eastern Region of Rajasthan diversity indices of spider webs:-

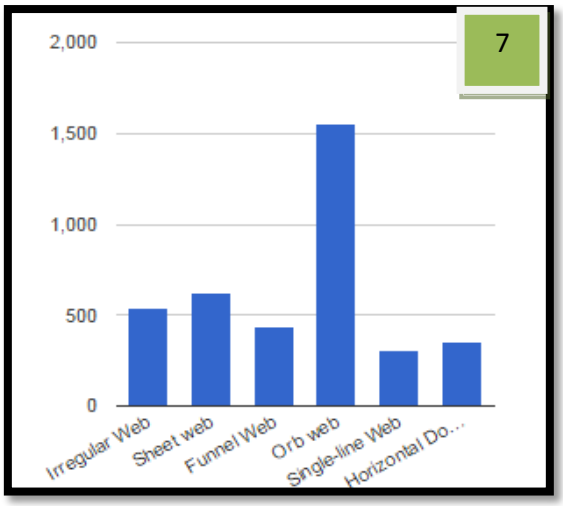
Table- 11- Diversity indices of spider webs in Eastern Region of Rajasthan

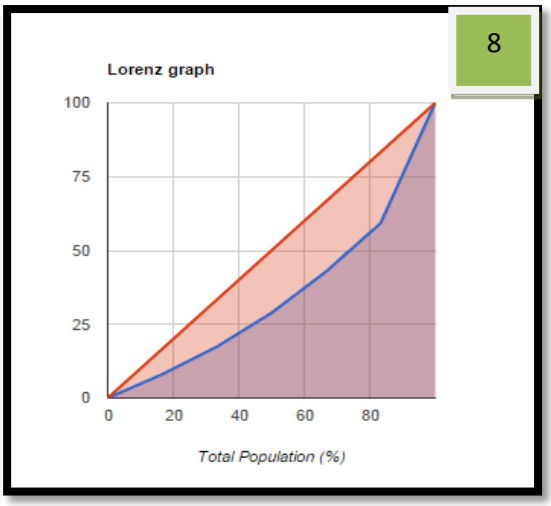
Diversity Indices	Formula for calculation	Diversity indices of webs in Eastern Region of Rajasthan		
		Year 2012-13	Year 2013-14	Year 2014-15
Alpha diversity of webs				
Total no. of Webs	-	**3822**	**3945**	**2499**
Total types of Web	-	**6**	**6**	**6**
Average population size	-	**637**	**657.5**	**416.5**
Simpson Index	$\frac{\sum_i n_i(n_i-1)}{N(N-1)}$	**0.2406**	**0.2866**	**0.2508**
Simpson Index Approximation	$\frac{\sum_i n_i^2}{N^2}$	0.2408	0.2867	0.2511
Reciprocal Simpson Index	$\frac{1}{\left(\frac{\sum_i n_i^2}{N^2}\right)}$	4.156	3.49	3.988
Alternate Reciprocal Simpson Index	$\frac{1}{\left(\frac{\sum_i n_i(n_i-1)}{N(N-1)}\right)}$	4.152	3.488	3.983
Dominance index	$1-\left(\frac{\sum_i n_i(n_i-1)}{N(N-1)}\right)$	**0.7594**	**0.7134**	**0.7492**
Dominance index Approximation	$1-\left(\frac{\sum_i n_i^2}{N^2}\right)$	0.7592	0.7133	0.7489
Shannon Index	$-\sum_i\left(\frac{n_i}{N}\cdot\log_2\left(\frac{n_i}{N}\right)\right)$	**2.323**	**2.195**	**2.28**
Shannon Index	$-\sum_i\left(\frac{n_i}{N}\cdot\ln\left(\frac{n_i}{N}\right)\right)$	1.61	1.521	1.58
Shannon Index	$\sum_i\left(\frac{n_i}{N}\cdot\log_{10}\left(\frac{n_i}{N}\right)\right)$	-0.6993	-0.6607	-0.6864
Berger-Parker Dominance	$\frac{n_{max}}{N}$	0.4074	0.4814	0.4186
Inverted Berger-Parker Dominance Index	$\frac{N}{n_{max}}$	2.455	2.077	2.389
Margalef Richness Index	$\frac{S-1}{\ln N}$	**0.6062**	**0.6038**	**0.6391**
Menhinick Index	$\frac{S}{\sqrt{\sum_i n_i}}$	0.09705	0.09553	0.12
Renyi Entropy/ Hill Numbers (r=0,1,2,∞)	$\frac{1}{1-r}\cdot\ln\left(\sum_i p_i^r\right)$	6, 5.005, 4.152, ≈∞	6, 4.58, 3.488, ≈∞	6, 4.859, 3.983, ≈∞
In ( ) of Hill Numbers (0,1,2,∞)	-	1.792, 1.61, 1.424, ≈ - ∞	1.792, 1.522, 1.249, ≈ 0.7319	1.792, 1.581, 1.382, ≈ - ∞
Buzas and Gibson's Index	$\frac{e^{-\sum_i\left(\frac{n_i}{N}\cdot\ln\left(\frac{n_i}{N}\right)\right)}}{S}$	0.834	0.763	0.8095
Gini Coeffificient	-	2.277	2.125	2.191
Equitability Index	$\frac{-\sum_i\left(\frac{n_i}{N}\cdot\ln\left(\frac{n_i}{N}\right)\right)}{\ln N}$	0.8987	0.849	0.8821
Beta diversity of webs				
Absolute Beta Value	$((S_0-c)-(S_1-c)...)$	**5**	**5**	**5**
Whittaker's Index	(S/alpha)	**1**	**1**	**1**
Alternate Whittaker's Index	Index (S/alpha-1)	0	0	0
Sorensen's Similarity Index	-	1	1	1

