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Temporo-spatial distribution of ground dwelling spider genera among fodder crops at Okara district, Pakistan

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Abstract

The present study was designed to record the temporo-spatial distribution of ground dwelling spider genera among fodder crops at Okara district. Sampling was made from berseem and mustard crops 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 collected and spider specimen were washed with distilled water and permanently stored in labeled glass vials. Each spider specimen was identified according to the taxonomic material and internet source. Overall maximum spatial distribution of spider population was documented in middle transect than boundary and centre of the fodder crops. It was observed that temperature, humidity and prey availability were the major factors effecting the spider's population. Population variations 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 spiders have direct correlation with temperature and suitable local conditions. Moreover, 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 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. 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, 2003; Rana *et al.*, 2016). 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 fodder crops in live-stock sector, the present study was designed to record the temporo-spatial distribution of ground dwelling spider genera by space and time among fodder crops 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 information 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, whereas on third side, it was surrounded by a Trifolium and Mustard fields.

Sampling design and techniques

The sampling was carried out from October, 2014 through April, 2015 to collect the ground dwelling spider fauna in fodder crops. 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 fodder crops, ideal field measuring 7200 sq. ft. were selected to observe the temporo-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, Department of Zoology, Wildlife and Fisheries, University of Agriculture, Faisalabad. All the specimens were identified according to the reference material. The field of fodder crops was sampled after 5 days intervals right from the pre-harvest stage. Moreover, 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

Population variations among genera in fodder crops

Overall comparison of spiders' population among genera recorded in berseem and mustard fields during the study represent the total 25 genera recorded from berseem crop and 21 genera recorded from mustard crops during the study. Four genera namely, *Micaria, Trochosa, Phelgra* and *Siticus* were recorded only in berseem field which were absent from mustard crop. Maximum population of identified genera from both the fodder crops were recorded in case of genus *Evapa* followed by *Lycosa*, *Drassodes* and *Gnaphosa* respectively. Minimum population of identified spider genera was recorded in case of genus *Thomisus* followed by *Cyclosa, Micaria, Runcinia, Plexipus, Gea, Neoscona, Xysticus* and *Trochosa,* respectively.

Overall relative abundance up to genus level

To weigh up the population of ground dwelling spiders among berseem crop at genus level (Table 1) relative abundance of ground dwelling spiders at Okara district was recorded. The most dominant genera and major contributor of population in Berseem crop was *Evippa* (Family: Lycosidae) 17.1% (n ≥ 79), *Lycosa*(Family: Lycosidae) 10.8% (n ≥ 50), *Drassodes* (Family: Clubionidae) 10.2% (n ≥ 47), *Zelotes* (Family: Gnaphosidae) *Pardosa* (Family: Lycosidae) 5.62% (n ≥ 26), *Tapinocyboides* (Family: Lyniphidae) 5.40% (n ≥ 25), *Gnaphosa*(Family: Gnaphosidae) 4.75% (n ≥ 22), and *Clubiona* (Family: Gnaphosidae), *Tchatkalophantes* (Family: Lyniphidae) 4.32% (n ≥ 20), *Tiso* (Family: Lyniphidae) 3.89% (n ≥ 18). Where in, the least abundant genera were *Cyclosa* (Family: Araneidae), *Micaria* (Family: Gnaphosidae), *Plexippus* (Family: Salticidae), *Runcinia* (Family: Thomisidae), 1.51% (n

≤ 07), *Xysticus* (Family: Thomisidae), 1.08% (n ≤ 05), *Trochosa* (Family: Lycosidae) 0.43% (n ≤ 02). Whereas, from mustard crop maximum relative abundance was recorded pertaining to *Evippa* (Family: Lycosidae) 14.25% (n ≥ 60), followed by *Lycosa*(Family: Lycosidae) 9.70% (n ≥ 41), *Drassodes* (Family: Clubionidae) 9.02% (n ≥ 38), *Pardosa* (Family: Lycosidae) 7.36% (n ≥ 31), *Tchatkalophantes*(Family: Lyniphidae) 6.65% (n ≥ 28), *Tiso* (Family: Lyniphidae) 6.17% (n ≥ 26), *Zelotes* (Family: Gnaphosidae) 5.22% (n ≥ 22), *Clubiona* (Family: Clubionidae) 4.98% (n ≥ 21). While least abundant genera were *Cyclosa* (Family: Aranidae) 1.90% (n ≤ 08) followed by *Gea* (Family: Aranidae) 1.66% (n ≤ 07), *Neoscona* (Family: Araneidae) 1.18% (n ≤ 05).

