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Species Composition and Population Dynamics of Spider Fauna of *Trifolium* and *Brassica* Field

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Abstract.- The study was conducted at Shorkot, district Jhang, Punjab, Pakistan. For the present study, spiders were collected from *Trifolium* and *Brassica* field during November 2009 through April 2010. Pitfall traps were used for the collection of spiders. A total of 545 specimens, representing 12 families, 34 genera, and 66 species, were sampled during the whole study. Lycosidae was the most dominant family and comprised 47% of the total catch, followed by Linyphiidae (27%) and Salticidae (13%). Numerically the most abundant species in the samples was *Pardosa sumatrana* (Thorell, 1890) (4.5 %) followed by *Evippa banarensis* Tikader & Malhotra, 1980 (3.6%), *Neoscona theisi* (Walckenaer, 1841) (2.9 %) and *Evippa rubiginosa* Simon, 1885 (2.2 %). From November through January, the spider number was low as compared to February through April. The abundance of the spider was significantly higher on margins, as compared to edge and central area in the sampling field. Richness and diversity was highest in the month of April while highest evenness was recorded during the month of November.

Key words: Spider fauna, population dynamics, *Trifolium, Brassica*.

INTRODUCTION

About 80-90% nutrient of livestock are met from fodder crops including *Trifolium* (Berseem) and *Brassica* (Mustard) from October-April (Younas and Yaqoob, 2005). Insect pests seriously damage fodder crops including *Brassica* and *Trifolium*. In Korea, *Brassica* crop face serious threat by the attack of insect pests belonging to genus *Pieris* and *Plutella* (Furlong *et al*., 2008). In Pakistan cabbage caterpillar and leafminer were found to be serious insect pests of mustard in Peshawar, Pakistan (Anonymous, 1993). Saljoqi *et al*. (2006) reported that aphids, *Lipaphis erysimi* Kalt, (Aphididae: Homoptera), cabbage caterpillar, *Pieris brassicae* (Linnaeus) (Pieridae: Lepidoptera) and leafminer, *Chromatomyia horticola* Goureau (Agromyzidae: Diptera) was major pests in canola crop in Pakistan. Recently, Razzaq *et al*. (2011) recorded serious insect attack and yield loss in late sown *Brassica* in Multan, Southern Punjab.

Many studies have shown that spiders can significantly reduce prey densities in agricultural fields and can be used as important biological control agents of insect pests (Symondson *et al*., 2002; Pearce and Zalucki, 2006; Schmidt *et al*., 2009; Prieto-Benítez and Méndez, 2011). Sahito *et al*. (2010) found that all stages of spiders prey on all stages of sucking insect pests in *Brassica* and play important role in reducing preys densities.

The spiders are found in great abundance and diversity in different agro-ecosystems Different species have different spatial preference in agricultural fields and also have variable seasonal dynamics which may be very helpful in controlling insect pests (Seyfulina and Tshernyshev, 2001; Seyfulina, 2003). Mari and Lohar (2010) recorded that white fly was the major pest in all six varieties and the presence of spiders along with other predators relates with the presence of insect pests. Malik *et al*. (2012) studied sucking insect pest attack and predatory activities of various predators including spiders in different varieties of mustard. They concluded that the population of spiders remained low in all varieties of *Brassica* during December and January due to low abundance of prey especially aphids.

Perennial crops and degree of heterogeneity in their surrounding landscape have been demonstrated to have a positive effect on spider abundance and species richness on arable land (Clough *et al*., 2005; Schmidt and Tscharntke, 2005;

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Schweiger *et al.*, 2005). Fodder crops are least disturbed by the modern agricultural practices so it can act as refuge to spiders. By habitat management we can conserve the biodiversity of natural enemies (including spiders) of arthropod pest (Douglas *et al*., 2000). Butt and Sherawat (2011) suggested that diversification of management activities including sowing of *Brassica* crop on edges of wheat fields can be very useful to maintain spider diversity in the crop which can be effective in insect pest management. Sherawat *et al.* (2012) concluded that strip cropping of *Brassica* in wheat fields increases the predators including spiders which decrease the aphid's population that results in enhancing the yield. They further recorded that there was positive correlation between aphid population and spiders.

