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Distribution of ground dwelling spider genera among berseem crop at Okara district, Pakistan

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Abstract

The present study was designed to record the distribution of ground dwelling spider genera among berseem crop at Okara district. Sampling was made from Trifolium crop on fortnight basis through pitfall traps. Equal number of traps were placed in three rows e.g. along the boundary, middle of the field and centre of the field. Each trap was filled with mixture solution of alcohol and glycerin (70:30%) along with few drops of kerosene oil. After 5 days interval sample traps was collected and spider specimens were washed with distilled water and permanently stored in labeled glass vials, and brought into the Pest Control Laboratory, Departmentof Zoology, Wildlife and Fisheries, University of Agriculture, Faisalabad. Thereafter, each spider specimen was identified according to the taxonomic material and internet source. Identified data was analyzed statistically to quantify their spatial distribution. Overall maximum spatial distribution of spider population was documented in middle transect than boundary and centre of the berseem crop. It was also observed that temperature, humidity, vegetation and prey availability were the major factors that effecting the spider population. Population variations were recorded during the months of February, March and April in 2015, due to rise of temperature, decrease of humidity and availability of prey. It was concluded that despite to cosmopolitan nature, spiders have some correlation with suitable local conditions or habitat. More over, spiders are cost effective, functionally significant and play a key role in regulating decomposer population.

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Introduction

Fodder crops are particularly refer to food for animals or live-stock. They comprise of straw, hay, pelleted feed, silage, oils, legumes and sprouted grains. Currently in Pakistan, various fodder crops are cultivated over 15 million hectares with 52 million ton annual fodder production (Anonymous, 2013). However, suitable rainfall and temperature range can enhance the present outcomes (Hussain *et al*., 2010). Because, in many parts of Pakistan, there is abrupt shortage of fodder for live-stock, and also the available fodder is of poor quality.

The farmers are facing a lot of problems to get maximum forage yield to meet the feed requirements. Improved fodder varieties along with control of damage by invading insect pest can overcome the situation. In this context, berseem provides valuable supplemental food to live-stock community e.g. nitrogen, energy, minerals and vitamins. Consequently, it increase the availability of nutrients for maintenance and ideal production status. (Douglas *et al*., 2000).

However, fodder crops especially, berseem provide more than 80% feeding to live-stock from October to April (Younas and Yaqoob, 2005). But, its production is low due to serious insect damage. Berseem (*Trifolium alexandrinum*) is important Rabi legume grown for green fodder. It is able to prepare about seven cuts of forages. (Khalil and Jan, 2000).

To enhance the yield, control of insect pests is a major issue and use of spiders to control these insect pests is of profound importance. Spiders have globally more than 40,000 identified species (Platnick, 2012). They have remarkable abundance and are highly diversified terrestrial predator especially in agro-ecosystems (Wise, 1993).

They can play a pivotal role in keeping insect and pest populations in check and balance and they are also serve as food for birds, snakes, fish and other animals. They eat insects and bugs which destroy different crops and consequently safeguard the agro-ecosystems. By habitat management. We can conserve the diversity of natural enemies (including spiders) of arthropod pest
(Douglas *et al*., 2000).

Spider's abundance and diversity vary in different agro-ecosystems and they have temporo-spatial distribution in all agricultural lands to effectively destruct the insect pest population (Seyfulina and Tshernyshev, 2001; Seyfulina, 2003). Their breeding success is directly related to amount of precipitation which act as potential factors to affect the abundance and species richness (Thomas *et al*., 2014). They are most important arthropods for economic point of view playing role as biological control agent and their adaptation towards different habitats (Kazim *et al*., 2014).

Keeping in view the importance of spider densities and role of berseem in live-stock sector, the present study was designed to record the population dynamics and spatial distribution of ground dwelling spider families and genea among berseem crop at Okara district.

Materials and methods

Study area

The present study was designed to record spatial distribution of ground dwelling spiders among berseem crop at Okara district. Because information about their distribution in any agro-ecosystem was pre-requisite to formulate any strategy to use them for bio-control purposes.

Presently, these informations were recorded from Okara district. Trifolium crop was cultivated in one acre rectangular field. The sampling field was surrounded by wheat fields from two sides, where as on third side, it was surrounded by a Trifolium and Mustard field.

