

Effects of Different Management Practices and Field Margins on the Abundance of Ground Spiders in Rice Ecosystems

Hafiz Muhammad Tahir* and Abida Butt

Department of Zoology University of the Punjab Lahore, Pakistan

Abstract.- Present study was designed to investigate the effect of different management practices and field margins on the abundance pattern of spiders in rice ecosystems. For this purpose four fields *viz.*, reduced input field (RIF), organic field (ORF), herbicide treated field (HFT) and tilled field (TLF) were selected in district Sheikupura, Punjab, Pakistan. In total, 4645 spiders belonging to 7 families, 16 genera and 21 species were captured in pitfall traps during rice growing season of 2006. Species and numbers of lycosids were numerically dominant. Average number of spiders per pitfall was highest in ORF and lowest in TLF. Mean abundance, richness, diversity and evenness of spiders at different distances among different fields were compared using two-way ANOVA. Results showed non-significant differences between diversity and evenness. However, mean abundance and richness differed significantly. When different distances from field's margins within each management practices were analyzed, significant differences between mean abundance, richness, diversity and evenness were recorded. Species composition did not differ significantly among fields or among distances but the active density of individuals in each species showed significant differences. Canonical correspondence analysis showed that active density of most dominant species (*Lycosa terrestris* and *Pardosa birmanica*) was associated with ORF and RIF and with field's margin (0 m distance).

Key words: Spider diversity, management practices, field margins, rice crops.

INTRODUCTION

Spiders constitute one of the major groups of generalist predators due to their high abundance and predominantly insectivorous feeding habits. They play an important predatory role in agroecosystems, woodlands, and other terrestrial ecosystems (Nyffeler and Benz, 1987; Nyffeler, 2000a,b; Symondson *et al.*, 2002). Several factors such as loss of habitat (Webb, 1990), the direct and indirect effect of pesticides and herbicides (Newton and Wyllie, 1992), increased use of drainage and fertilizers (Fuller, 1987), the loss and degradation of field boundary features (Barr *et al.*, 1993), and changing patterns of cropping (Gibbons *et al.*, 1993) cause reduction in diversity and abundance of spiders in agricultural fields.

Tillage cause reduction in plant complexity and thus reduces spider diversity (Haskins and Shaddy, 1986). Reduce tillage results in, more weeds; more plants residues, less disturbance, higher soil surface moisture (Wardle, 1995) and proliferation of detritivores (Robertson *et al.*, 1994).

Herbicide can reduce population of phytophagous insects, which result in less available prey for spiders (Amalin *et al.*, 2001). Disturbance created by herbicide can decrease the population size for more than a month after application (Clausen, 1990).

Organic fields support a higher abundance of spiders than conventionally farmed fields (Wisniewska and Prokopy, 1997; Birnie *et al.*, 1998; Feber *et al.*, 1998; Yardim and Edwards, 1998; Schmidt *et al.*, 2005). Addition of organic manure in rice fields cause rapid increase in the populations of detritivores (such as collembolans and ephydrid flies) and plankton feeders (such as mosquito larvae and chironomid midge larvae), which are important alternative prey for ground spiders during early crop session when potential prey items are not present (Settle *et al.*, 1996). In organic management, where agrochemical application is prohibited, diversity of spiders is economically important (Östman *et al.*, 2003). Organic fields provide more complex and diverse physical milieu, which give spiders more protection from natural enemies, and improves microhabitat as well. Organic practice may add diversity to the soil structure and increase the abundance of prey and in turn the abundance of spiders (Öberg, 2007).

In order to maintain sustainable

* Corresponding author: tahirvector@hotmail.com
0030-9923/2009/0002-0085 \$ 8.00/0
Copyright 2009 Zoological Society of Pakistan.

agroecosystems presence of permanent, undisturbed natural habitat adjacent to the crop fields is also necessary. Nearby perennial habitats and their vegetation provide food, refuge and over wintering sites for many spider species (Thomas and Marshall, 1999; Marshall and Moonen, 2002) in the fields which are frequently disturbed by different management practices (Lemke and Poehling, 2002; Piffner and Wyss, 2004; Schmidt and Tschardtke, 2005b; Öberg and Ekblom, 2006) A high proportion of perennial crops and degree of heterogeneity in the 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 Tschardtke, 2005a; Schweiger *et al.*, 2005).