In Pakistan, pesticides are rarely used on fodder crops to control insect pests due to their harmful effects to dairy and livestock. In these conditions spiders along with other natural enemies may be used to control pest insects without polluting the environment and the yield of these crops can also be increased.

The main aim of the present study is to determine the species composition and population dynamics of spiders in *Trifolium* and *Brassica* crops, so that they can be used in IPM of insect pest in these crops.

MATERIALS AND METHODS

Study area

The study area was located at Shorkot (30.50N, 72.4E) district Jhang, Punjab, Pakistan. *Trifolium* and *Brassica* were cultivated in one acre rectangular field. These crops were sown in the selected field during the month of November 2009. The field was not treated with any kind of insecticide during the whole period of sampling. The sampling field was surrounded by wheat fields from three sides, whereas on fourth side it was surrounded by a *Trifolium* and *Brassica* field. The *Brassica* crop was present only during the month of November and December in the field after that it was harvested to use as fodder for livestock.

Sampling

The sampling was carried out from November 2009 through April 2010. The ground spider fauna was sampled every month during the period of study. Twenty five stations were randomly selected each month. The traps were set for five successive days (120 h). The distance between two successive traps was 3m. Twenty five traps were set diagonally and the corners were selected randomly each time.

The 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. The traps were buried in the ground so that the upper rim was at level of the soil surface. After 60 h of operation, all traps were replaced by others containing fresh preserving fluid. The latter were also operated for 60 h.

Preservation

All traps were taken to the laboratory, where the specimens were washed with xylene and preserved in 95% ethanol containing few drops of glycerin. Specimens were preserved separately in small glass bottles indicating with trap number and the date of capture.

Identification

The specimens were identified by using Dyal (1935), Tikader (1980, 1982), Tikader and Malhotra (1980), Tikader and Biswas (1981), Majumder and Tikader (1991), Barrion and Litsinger (1995), Yin *et al*. (1997), Song and Zhu (1997), Proszynski (2003), Zhu *et al*. (2003), Platnick (2012) and other relevant literature. All specimens were deposited in the Museum, Department of Biological Sciences, University of Sargodha.

Crop cover and meteorological data

The vegetation cover and meteorological data were also recorded as they play significant role in the abundance, distribution and diversity of spiders. Number of plants in the sampling field (93, 20,421) was estimated only once (as the thinning of crop was not done) by quadrate method. Six quadrates ($1m^2$ each) were randomly placed in the field for this purpose. During each sampling the average height of plants was measured by random sampling to determine the crop cover (Table I). Average

monthly temperature, humidity and rain fall of Jhang (59km away from study area) was obtained from the Meteorological Department (Table II).

Table I.- Average height of plants during each sampling period from November 2009 to April 2010.

Month	Average height of plants in inches
November	12
December	17
January	17
February	18
March	18
April	13

Table II.- Monthly average temperature (maximum and minimum) and relative percentage of humidity recorded from Jhang during November 2009 to April 2010.

Month	Average maximum temperature °C	Average minimum temperature °C	Average relative humidity %
November	26.5	10.6	70
December	23.5	5.8	67
January	20.2	6.3	70
February	23.8	9.2	67
March	31.5	16.2	59
April	38.7	20.7	38

Data analyses

The diversity of spiders during different trapping sessions were analyzed by widely used indices *viz.*, the Shannon-Wiener index and the Simpson index (Solow, 1993). Evenness was calculated by using Hill's ratio. To calculate the richness, Margalef index was used. SPDIVERS. BAS was used to compute Margalef, Shannon-Wiener index and Simpson index (Ludwig and Reynolds, 1988). ANOVA was used to compare the number of spider specimens on edge, margin and center of the field.

RESULTS AND DISCUSSION

A total of 545 specimens of spiders, belonging to 12 families, 34 genera, and 66 species were collected during the entire sampling period (Table III). Lycosidae was the most dominant family, comprising 48% of the total catch followed by Linyphiidae (25%) and Salticidae (13%). These three families comprise 86% of the total specimens. All the other families (Araneidae, Thomisidae, Tetragnathidae, Miturgidae, Gnaphosidae, Clubionidae, Mimetidae and Theridiidae) comprised 14% of the total catch (Fig. 1). From all the specimens captured, 17.8% (97) specimens were immature, 51% (278) adult males and 31.2% (170) were adult females. The number of females was low as compared to the males (Fig. 2).