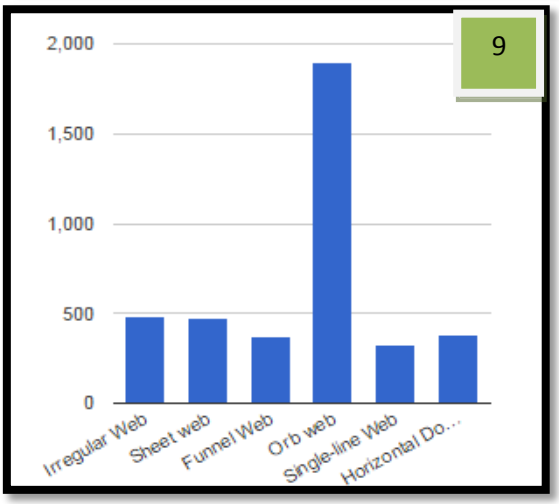
Sorensen's Similarity Index (%)	-	100%	100%	100%
Jaccard Index	-	-1	-1	-1
Jaccard Index (%)	-	-100%	-100%	-100%
Routledge beta-R Index	-	2	2	2
Mountford Index	-	-0.5	-0.5	-0.5
Mountford Index (%)	-	-50%	-50%	-50%
Bray Curtis Dissimilarity	-	0	0	0
Number of Common web	-	6	6	6
Gamma diversity of webs				
Absolute gamma	$(S_0+S_1...-c)$	**0**	**0**	**0**

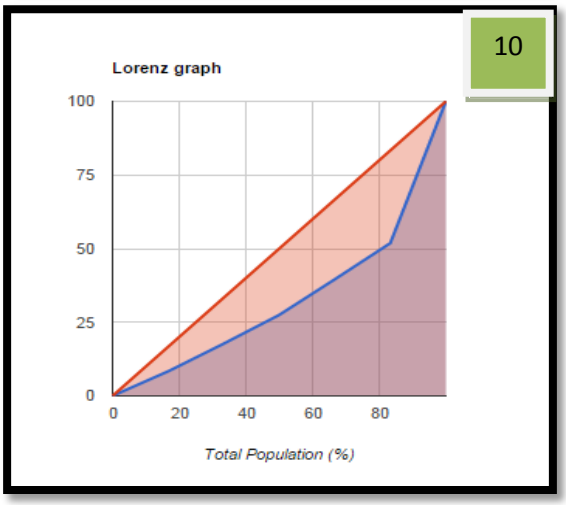
Spider's web richness was estimated in each Season. Similarity of spider species among different seasons was examined using the diversity indices including, Simpson index, Shannon – weiner index and Margalef richness index. The diversity, richness, and evenness indices for spiders were calculated using the Biodiversity calculator (www. Alyoung.com/labs/biodiversity calculator_html).