Suppression of insect pests in rice ecosystems by local population of natural enemies (*i.e.*, conservation biological control) is particularly important for farmers who wish to reduce or eliminate the use of agrochemicals. In order to conserve natural enemies in rice ecosystems of Pakistan it is necessary to adapt management practices that enhance abundance of spiders or at least have a minimal lethal effect on them. Present study was aimed at determining (i) the effect of different management practices and field margins on abundance pattern of ground spiders, and (ii) time required for restoration of spiders population after disturbance by management practices (herbicide application and tillage activity).

MATERIALS AND METHODS

To study the effects of management practices on spatial and temporal distribution pattern of spider in rice ecosystems four fields were selected in district Sheikupura, Punjab Pakistan. Fields were located in 5 km area. The treatments in the fields were given by local farmers according to their management practices. Each selected field consisted of three transects (area of each transect was 50 m²) separated from one another by grassy strips (60 cm). These fields were classified into four types *i.e.*, reduced input field (RIF), organic field (ORF), herbicide treated field (HTF) and tilled field (TLF). RIF was taken as control, because it was free from

any conventional management practice (*e.g.*, pesticides, tillage, organic manure and fertilizers) and was surrounded by rice fields from all sides. Organic manure was added only once in ORF on 11 September at the rate of 125 kg/acre. Herbicide (Acetochlor) was applied in HTF on 17 September and tillage activity on 9 September in TLF. Except these treatments no other conventional method was applied and fields were exactly similar to RIF (control). Irrigation dates were also similar in all the fields.

Sampling method

Collection was done using pitfall method from August through November 2006. In each field thirty-six (twelve in each transect) wide mouth glass jars (6 cm diameter x 12 cm deep) were used as pitfall traps. During sampling, the jars were dug in the soil such that their rims were at level of ground (Samu and Szinetar, 2002). In each transect of selected fields, three pitfall traps were placed at margin (0 m) of the field, while subsequent traps were set at 10 m, 20 m and 40 m from the margin of the field. Distance between each pitfall trap was 10 m. Two hundred and 50 ml of 95% ethylene glycol and two drops of 1% liquid detergent were added to each trap to break the surface tension. A rain cover (18x18cm) constructed of 0.6 cm plywood, and supported by three nails (9 cm length) was placed over each trap to prevent flooding. Transplantation of rice plants from nursery to fields was completed in the second week of July. At each field, traps were operated consecutively for 72 hours (= trapping session) after every two weeks from August till the end of November (harvesting). Captured organisms were placed in small jars with 70% ethanol and transported to the laboratory for sorting and identification of spiders. Only sexually mature spiders were identified to the species level with the help of the keys and catalogues provided by Dyal (1935), Tikader and Malhotra (1980), Tikader (1987), Barrion and Litsinger (1995), Platnick (2007) and Proszynski (2003). Juveniles, including penultimate stages, were identified only to genus level. Representative specimens of all identified species were deposited in the Arachnology Laboratory, Department of Zoology, University of the Punjab, Lahore, Pakistan.

Data analysis

Mean abundance, richness, diversity and evenness of spiders at each management practice as well as at each distance of field's margin were calculated. Because three transects of each field were similar in all aspects data recorded from three transects of each field was pooled together for statistical analysis. To analyze the diversity of spiders Simpson's index, which is sensitive to changes in the most abundant species in a community (Sebastian *et al.*, 2005) was used. Simpson's index, which varies from 0 to 1, gives the probability that two individuals drawn at random from the population belong to the same species. If, the probability is high that both individuals belong to the same species, then the diversity of the community sample is low.

The Margalef index, a species richness index, was used to calculate species richness. It increases with increasing the sample size. The estimated species richness was calculated by rarefaction curve to determine whether or not the fields had been sufficiently sampled. Evenness index was calculated using modified Hill's ratio (E5). The Shannon-Wiener, Simpson, Margalef, rarefaction curve and Evenness (E5) indices were computed using the statistical software, Spdivers. Bas of Ludwig and Reynolds (1988). Two-way ANOVA (SPSS version 10) followed by Tukey's test was used to assess the differences in mean abundance, richness, diversity and evenness of spiders at different distances from the margin of each field. To investigate the variation in community composition within fields and within distances of the field's margin Canonical correspondence analysis (CCA) was performed using Multivariate Statistical Package (MVSP Version 3.1). The gradient length indicated a unimodal method, suggested that CCA should be performed. For CCA only those species were utilized that constituted at least 1% of the total sample. The distributions of species were graphically inspected in order to determine association among management practices and species, and among distances and species.