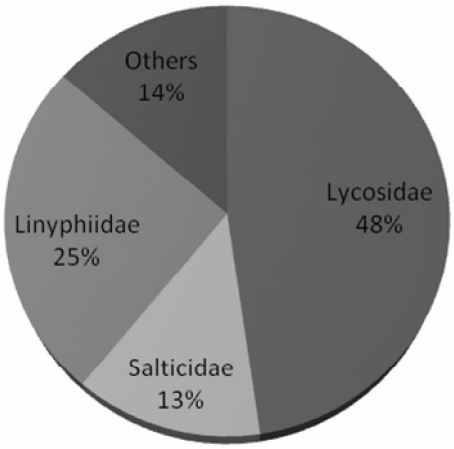

Fig. 1. Relative abundance of spider families during the study period.

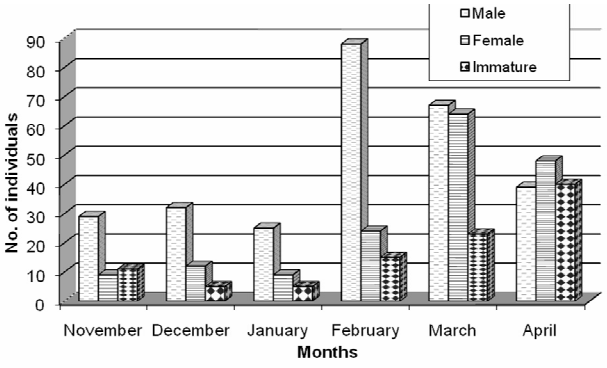

Fig. 2. Monthly variation in the abundance of male, female and immature spiders during the study period.

Table III.- Abundance of spiders collected from *Trifolium* and *Brassica* field during November 2009 through April 2010.

Family/Species name	Total	Relative %
Araneidae		
Araneus mitificus (Simon, 1886)	1	0.18
Cyclosa sp.	1	0.18
Gea subarmata Thorell, 1890	1	0.18
Neoscona theisi (Walckenaer, 1841)	16	2.9
Araneidae sp.	4	0.7
Clubionidae		
Clubiona drassodes O. P.-Cambridge, 1874	3	0.5
Clubiona filicata O. P.-Cambridge, 1874	1	0.18
Clubiona sp.	3	0.5
Clubionidae sp.	3	0.5
Gnaphosidae		
Poecilochroa sedula (Simon, 1897)	1	0.18
Scotophaeus poonaensis Tikader, 1982	1	0.18
Gnaphosidae sp.	4	0.7
Linyphiidae		
Linyphiidae sp.	138	25
Lycosidae		
Draposa oakleyi (Gravely, 1924)	1	0.18
Evippa banarensis Tikader & Malhotra, 1980	20	3.7
Evippa praelongipes (O. P.-Cambridge, 1870)	10	1.8
Evippa rajasthanea Tikader & Malhotra, 1980	3	0.5
Evippa rubiginosa Simon, 1885	12	2.2
Evippa shivajii Tikader & Malhotra, 1980	6	1.1
Evippa sohani Tikader & Malhotra, 1980	6	1.1
Evippa solanensis Tikader & Malhotra, 1980	12	2.2
Evippa sp.	1	0.18
Hogna himalayensis (Gravely, 1924)	1	0.18
Lycosa barnesi Gravely, 1924	5	0.92
Lycosa bistriata Gravely, 1924	6	1.1
Lycosa carmichaeli Gravely, 1924	3	0.5
Lycosa geotubalis Tikader & Malhotra, 1980	1	0.18
Lycosa mackenziei Gravely, 1924	9	1.6
Lycosa maculata Butt, Anwar & Tahir, 2006	6	1.1
Lycosa madani Pocock, 1901	8	1.4
Lycosa mahabaleshwarensis Tikader & Malhotra, 1980	1	0.18
Lycosa masteri Pocock, 1901	2	0.36
Lycosa moulmeinensis Gravely, 1924	1	0.18
Lycosa nigrotibialis Simon, 1884	2	0.36
Lycosa pictula Pocock, 1901	1	0.18
Lycosa poonaensis Tikader & Malhotra, 1980	11	2
Lycosa tista Tikader, 1970	2	0.36
Lycosa sp.	6	1.1
Pardosa amkhasensis Tikader & Malhotra, 1976	2	0.36
Pardosa birmanica Simon, 1884	8	1.4
Pardosa mysorensis (Tikader & Mukerji, 1971)	2	0.36
Pardosa pusiola (Thorell, 1891)	5	0.91
Pardosa shyamae (Tikader, 1970)	2	0.36
Pardosa songosa Tikader & Malhotra, 1976	6	1.1
Pardosa sumatrana (Thorell, 1890)	25	4.5
Trochosa punctipes (Gravely, 1924)	5	0.92
Trochosa sp.	3	0.5
Lycosidae sp.	69	12.6
Mimetidae		
Mimetidae sp.	1	0.18
Miturgidae		
Cheiracanthium sp.1 (unpublished)	2	0.36
Cheiracanthium sp. 2	2	0.36
Miturgidae sp.	7	1.4
Philodromidae		
Philodromus sp.	1	0.18
Tibellus sp.	2	0.36
Salticidae		
Myrmarachne sp.	1	0.18
Phlegra dhakuriensis (Tikader, 1974)	3	0.54
Plexippus paykulli (Audouin, 1825)	1	0.18
Sitticus distinguendus (Simon, 1868)	1	0.18
Salticidae sp.	62	11.48
Tetragnathidae		
Leucauge decorata (Blackwall, 1864)	2	0.36
Tetragnatha virescens Okuma, 1979	7	1.5
Theridiidae		
Theridiidae sp.	1	0.18
Thomisidae		
Runcinia affinis Simon, 1897	4	0.7
Thomisus pugilis Stoliczka, 1869	3	0.5
Xysticus sp.	1	0.18
Thomisidae sp.	6	1.1
Total	545	