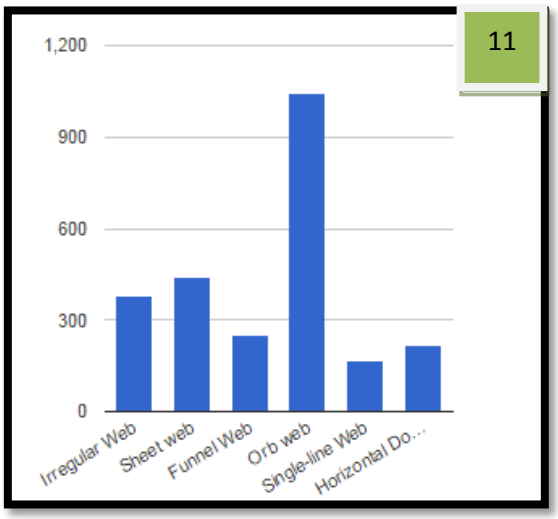
Spider web diversity indices were calculated and are shown in table- 11. The dominance index (1-Simpson index) of spider's web calculated for the year 2013-14 is 0.7594 and the Shannon index as 2.323. The Shannon indices of webs calculated for 2014-15 and 2014-15 years were 2.195 and 2.28 respectively. Margalef richness index is the highest (0.6391) for spider web diversity in year 2015-16. The Margalef richness indices are in the order year 2015-16 (0.6391) > 2013-14 (0.6062) > 2014-15 (0.6038).