Table 1. Overall relative abundance of ground dwelling spiders up to genus level from berseem and mustard crops at Okara district.

Family	Genera	Berseem	R.A	Mustard	R.A
Aranidae	*Araneus* Clerck, 1757	11	2.38	14	3.33
	Gea C. L. Koch, 1843	8	1.73	7	1.66
	Neoscona Simon, 1864	8	1.73	5	1.19
	Cyclosa Menge, 1866	7	1.51	8	1.9
Clubionidae	*Clubiona* latreille,1804	20	4.32	21	4.99
Gnaphosidae	*Drassodes*	47	10.2	38	9.03
	Gnaphosa Latreille, 1804	22	4.75	13	3.09
	Scotophaeus Simon, 1893	20	4.32	17	4.04
	Zelotes Gistel, 1848	26	5.62	22	5.23
	Micaria Westring, 1851	7	1.51	0	0.00
Linyphidae	*Tapinocyboides*	25	5.4	21	4.99
	Tchatkalophantes	20	4.32	28	6.65
	Tiso Simon, 1884	18	3.89	26	6.18
Lycosidae	*Evippa* Simon, 1882	79	17.1	60	14.3
	Hogna Simon,1885	8	1.73	15	3.56
	Lycosa Latreille, 1804	50	10.8	41	9.74
	Pardosa C. L. Koch, 1847	26	5.62	31	7.36
	Trochosa C. L. Koch, 1847	2	0.43	0	0.00
Saltisidae	*Myrmarachne* MacLeay, 1839	13	2.81	11	2.61
	Phlegra Simon, 1876	9	1.94	0	0.00
	Plexippus C. L. Koch, 1846	7	1.51	10	2.38
	Sitticus Simon, 1901	8	1.73	0	0.00
Thomisidea	*Runcinia* Simon, 1875	7	1.51	13	3.09
	Thomisus Walckenaer, 1805	10	2.16	9	2.14
	Xysticus	5	1.08	11	2.61
Grand Total		463		421	

Overall relative abundance up to family level

If we consider population dynamic of spiders with relative abundance at family level (Table 2), we will find out that which family supported best and playing important role in managing herbivory problem and other ecological issues. Hence, by this way, we will also find out important families among fodder crops regarding ground dwelling spiders' fauna for future conservational aspects and milestone for bio-control strategies. Therefore for berseem crop, highest value of relative abundance was recorded for family Lycosidae (Wolf spiders) 35.6% (n ≤ 165) followed by Gnaphosidae (Flat bellied ground spiders) 26.3% (n ≥ 122), Lyniphiidae (Sheet weaving spiders) 13.6% (n ≥ 63), Salticidae (Jumping spiders) 7.99% (n ≥ 37), Araneidae (Orb-Weaver) 7.34% (n ≥ 34), Thomisidae (Crab spiders spiders) 4.75% (n ≥ 22) and Clubionidae (Sac spiders) 4.32% (n ≥ 20). Almost similar trend was recorded in mustard crop. The highest value of relative abundance was recorded for family Lycosidae (Wolf spiders) 34.9% (n ≤ 147) followed by Gnaphosidae (Flat bellied ground spiders) 21.14% (n ≥ 90), Lyniphiidae (Sheet weaving spiders) 17.18% (n ≥ 75), Thomisidae (Crab spiders) 7.84% (n ≥ 33) Araneidae (Orb-weaver spiders) 7.36% (n ≥ 31), Clubionidae (Sac spiders) 5.7% (n ≥ 24) and Salticidae (Jumping spiders) 4.99% (n ≥ 21). Minimum value of relative abundance from berseem crop was recorded for family Thomisidae (Crab spiders) 4.75% (n ≤ 22) and Clubionidae (Sac spiders) 4.32% (n ≤ 20).

Table 2. Overall relative abundance of spiders up to family level from fodder crops at Okara district.

Families	Berseem	Mustard	Total
Araneidae	7.34(34)	7.36(31)	65
Clubionidae	4.32(20)	5.7(24)	44
Gnaphosidae	26.3(122)	21.14(90)	212
Linyphiidae	13.6(63)	17.18(75)	138
Lycosidae	35.6(165)	34.9(147)	312
Salticidae	7.99(37)	4.99(21)	58
Thomisidea	4.75(22)	7.84(33)	55
Grand Total	463	421	884

While least value of relative abundance from mustard crop was recorded for family Clubionidae (Sac spiders) 5.7% (n ≤ 24) and Salticidae (Jumping spiders) 4.99% (n ≤ 21). Overall high population of most abundant families from berseem and mustard crops were recorded because both fodder crops were surrounded by wheat and mustard crops and dense vegetation was existing among them which was favorable environment for the population of ground dwelling spiders. Moreover, these spiders were temperature tolerant and can tolerate temperature fluctuations in the environment. These are ground dwelling hunting spiders, which spent their nights in hunting prey and the specimen collecting methodology was mainly pitfall that's why they were collected in maximum number. Overall low population of least abundant families recorded from berseem and mustard crops were due to that they were foliage spiders and prefer to live in shady and littered places. They were frequently present in small vegetation and grassy areas, so they were recorded in least number.