Numerically the most abundant species in the samples was *Pardosa sumatrana* (Thorell, 1890) (4.5 %) followed by *Evippa banarensis* Tikader and Malhotra, 1982 (3.7%), *Neoscona theisi* (Walckenaer, 1841) (2.9 %) and *Evippa rubiginosa* Simon, 1885 (2.2 %) (Table III). These four species collectively contributed 13.3% of the total collection. During the first three months of the sampling, the number of specimens was low as compared to the last three months (Fig. 3).

Lycosidae was the most dominant family and comprised 48% of the total catch. In agro-ecosystem, the Lycosidae is usually one of the most abundant families of ground spiders as recorded by several workers in Pakistan and other countries **(**Patel *et al*., 1986; Patel and Pillai, 1988; Tahir *et al*., 2011; Butt and Sherawat, 2011). All the collection was done by pitfall trapping and lycosids are active foragers on the ground, this might be the one possible reason for their high abundance in the collection.

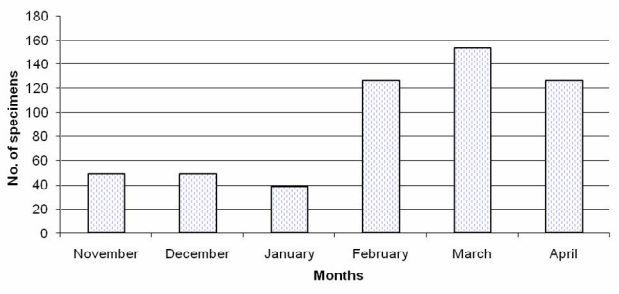

Fig. 3. Monthly variation in the abundance of spiders from sampling field.

During the first three months (November through January) of the sampling period, the number of specimens was low as compared to the last three months (February through April). In the first three months, the minimum average temperature was 10.6°C, 5.8 and 6.3°C, respectively (Table II). Decrease in number of spiders during the colder months might be due to the harsh environmental conditions that resulted in the decline of their activities or they went in to dormancy. Scarcity of food (insects and other preys) and risk of predation might be other important factors for their mortality as the crop was small and less cover was available to the spiders. These results are also in accordance with the previous findings (Ford, 1978; Gunnarsson, 1988; Mari and Lohar (2010). Malik *et al*. (2012) also found that the population of spiders remained low in all varieties of *Brassica* during December and January due to low abundance of prey especially aphids. Sherawat *et al.* (2012) recorded that there was positive correlation between aphid population and spiders.