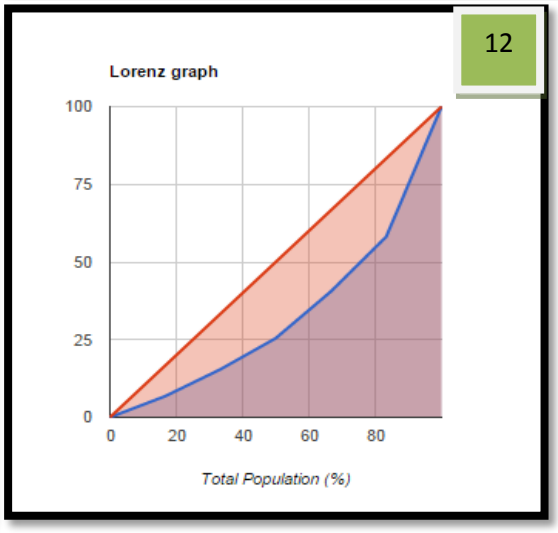












7&8- Web Count and Larenz Graph for spider web population in the year 2013-14

9&10- Web Count and Larenz Graph for spider web population in the year 2014-15

11&12- Web Count and Larenz Graph for spider web population in the year 2015-16

Note- Lorenz graph representing cumulative % population of Spider's web

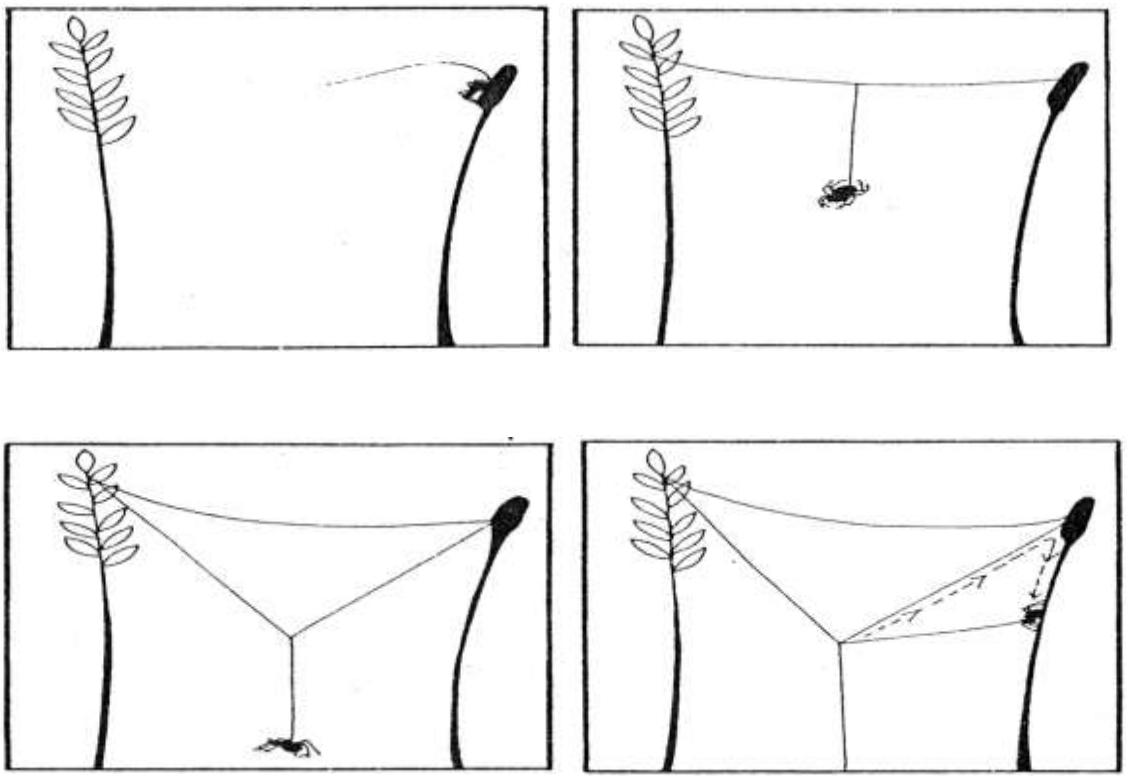
Web spinning behavior

How to spider make web: - In spiders spinnerets are present at the base of abdomen. These glands produce a thread like material for making a web. There are seven different types of glands. Generally a spider has three pairs of spinnerets, but the no. of web may vary with species from one to four pair. Each spinneret has its own special function. The orb weavers make their webs during night time and usually take them down in the morning times. They eat the silk thread, leaving only the base line to re-build on. The large amount of protein required at the time of constructing the web. After some time silk becomes inefficient at capturing prey and will lose its stickiness. Eating own web is a process for the spider to regain some of the energy it's used in spinning. The silk proteins are thus 'recycled'.

The process of web making start by creating an initial base line where spider uses air to carry its sticky thread. The silk which is produced by the spinnerats, sticks to a surface area then the spider slowly and carefully walk over the thread and strengthen it with a second thread. The same process is repeated until the primary thread is strong enough to support the rest of the netting. After strengthening the primary thread, the spider will continue to make Y shaped netting. The first three radials of web are now constructed. More others radials are added making sure that the distance between each radial is short enough to cross.

Then spiral of non-sticky, evenly spaced, circular threads are helpful for the spider to easily move around its own web during construction. After this, beginning from the outside in, spider will methodically create the spiral and adhesive threads. It will use initial radiating lines as well as the non-sticky spirals as guide lines. The spaces between each spiral thread will be directly proportional to the distance from the tip of its back legs to its spinners. Spider uses its own body as a measuring or spacing device. While the sticky spirals threads are formed, the non-adhesive spirals are removed as they are not needed any more.

After completed its web, the spider will chew off the initial three centre spiral threads then wait with its head down, in the web for prey to come along. If the web and its thread are broken without any structural damage during the construction, the spider does not try to repair it as this would use up too much energy and it will probably be taken down in the morning or repaired the next night.