Table 3. 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	November	11	17	2.2624	0.1211	0.9435	0.0565
	December	6	6	1.7918	0.1667	1.0000	0.000
	January	3	3	1.0986	0.3333	1.0000	0.000
	February	15	24	2.5209	0.0972	0.9309	0.0691
	March	19	45	2.6839	0.0884	0.9115	0.0885
	April	25	73	2.9098	0.0696	0.9040	0.096
Middle	November	9	12	2.0947	0.1389	0.9534	0.0466
	December	5	5	1.6094	0.2000	1.0000	0.000
	January	5	5	1.6094	0.2000	1.0000	0.000
	February	18	40	2.6485	0.0938	0.9163	0.0837
	March	25	66	2.8543	0.0804	0.8868	0.1132
	April	23	103	2.8428	0.0755	0.9067	0.0933
Centre	November	5	5	1.6094	0.2000	1.0000	0.000
	December	2	2	0.6932	0.5000	1.0000	0.000
	January	0	0	0.000	0.000	0.000	0.000
	February	4	4	1.3863	0.2500	1.0000	0.000
	March	11	14	2.3420	0.1020	0.9767	0.0233
	April	16	39	2.4830	0.1059	0.8956	0.1044

Where S = Number of species
N = Total number of samples (sum).

Spatial diversity of spider genera in berseem crop

Data presented in Table 3, is pertaining the month wise comparison of diversity indices among species at three transects 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.

Table 5. 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.

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.

Spatial diversity of spider genera in mustard crop

Data presented in Table 4, is pertaining the month wise comparison of diversity indices among species at three transects i.e. boundary, middle and centre of the berseem crop. During the month of November maximum diversity (H") at boundary recorded was 2.5986, eveness 0.9596 and dominance was 0.0404, when compared with middle, maximum diversity was 2.4583, eveness 0.9893, and dominance 0.0107, and at centre, no diversity was found. During the month of December maximum diversity (H") at boundary recorded was 1.6994, 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, no diversity was found. 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 0.6932, eveness 1.0000, and dominance 0.000 and at centre, no diversity was found During the month of February maximum diversity (H") at boundary recorded was 2.6851, eveness 0.9477 and dominance was 0.0523 when compared with middle, maximum diversity was 2.7622, eveness 0.9381, and dominance 0.0619 and at centre, maximum diversity 2.3979, eveness 1.0000 and dominance 0.0000.

Table 5. 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).

Continued. 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).

Continued. Crops × Transect interaction mean ± SE.

Transect	Fodder Crop				Mean ± SE	
	Berseem		Mustard			
Boundary	28.00	± 10.89	27.50	± 8.82	27.75	± 6.68A
Middle	38.50	± 16.19	34.00	± 12.87	36.25	± 9.89A
Center	10.67	± 6.00	8.67	± 3.71	9.67	± 3.38B
Mean	25.72	± 6.97A	23.39	± 5.66A		

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

During the month of March maximum diversity (H) at boundary recorded was 2.7219, eveness 0.9244 and dominance was 0.0756 when compared with middle, maximum diversity was 2.8775, eveness 0.9451, and dominance 0.0549 and at centre, maximum diversity 2.4260, eveness 0.9763 and dominance 0.0237.During the month of April, maximum diversity (H) at boundary recorded was 2.8910, eveness 0.9496 and dominance was 0.0504, when compared with middle, maximum diversity was 2.7324, eveness 0.9121, and dominance 0.0879 and at centre, maximum diversity 2.3864, eveness 0.9304 and dominance 0.0696. Overall maximum diversity (H) recorded in the month of April at the boundary was 2.8910, eveness 0.9496 and dominance 0.0879 recorded in the middle of the crop.

Effects of temperature and humidity

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, imbalance the relationship between organism and the environment (Fig. 1). 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. It was 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.

Analysis of variance

Data represented in Table 5, pertaining to Analysis of variance for transect-wise abundance of different genera of spiders for different fodder crops. The mean number of spider genera in both fodder crops i.e. berseem and mustard at district Okara were 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 nonsignificant ($P>0.05$), 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 significant ($P<0.05$) in both the fodder crops. 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 ($P<0.05$) in both fodder crops. Overall mean number of spider genera in berseem (25.72±6.97) and mustard (23.39±5.66) crops were statistically non-significant ($P>0.05$).