During sampling, the higher number of the males in pitfall traps was not strange due to their more active predatory behaviour and search for the mates. Females were significantly low in number as they were not much active and need to conserve their energy for reproduction. These findings agreed with the work of other scientists (Adis, 2002; Kok *et al*., 2004). Immatures were captured in good number during March and April as it was the breeding season and recruitment of new individuals took place. Females were also found more in these months as they were more due to their breeding season. The number of males decreased significantly in April that might be due to post mating cannibalistic behaviour by females to fulfill their energy requirements and to maximize their reproductive success or the males exhausted after breeding and died.

The number of spiders was significantly higher on margin, as compared to edge and central area in the sampling field ($F_{2, 15} = 7.03$; $P = 0.006$, Fig. 4). One possible reason for this low number was that the edge of the field was highly disturbed due to the movement of people. In the sampling field, the crop cover was not evenly distributed. The less cover and small food supply in the centre of the field resulted in low number of spiders.

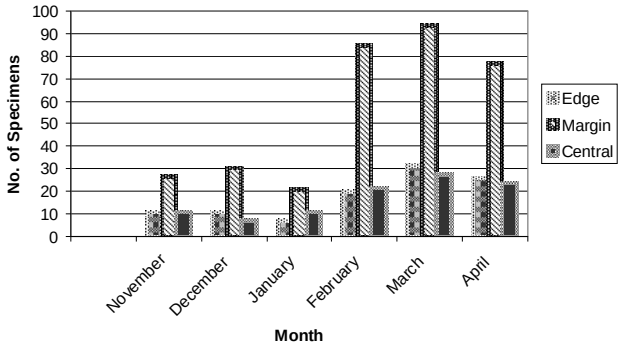

Fig. 4. The relative abundance of the spiders on edge, margin and center of the field.

Both species richness and abundance was considerably low during the colder months of the study period. Highest diversity and richness was recorded during the month of April and lowest was in January. The evenness was highest during November and lowest in March (Table IV). The diversity index and species richness increased during the warmer months of the year while the evenness index value was high during colder months. Butt *et al.* (1997) also found similar results. Thus those species that attained the high abundance during the early and late phases of the crop were important from the view point of biological control of insect pests (Table III). The one possible reason for the high value of evenness during November was low cover and small crop size in the start of cultivation that's why only few spider species were dominant. With the growth in crop size / cover, the diversity and richness increased but the evenness decreased.

Table IV.- Diversity, richness and evenness of spiders during different trapping sessions (2009-2010).

Diversity measures	November	December	January	February	March	April
Diversity						
Shannon-Wiener index (H')	2.79	2.19	2.06	2.1	2.45	2.95
Simpson index (1-D)	16.24	8.91	7.84	8.15	11.53	19.2
Richness						
Margalef index (R1)	5.39	3.1	2.44	3.1	5.95	6.9
Evenness						
Evenness index (E5)	0.91	0.81	0.83	0.62	0.58	0.62

REFERENCES

ADIS, J., 2002. Recommended sampling techniques. In: *Amazonian Arachnida and Myriapoda. Identification keys to all classes, orders, families, some genera, and lists of known terrestrial species* (ed. J. Adis) Sofia, Bulgaria, Pensoft Publishers, pp. 555-576.

ANONYMOUS, 1993. *Population dynamics of major insect pests of mustard. Annual progress report for year 1993*. Agric. Res. Inst. Tarnab, Peshawar, pp. 123.

BARRION, A.T. AND LITSINGER, J.A., 1995. *Riceland spiders of South and Southeast Asia*. CAB Int. Wallingford, UK., pp. 700.

BUTT, A. AND SHERAWAT, S.M., 2011. Effect of different agricultural practices on spiders and their prey populations in small wheat fields. *Acta Agric. Scand*., DOI:10.1080/09064710.2011.624544.

BUTT, A., BEG, M.A. AND AKHTAR, M., 1997. Temporal variability in a community of spiders inhabiting the ground surface of a citrus orchard. *Pakistan J. agric. Sci.*, **34**: 20-21.

CLOUGH, Y., KRUESS, A., KLEIJN, D. AND TSCHARNTKE, T., 2005. Spider diversity in cereal fields: comparing factors at local, landscape and regional scales. *J. Biogeogr*., **32**: 2007–2014.