Okara district

Okara district is situated in Punjab province at 30,

8081 (304829.160"N) latitude and 73, 4458 (732644.880"E) longitude. This district is bounded on the East by Kasur district, Sahiwal and Pakpattan districts on the West, Sheikhupura and Faisalabad districts on the North and Bahawalnagar district on the South. The Indian border also lies on the South-Eastern side of the district. Okara district has a total area of 4,377 square kilometres and comprises of three tehsils i.e. Okara, Depalpur and Renala Khurd.

Climate

The climate of the Okara district is hot in summer and cold in winter. May and June are hottest months and January is the coldest one.Temperature ranges between 36-44°C in summer and 2-28°C in winter. Soil of the district is loamy and sandy loamy with annual rainfall up to 200 mm.

Sampling design and techniques

The sampling was carried out from October, 2014 through April, 2015 to collect the ground dwelling spider fauna in berseem crop.Total thirty traps were set in the field for five successive days. The two successive traps were at equal distance from each other and the distance from outer boundary of the field was 5m. Pitfall traps were 12cm long glass jars with 6cm (diameter) wide mouths. Each trap contained 150 ml of 70% ethyl alcohol and a small amount of kerosene oil which served as preservative and killing agent.Ten pitfall traps were laid along each transect line i.e. boundary, middle and centre at an equal interval from each other.

Collection of data

For berseem crop, ideal field measuring 7200 sq. ft. were selected to observe the spatial distribution of ground dwelling spiders through pitfall trap method. However, trapping was made by three layers inside the field radius wise to observe the infestation along the entire field. Data was collected fortnightly and collected specimens were brought into the Pest Control Laboratory, Departmentof Zoology, Wildlife and Fisheries, University of Agriculture, Faisalabad. All the specimens were identified according to the reference material. The field of berseem was sampled after 5 days intervals right from the pre-harvest stage. More over, minimum and maximum temperature and humidity of area was also recorded.

Preservation

All traps were taken to Pest Control Laboratory, Department of Zoology, Wildlife and Fisheries, University of Agriculture, Faisalabad. Where the specimens were washed with xylene and preserved in 95% ethanol containing few drops of glycerin. Specimens were preserved separately in small glass vials indicating with trap number and the date of capture.

Identification

The collected samples were identified with the aid of naked eye, magnifying glass and under the microscope. All the specimens were identified up to species level according to the taxonomic and reference material (Tikader and Malhotra (1982), Tikader and Biswas (1981), Barrion and Litsinger (1995), Zhu *et al.* (2003), Platnick (2012), other relevant literature and internet source.

Statistical analysis

Thereafter, all the identified specimens were arranged in table form according to their morphological characters e.g. family, genus. To determine the various aspects of diversity, Shannon Diversity Index was used (Magurran, 1988). Analysis of Variance was made to compare the population means between three transects, i.e. Boundary, middle and centre of berseem crop. The richness, diversity and evenness indices were computed by using the Programme SPDIVERS.BAS.

Results

The present study was conducted to highlight the spatial distribution of ground dwelling spiders among berseem crop at Okara district. A total number of 463 specimen pertaining to 25 genera and 7 families among berseem crop were identified from Okara district (Table 1).

Table 1. The number of families, specimen and genera recorded from berseem field at Okara district.

Sr.No.	Families	No. of Specimen	No. of Genera
1	Araneidae	34	4
2	Clubionidae	20	1
3	Gnaphosidae	122	5
4	Linyphiidae	63	3
5	Lycosidae	165	5
6	Salticidae	37	4
7	Thomisidea	22	3
Total	7	463	25

Table 2. Monthly record of spider families captured from berseem crop at Okara district.

Families	No.of spiders in Nov-14	No.of spiders in Dec-14	No.of spiders in Jan-15	No.of spiders in Feb-15	No.of spiders in Mar-15	No.of spiders in Apr-15	Total No. of spiders
Araneidae	2	2	0	4	9	17	34
Clubionidae	0	0	0	3	5	12	20
Gnaphosidae	9	3	1	18	31	60	122
Linyphiidae	5	3	3	7	14	31	63
Lycosidae	11	4	3	25	50	72	165
Salticidae	3	1	0	8	10	15	37
Thomisidea	3	1	1	3	6	8	22
Grand Total	33	14	8	68	125	215	463

Population variations among families in berseem crop

Data presented in Table 2, is pertaining to family's wise comparison of spiders' population recorded from two fodder crops during the study. In Berseem crop, the population of wolf spiders – family Lycosidae was recorded with highest population (N = 165), followed by Flat bellied ground spiders – family Gnaphosidae (N = 122), Sheat weaver spiders – family Linyphiidae (N = 63), Jumping spiders – family Salticidae (N = 37), Orb-weaver spiders – family Araneidae (N = 34), Crab spiders-- family--Thomisidea (N = 22) and Sac spiders-- family—Clubionidae (N = 21) respectively.