RESULTS

In total, 4645 spiders belonging to 7 families,

16 genera and 21 species were captured (Table I). Lycosidae was the only dominant family and comprised 77.37% of the total catch. Of the total specimens, 1356 spiders (1168 lycosids and 188 others) were captured from RIF, 1727 spiders (1494 lycosids, 233 others) from ORF, 815 spiders (669 lycosids, 146 others) from HTF and 747 spiders (656 lycosids, 91 others) from TLF. For the entire sampling period average number of spiders per pitfall trap was 6.74 in ORF, 5.29 in RIF, 3.18 in HTF and 2.91 in TLF.

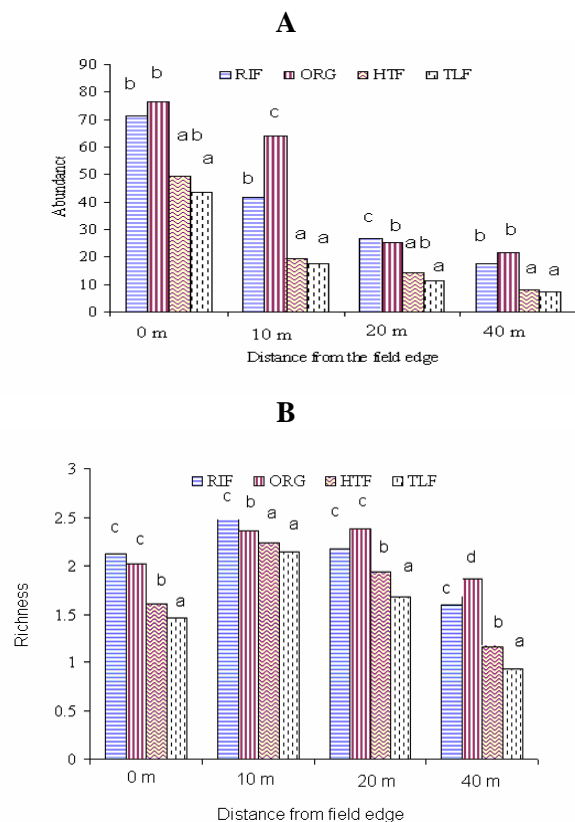


Fig. 1. Differences in relative abundance (A) and richness (B) at different distances among fields (management practices).

ORF, organic field; HTF, Herbicide treated field; TLF, Tilled field; RIF, reduced input field.

Mean abundance, richness, diversity and evenness of spiders at different distances among different fields were compared using two-way ANOVA. Results showed non-significant differences between diversity ($df=3, 15; F= 2.69; P= 0.109$) and