DOUGLAS, A.L., STEPHEN, D.W. AND GEOFF, M.G., 2000. Habitat management to conserve natural enemies of arthropod pests in agriculture. *Annu. Rev. Ent*., **45**: 175–201.

DYAL, S., 1935. Fauna of Lahore: Spiders of Lahore. *Bull. Deptt. Zool. Univ. Punjab***, 1**: 119–252.

FORD, M.J., 1978. Locomotory activity and the predation strategy of the wolf spider *Pardosa amentata* (Clerck) (Lycosidae). *Anim. Behav*., **26**: 31-35.

FURLONG, M.J., JU, K.H., SU, P.W., CHOL, J.K., IL, R.C. AND ZALUCKI, M.P., 2008. Integration of endemic natural enemies and *Bacillus thuringiensis* to manage *Brassica* crop pests in the Democratic People's Republic of Korea. The management of diamondback moth and other crucifer pests: *Proc. fifth Int. worksh*, pp. 287-302.

GUNNARSSON, B., 1988. Body size and survival: Implication for overwintering spiders. *Oikos*, **52**: 274-282.

KOK, B.O., LOTZ, N.L. AND HADDAD, R.C., 2004. Diversity and ecology of spiders (Arachnida: Araneae) of Deosai Plateau, Northern Pakistan. *Pak J. biol. Sci*., **7**: 1689-1694.

LUDWIG, J.A. AND REYNOLDS, J.F., 1988. *Statistical ecology. A primer on methods in computing*. John Wiley and Sons, New York, pp. 337.

MAJUMDER, S.C. AND TIKADER, B.K., 1991. Studies on some spiders of family Clubionidae from India. *Rec. Zool. Surv. India, Occ. Pap*., **102**: 1–173.

MALIK, S., JABEEN, T., SOLANGI, B.K. AND QURESHI, N.A., 2012. Insect pests and Predators associated with different Mustard varieties at Tandojam. *Sindh Univ. Res. J. (Sci. Ser.)* **.44:** 221-226.

MARI, J.M. AND LOHAR, M.K., 2010. Pests and predators recorded in brassica ecosystem. *Pak. J. Agric. agric. Engg., Vet. Sci*., **26**: 58-65.

PATEL, B.H. AND PILLAI, G.K., 1988. Studies on the spider fauna of groundnut fields in Gujrat, India. *J. biol. Control*, **2**: 83-88.

PATEL, B.H., PILLAI, G.K. AND SEBASTIAN, P.A., 1986. The ground activity of spiders in cotton fields in Gujarat, India. Actas X Congr. *Int. J. Arachnol. Jaca/Espana*. **1**: 245-251.

PEARCE, S. AND ZALUCKI, M.P., 2006. Do predators aggregate in response to pest density in agroecosystem? Assessing within field spatial patterns. *J. appl. Ecol*., **43**: 128-140.

PLATNICK, N.I., 2012. *The world spider catalog, version 12.5*. American Museum of Natural History, online at http://research.amnh.org/iz/spiders/catalog. DOI: 10.5531/db.iz.0001.

PRIETO-BENÍTEZ, S. AND MÉNDEZ, M., 2011. Effects of land management on the abundance and richness of spiders (Araneae): a meta-analysis. *Biol. Conserv.*, **144**: 683–691.

PRÓSZYN'SKI, J., 2003. Salticidae (Araneae) of the Levant. *Annls. Zool. Warsz.* **53:** 1-180.

RAZAQ, M., MEHMOOD, A., ASLAM, M., ISMAIL, M., AFZAL, M. AND SHAD, S.A., 2011. Losses in yield and yield components caused by aphids to late sown *Brassica napus* l., *Brassica juncea* L. and *Brassica carrinata* A. Braun at Multan, Punjab (Pakistan). *Pak. J. Bot*., **43**: 319-324.

SAHITO, H.A., LANJAR, A.G. AND MAL, B., 2010. Studies on population dynamics of sucking insect pests of mustard crop (*Brassica campestris*). *Pak. J. Agric., agric. Engg., Vet. Sci*., **26**: 66-74.

SALJOQI, A.U.R., REHMAN S., HUSSAIN N. AND KHAN, S.A., 2006. Insect pests of canola crop (Other Than Aphid). *J. Agric. biol. Sci*., **1**: 19-21.