Table 3. Population variations of spider genera among berseem field at Okara district.

Family	Genera	Nov-14	Dec-14	Jan-15	Feb-15	Mar-15	Apr-15	Total
Araneidae	*Araneus* Clerck, 1757	1	0	0	3	2	5	11
	Gea C. L. Koch, 1843	0	2	0	0	2	4	8
	Neoscona Simon, 1864	1	0	0	1	3	3	8
	Cyclosa Menge, 1866	0	0	0	0	2	5	7
Clubionidae	*Clubiona* latreille,1804	0	0	0	3	5	12	20
Gnaphosidae	*Drassodes*	4	2	1	8	12	20	47
	Gnaphosa Latreille, 1804	2	0	0	3	6	11	22
	Scotophaeus Simon, 1893	2	0	0	3	5	10	20
	Zelotes Gistel, 1848	1	1	0	4	6	14	26
	Micaria Westring, 1851	0	0	0	0	2	5	7
Linyphiidae	*Tapinocyboides* Wiehle, 1960	1	1	0	2	5	16	25
	Tchatkalophantes Tanasevitch, 2001	2	1	2	3	4	8	20
	Tiso Simon, 1884	2	1	1	2	5	7	18
Lycosidae	*Evippa* Simon, 1882	5	2	1	14	21	36	79
	Hogna Simon,1885	1		1	1	2	3	8
	Lycosa Latreille, 1804	3	1	0	8	18	20	50
	Pardosa C. L. Koch, 1847	2	1	1	2	8	12	26
	Trochosa C. L. Koch, 1847	0	0	0	0	1	1	2
Salticidae	*Myrmarachne* MacLeay, 1839	2	0	0	2	4	5	13
	Phlegra Simon, 1876		1	0	2	2	4	9
	Plexippus C. L. Koch, 1846	1	0	0	1	2	3	7
	Sitticus Simon, 1901	0	0	0	3	2	3	8
Thomisidea	*Runcinia* Simon, 1875	1	1	1		2	2	7
	Thomisus Walckenaer, 1805	1	0	0	3	2	4	10
	Xysticus	1	0	0	0	2	2	5
	Grand Total	33	14	8	68	125	215	463

The maximum population of wolf spiders – family Lycosidae was recorded due to that they were strictly ground dwelling spiders. Second and third highest population recorded were of Flat bellied ground spiders – family Gnaphosidae and Sheat weaver spiders – family Linyphiidae respectively due to the reason that they were also ground living and live in high vegetation density, therefore the existing environment was supportive for them. However minimum population of identified spiders in case of Jumping spiders – family Salticidae followed by Orb-weaver spiders – family Araneidae, Crab spiders-- family Thomisidea and Sac spiders -- family Clubionidae was recorded from berseem field.Their low population was recorded due to that they live in leaf litter and shaddy areas. The study area was surrounded by wheat crops from north and east side and mustard crop from west side. Whole cultivated area was comprised of crop land and there was no shaddy tree near the study area. Another reason for their least collection was that, they were foliage spiders and pitfall method was applied for the collection of spiders.

Table 4. Number of genera (S), total number of samples (N), Shannon diversity index, Lambda value and Evenness for transect-wise monthly data of berseem crop for different genera.

Site	Month	S	N	H' Shannon	Lambda	Evenness	Dominance
Boundary	Nov.	11	17	2.2624	0.1211	0.9435	0.0565
	Dec.	6	6	1.7918	0.1667	1.0000	0.000
	Jan.	3	3	1.0986	0.3333	1.0000	0.000
	Feb.	15	24	2.5209	0.0972	0.9309	0.0691
	Mar.	19	45	2.6839	0.0884	0.9115	0.0885
	Apr.	25	73	2.9098	0.0696	0.9040	0.096
Middle	Nov.	9	12	2.0947	0.1389	0.9534	0.0466
	Dec.	5	5	1.6094	0.2000	1.0000	0.000
	Jan.	5	5	1.6094	0.2000	1.0000	0.000
	Feb.	18	40	2.6485	0.0938	0.9163	0.0837
	Mar.	25	66	2.8543	0.0804	0.8868	0.1132
	Apr.	23	103	2.8428	0.0755	0.9067	0.0933
Center	Nov.	5	5	1.6094	0.2000	1.0000	0.000
	Dec.	2	2	0.6932	0.5000	1.0000	0.000
	Jan.	-	-	-	-	-	-
	Feb.	4	4	1.3863	0.2500	1.0000	0.000
	Mar.	11	14	2.3420	0.1020	0.9767	0.0233
	Apr.	16	39	2.4830	0.1059	0.8956	0.1044