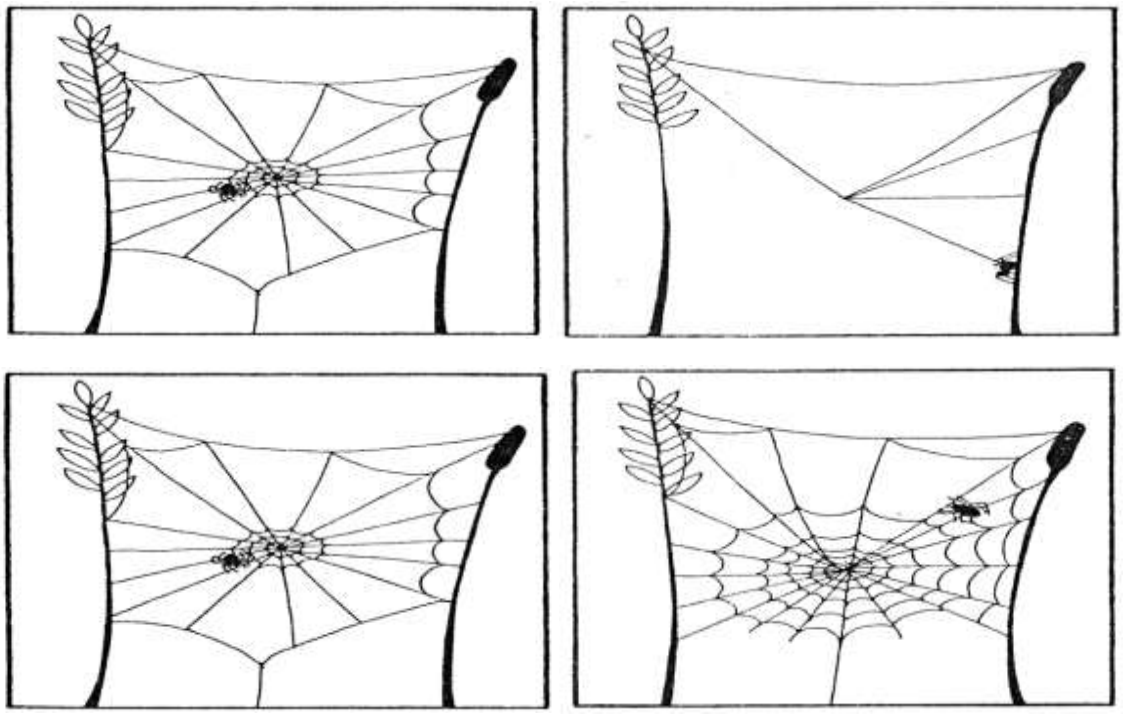


Fig. 7- Process of spider web formation

The spider constitutes a very interesting group of primitive animal. Which are cosmopolitan in nature. Spiders attract special attention to the zoologist on account of their unique weaving capability of constructing webs with geometrical precision. They are best friends of mankind as they feed on insects, which are generally harmful to mankind. In the present study the seasonal abundance of spider's web was studied. We studied web pattern and architecture of 9 families in the study area. During the study six types of web pattern formation are identified and analyzed by comparing with the studies and reports related to the same topic. Web formation by the spiders was also been studied during this study. The gradations of the web patterns can be written in the following order: Orb web > Sheet web > Irregular web > Funnel web > Single line snare web > Horizontal dome shape web. The orb web and Sheet web were very commonly observed during this study. These results indicated that web's diversity in Eastern Region of Rajasthan is mostly dependant on the presence of food and paste species in the said area. Due to presence of ample food and paste diversity the Monsoon season represented high diversity of spider's web 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 webs. Therefore, only those web constructing spiders were reported, which could construct their webs in a limited space and secondly most of them are nocturnal. During evening, they construct the web, prey whole the night on the pests caught in the web and by dawn, they eat their webs (*Neoscona*). Among web builder, *Argiope* and *Cyclosa* dominated all the three seasons. Cyclosa is thus the most successful web builder as they require a small space to construct mostly the basal webs. The webs built by the spiders are used mainly for three purposes: for capturing the prey, for egg laying and their development, and for defense. It was concluded that a long-term study is needed to know more about spiders and their webs. This helps in their conservation.

5. ACKNOWLEDGEMENT

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