SCHMIDT, M.H. AND TSCHARNTKE, T., 2005. The role of perennial habitats for Central European farmland spiders. *Agric. Ecosyst. Environ.*, **105**: 235–242.

SCHMIDT, M.H., THIES, C. AND TSCHARNTKE, T., 2009. Landscape context of arthropod biological control. In: *Ecological engineering for pest management: advances in habitat manipulation for arthropods* (eds. G.M. Gurr, S.D. Wratten, M.A. Altier) CSIRO Press, Collingwood, pp. 55-63.

SCHWEIGER, O., MAELFAIT, J.P., VAN-WINGERDEN, W., HENDRICKX, F., BILLETER, R., SPEELMANS, M., AUGENSTEIN, I., AUKEMA, B., AVIRON, S., BAILEY, D., BUKACEK, R., BUREL, F., DIEKÖTTER, T., DIRKSEN, J., FRENZEL, M., HERZOG, F., LIIRA, J., ROUBALOVA, M. AND BUGTER, R., 2005. Quantifying the impact of environmental factors on arthropod communities in agricultural landscapes across organizational levels and spatial scales. *J. appl. Ecol*., **42**: 1129–1139.

SEYFULINA, R.R. AND TSHERNYSHEV, V.B., 2001. Hortobiont spiders (Arachnida, Araneae) in agroecosystems of Moscow Province (species composition, spatial distribution, and seasonal dynamics). *Ent. Obozr*., **81**: Suppl. 1: 137-148.

SEYFULINA, R.R., 2003. Spatial distribution of spiders (Arachnida: Araneae) in agro ecosystems of the European part of Russia. *Proc. 21st Eur. Colloq. Arachnol*., pp. 275-292.

SHERAWAT, S.M., BUTT, A. AND TAHIR, H.M., 2012. Effect of *Brassica* strips on the population of aphids and arthropod predators in wheat ecosystem. *Pakistan J. Zool*., **44**: 173-179.

SOLOW, A.R., 1993. A simple test for change in community structure. *J. Anim. Ecol*., **62**: 191–193.

SONG, D.X. AND ZHU, M.S., 1997. *Fauna Sinica: Arachnida: Araneae: Thomisidae, Philodromidae*. Science Press, Beijing, China, pp. 259.

SYMONDSON, W.O.C., SUNDERLAND, K.D. AND GREENSTONE, M.H., 2002. Can generalist predators be effective biocontrol agents? *Annu. Rev. Ent*., **47**: 561–594.

TAHIR, H.M., BUTT, A., MUKHTAR, M.K., KHAN, S.Y., ARSHAD, M. AND AHSAN, M.M., 2011. Effect of carbofuran on the diversity and mean abundance of ground spiders. *Afr. J. Biotechnol.,* **10**: 12303-12308.

TIKADER, B.K. AND BISWAS, B., 1981. Spider fauna of Calcutta and vicinity. *Rec. Zool. Surv. India, Misc. Publ. Occ. Pap*., **30**: 1–149.

TIKADER, B.K. AND MALHOTRA, M.S., 1980. The fauna of India. *Zool. Surv. India*, **1**: 272-439.

TIKADER, B.K., 1980. The Fauna of India: Araneae: Thomisidae. *Zool. Surv. India*, **1**: 1–247.

TIKADER, B.K., 1982. The Fauna of India: Araneae: Araneidae, Gnaphosidae. *Zool. Surv. India*, **2**: 1–536.

YIN, C.M., WANG, J.F., ZHU, M.S., XIE, L.P., PENG, X.J. AND BAO, Y.H., 1997. *Fauna Sinica: Arachnida: Araneae: Araneidae*. Science Press, Beijing, China, pp. 460.

YOUNAS, M. AND YAQOOB, M., 2005. Feed resources of livestock in the Punjab, Pakistan. Livestock Resarch for Rural Development. http://www.cipav.org.co/lrrd/lrrd17/2/youn17018.htm.

ZHU, M.S., SONG, D.X. AND ZHANG, J.X., 2003. *Fauna Sinica: Invertebrata Vol. 35: Arachnida: Araneae: Tetragnathidae.* Science Press, Beijing, China, pp. 418.

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