Where S = Number of species

N = Total number of samples (sum).

Population variations among genera in berseem crop

Data presented in Table 3, is regarding the comparison of spider's population among genera recorded in berseem field during the study. Out of 25 genera, maximum population of identified genera was recorded in case of genus *Evapa* (N=79) followed by *Lycosa* (N=50) and *Drassodes* (N=47) respectively. Minimum population of identified spider genera was recorded in case of genus *Cyclosa* (N=7), Micaria (N=7), *Plexipus* (N=7), *Runcinia* (N=7), *Xysticus* (N=5), and *Trochosa* (N=2) respectively.

Least population was recorded in case of genus *Cyclosa, Micaria, plexipus, Runcinia, Xysticus*, and *Trochosa* respectively. Because they were ground dwelling spiders and live in shelter places while in berseem field, fodder was cut down again and again that's why their minimum population was recorded.

Table 5. Number of genera(S), total number of samples(N), Shannon diversity index, Lambda value, Evenness and dominance for transect-wise monthly record of berseem crop for different genera.

Month	S	N	H Shannon	Lambda	Evenness	Dominance
November	18	33	2.7327	0.0762	0.9455	0.0545
December	11	14	2.342	0.102	0.9767	0.0233
January	7	8	1.9062	0.1563	0.9796	0.0204
February	19	68	2.6641	0.0921	0.9048	0.0952
March	25	125	2.8624	0.0788	0.8893	0.1107
April	25	215	2.8859	0.0728	0.8966	0.1034

Spatial diversity of spider genera in berseem cropData presented in Tabl 4, is pertaining the month wise comparison of diversity indices among species at three trasects i.e. boundary, middle and centre of the berseem crop. During the month of November maximum diversity (H) at boundary recorded was 2.2624, eveness 0.9435 and dominance was 0.0565 when compared with middle, maximum diversity was 2.0947, eveness 0.9534, and dominance 0.0466. and at centre, maximum diversity 1.6094, eveness 1.0000 and dominance 0.0000.During the month of December maximum diversity (H) at boundary recorded was 1.7918, eveness 1.0000 and dominance was 0.0000, when compared with middle, maximum diversity was 1.6094, eveness 1.0000, and dominance 0.000. and at centre, maximum diversity 0.6932, eveness 1.0000 and dominance 0.0000.During the month of January maximum diversity (H) at boundary recorded was 1.0986, eveness 1.0000 and dominance was 0.0000 when compared with middle, maximum diversity was 1.6094, eveness 1.0000, and dominance 0.000. and no diversity was recorded in centre.During the month of February maximum diversity (H) at boundary recorded was 2.5209, eveness 0.9309 and dominance was 0.0691 when compared with middle, maximum diversity was 2.6485, eveness 0.9163, and dominance 0.0837. and at centre, maximum diversity 1.3863, eveness 1.0000 and dominance 0.0000.During the month of March maximum diversity (H") at boundary recorded was 2.6839, eveness 0.9115 and dominance was 0.0885 when compared with middle, maximum diversity was 2.8543, eveness 0.8868, and dominance 0.1132 and at centre, maximum diversity 2.3420, eveness 0.9767 and dominance 0.0233.During the month of April, maximum diversity (H) at boundary recorded was 2.9098, eveness 0.9040 and dominance was 0.096 when compared with middle, maximum diversity was 2.8428, eveness 0.9067, and dominance 0.0933 and at centre, maximum diversity 2.4830, eveness 0.8956 and dominance 0.1044. Overall maximum diversity (H") recorded in the month of April at the boundary was 2.9098, eveness 0.9040 and dominance was 0.096 respectively, when compared with boundary and centre of the berseem crop.