Discussion

Ecological distribution

Due to global warming, temperature and humidity are alarming in Pakistan (Govt. of Pakistan, 2010) resulting imbalancement in ecological conditions (Schmidt *et al.*, 2005). According to Rittschof (2012); Herberstein and Fleisch (2003); Rana *et al.* (2016), temperature is limiting factor in the life history of spiders' community. For instance, in temperate region, decline in temperature result as end of the reproductive season (Herberstein and Fleisch, 2003). According to these researchers, spiders also alter their web-site with regard to temperature and during *in-situ* conditions; low temperature affects egg development and the female's ability to oviposit. During present study, it was noted that species diversity, relative abundance, evenness, and richness increased with least use of pesticides. Mushtaq *et al.* (2003 & 2005); Schmidt *et al.* (2008) reported that sustainable agricultural practices can enhance spider population as well as species diversity, relative abundance and richness. The coexistence of more species during February, March and April is due to the availability of excess insect prey, reduced micro-climatic changes and increased structural forms of plants during these months. Spiders are most prominent insectivores in terrestrial ecosystem and shows diversity of life style and foraging behavior. They are important predator fauna of agricultural lands because they are capable of propagating their population rapidly (Harwood *et al.*, 2001). The findings of present study were according to views of these researches in Pakistan and other geographic regions of the world. These findings have also confirmed our expectation about impact of temperature and humidity.

Seasonal variations

Evidences regarding sesaonal variations of spider population was underlined by considering the findings of previous researchers because field type, management pattern, agronomic operations, soil culture and floral structures significantly affect spider's population (Heidger and Nentwing, 1989; Thomas and Waage, 1996; Liljesthrom *et al.*, 2002; Ahmad *et al.*, 2005). It was also estimated that start of breeding season, enhancment in growth and acceleration in maturity were proportional to temperature and humidity (Rittschof, 2012; Rana *et al.* 2016). 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. These findings are also in same context as already reported in Pakistan (Mushtaq *et al.*, 2003, 2005; Ghafoor, 2002; Ghaffar *et al.*, 2011; Rana *et al.*, 2016). Findings of present study were in-line with these researchers. It was noted that seasonal distribution trend was affected by temperature, humidity, migration, micro-habitat preferences as well as prey availability (Fig. 1).

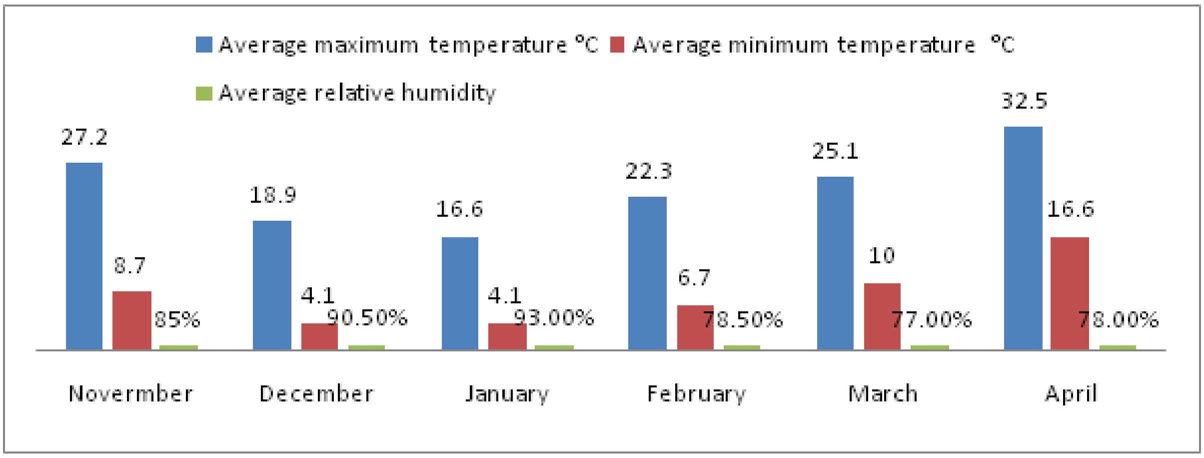

Fig. 1. Month wise temperature and humidity in fodder crops at Okara district.

Conclusion

Hence, it was concluded from the present work that spiders have direct correlation with temperature and suitable local conditions. However, it was observed that spider's population in the same study region were also affected 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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