Overall comparison of diversity indices among berseem crop

Data presented in Table 5, is pertaining the month wise comparison of diversity indices among genera from Berseem crop. Overall genera wise maximum diversity (H") recorded in Berseem crop during the month of November was 3.7327, evenness 0.9455 and dominance 0.0545 respectively. During the month of December maximum diversity 2.3420, evenness 0.9767 and dominance 0.0233 was recorded. During the month of January maximum diversity 1.9062, evenness 0.9796 and dominance 0.0204 was recorded. During the month of February maximum diversity 2.6641, evenness 0.9048 and dominance 0.0952 was recorded. During the month of March maximum diversity 2.8624, evenness 0.8893 and dominance 0.1107 was recorded. During the month of April maximum diversity 2.8859, evenness 0.8966 and dominance 0.1034 was recorded.

Table 6. Analysis of variance table for transect-wise abundance of different genera for different crops.

Source of variation	Degrees of freedom	Sum of squares	Mean squares	F-value
Months	5	16332.6	3266.51	20.98**
Crop	1	49.0	49.00	0.31^{NS}
Transect	2	4423.7	2211.86	14.20**
Crop x Transect	2	24.5	12.25	0.08^{NS}
Error	25	3893.1	155.72	
Total	35	24722.9		

NS = Non-significant (P>0.05); * = Significant (P<0.05); ** = Highly significant (P<0.01).

Month wise mean ± SE.

Month	Mean ± SE	
November-14	11.50±3.03	CD
December-14	4.00±0.82	D
January-15	2.33±0.71	D
February-15	26.33±6.73	C
March-15	42.33±9.22	B
April-15	60.83±11.79	A

Means sharing similar letters are statistically non-significant (P>0.05).

Crops x Transect interaction mean ± SE.

Transect	Berseem Crop	
	Mean ± SE	
Boundary	28.00 ± 10.89A	
Middle	38.50 ± 16.19A	
Center	10.67 ± 6.00B	
Mean	25.72 ± 6.97A	

Means sharing similar letter in a row or in a column are statistically non-significant (P>0.05).

Maximum diversity 2.8859 was recorded during the month of April .while evenness 0.9796, and dominance 0.1107 were recoded during the month of January and March respectively.

Relative abundance

Pie graph (Fig. 1) represent the relative abundance of identified spider families in berseem crop at Okara district. Maximum abundance of spiders was recorded in case of family Lycosidae 36% followed by Gnaphosidae 26% and Lyniphiidae 14%. Minimum abundance of spiders was recorded in family Araneidae 7% followed by Thomisidae 5% and Clubionidae 4% respectively.

Ecological distribution

Temperature of the country is increasing day by day due to global warming. Consequently, the change in temperature also alter the humidity of the environment. Due to change of temperature and humidity, imbalanece the relation ship between organism and the environment (Table 7). This issue was observed on scientific basis among ground dwelling spiders to record the effect of ecological changes. It was recorded that population of spiders was increased with the increase in temperature and

decreasing tendency was recorded in case of humidity. Because, breeding season of spiders started during April and peaks were recorded with the increase in temperature. Temperature also affects the body processes and egg development. They concluded that females may be able to protect themselves against temperatures that are prohibitively low for reproduction. From these results, it was concluded that variations in population density were due to effect of temperature, humidity, availability of prey, nature of crop rotation and pesticides uses instead of ecological successions.

Table 7. Monthly average temperature (maximum and minimum), percentage of humidity recorded from Okara district.

Month	Average maximum temperature °C	Average minimum temperature °C	Average relative humidity
Novermber	27.2	8.7	85%
December	18.9	4.1	90.50%
January	16.6	4.1	93.00%
February	22.3	6.7	78.50%
March	25.1	10	77.00%
April	32.5	16.6	78.00%

Analysis of variance

Data represented in Table 6, pertaining to Analysis of variance for transect-wise abundance of different genera of spiders for berseem crop.The mean number of spider genera in berseem at district Okara was statistically similar. The mean number of spider's population month wise and transect wise were statistically highly significant ($P<0.01$). The mean number of spider's population during the month of December (4.00±0.82) and January (2.33±0.71) were statistically non significant ($P>0.05$), when compared with mean number in November (11.50±3.03), February (26.33±6.73), March (42.33±9.22) and April (60.83±11.79) was statistically significan ($P<0.05$). Crop x Transect-wise mean number of spider genera in boundary (27.75±6.68) and middle (36.25±9.89) were statistically non significant ($P>0.05$) when compared with mean number in centre (9.63±3.38) was statistically significant ($P<0.05$) among berseem crop. Overall mean number of spider genera in berseem (25.72±6.97) crop was statistically non significant ($P>0.05$).

It is obvious from the indices calculations that spiders abundance decrease with the decrease in temperature and increase in humidity. Resultantly, ecological imbalance of prey verses predators develops which upset the all ecological pyramids and natural cycling. Sustainable prey and predator status is limiting for integrity of any natural system for long term functions.

Discussion

Seasonal variations in spider population

Evidences regarding sesaonal variations of spider population was underlined by considering the findings of previous researchers because field type, management pattern, agronomic operations and use of pesticides, soil culture and floral structures significantly affect spider's population (Liljesthrom *et al.*, 2002; Ahmad *et al.*, 2005; Pradeep *et al.*, 2015). It was also estimated that start of breeding season, enhancment in growth and acceleration in maturity were proportional to temperature and humidity. As temperature reached above 25°C, start in breeding occur and with decrease in temperature up to the same situation and increase in humidity, it comes to the end. Findings of present study are in agreement with Rajeswaran *et al.* (2005); Dippenaar-Schoeman (2006); Mushtaq *et al.* (2003 & 2005); Kazim *et al.* (2014), Pradeep *et al.* (2015).

It is obvious from the indices calculations that spider's abundance decrease with the decrease in

temperature and increase in humidity. These findings support the earlier reports of Mushtaq *et al.* (2003 & 2005); Iqbal *et al.* (2009) and Pradeep *et al.* (2015). Resultantly, ecological imbalance of prey verses predators develops which upset the all ecological pyramids and natural cycling. Sustainable prey and predator status is limiting for integrity of any natural system for long term functions. These findings are in same cotext as reported by Rajeswaran *et al.* (2005); Dippenaar-Schoeman (2006); Mushtaq *et al.* (2003 & 2005); Kazim *et al.* (2014), Pradeep *et al.* (2015).

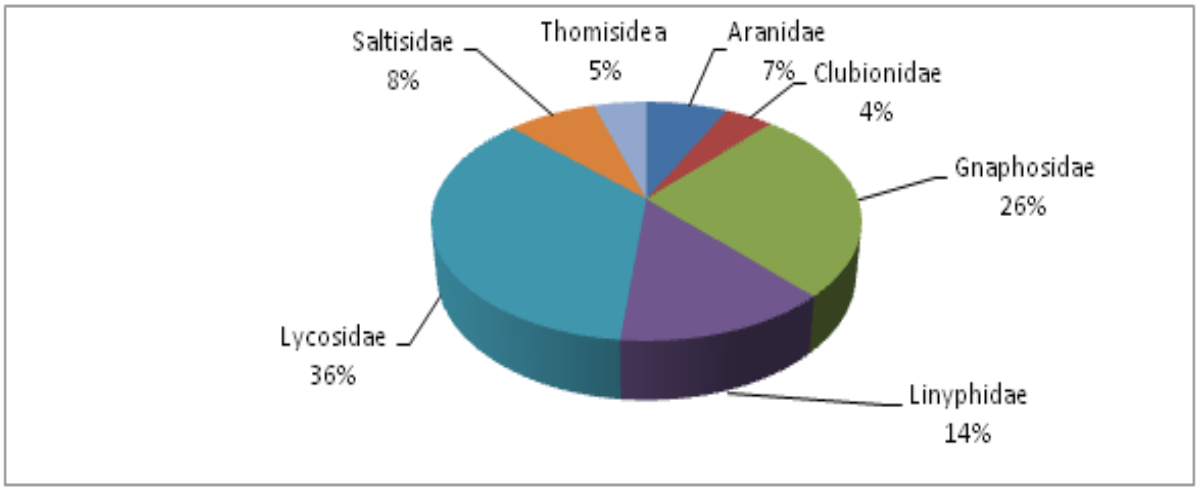

Fig. 1. Pie graph represent the relative abundance of spider families in berseem crop.

Conclusion

Hence, it was concluded from the present work that despite to cosmopolitan nature, spiders have some correlation with suitable local conditions or habitat. However, it was also observed that spider's population in the same study region were also effected by increase or decrease in temperature and humidity. So, there is necessity of future research for the proper use of spider fauna as biological control agent in IPM programmes.

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