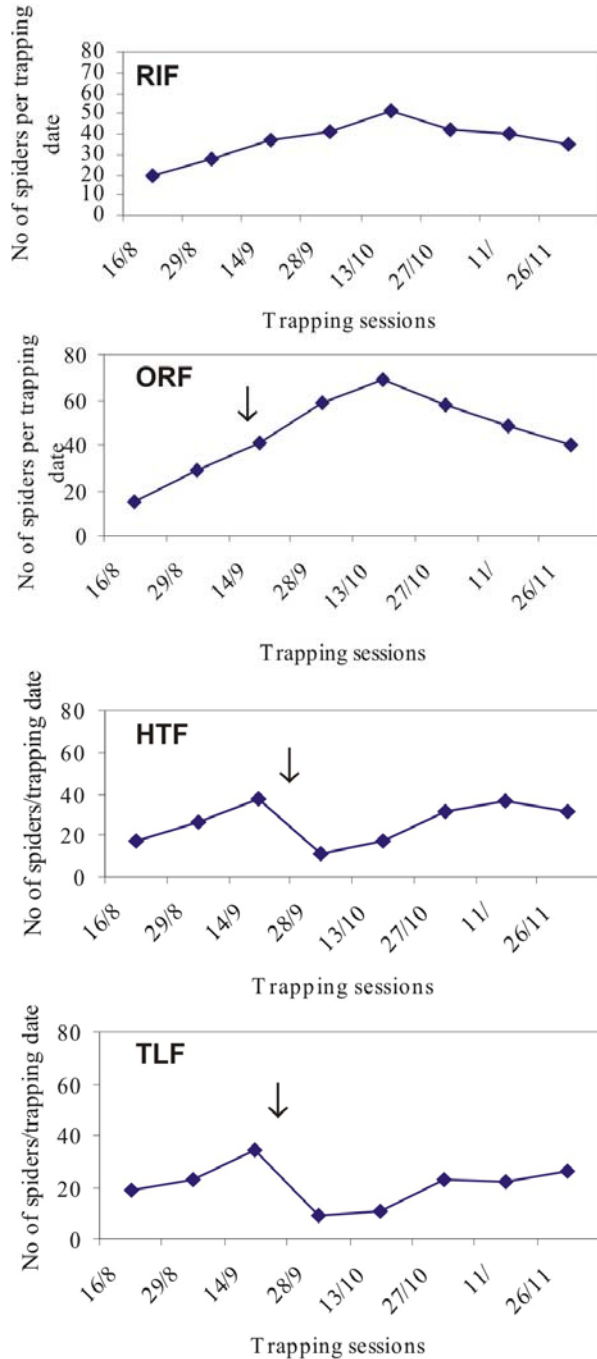


Fig. 2. Temporal distribution of spiders in four rice fields with different management practices. Arrows in the figure represent treatment dates.

RIF, reduced input field; ORF, organic field; HTF, herbicide treated field; TLF, tilled field.

evenness ($df= 3, 15; F= 13.36; P= 0.177$) at different distances among fields (management practices). However, mean abundance ($df= 3, 15; F= 13.36; P<0.001$) and richness ($df= 3, 15; F= 16.62; P<0.001$) differed significantly (Fig. 1). When different distances from field's margins within each management practices were analyzed, significant differences between mean abundance ($df= 3, 15; F= 37.17; P <0.001$), richness ($df= 3, 15; F= 30.69; P <0.001$), diversity ($df= 3, 15; F= 8.94; P < 0.001$) and evenness ($df= 3, 15; F= 5.47; P = 0.020$) were recorded.

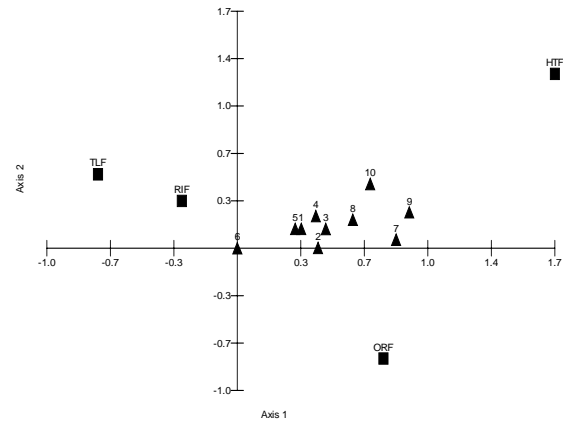


Fig. 3. Canonical correspondence analysis (CCA) biplot showing association of species with specific fields.

1, *Lycosa terrestris* 2, *Pardosa birmanica*; 3, *Binor albobimaculatus*; 4, *Hasarius adansoni*, 5, *Thomisus cherapunjeus* 6= *Pardosa oakleyi*; 7 = *Lycosa nigricans*; 8, *Plexippus paykulli*; 9, *Oxyopes javanus* and 10, *Hippasa* sp.

Temporal distribution of spiders captured from four different fields is given in Figure 2. In all fields the trend of mean abundance curve was similar during early three trapping sessions (till mid-September). The number of spiders dropped rapidly at the end of September in HTF and TLF. Number of spiders was reestablished in HTF within 30 days following the herbicide application. In TLF number of spiders began to increase after 15 days but number of spiders remained low in all trapping sessions after tillage activity, compared to other fields. Density of spiders in ORF increased rapidly after third trapping session due to addition of

organic manure.

Results of CCA are given in Figs. 3 and 4. Species lying close to any variable (*i.e.*, field or distance) in CCA biplots are associated with that variable in particular. Species are numbered in decreasing activity density order. Most of the species were found to be associated with ORF and RIF (Fig. 3) and with 0 m distance (Fig. 4).

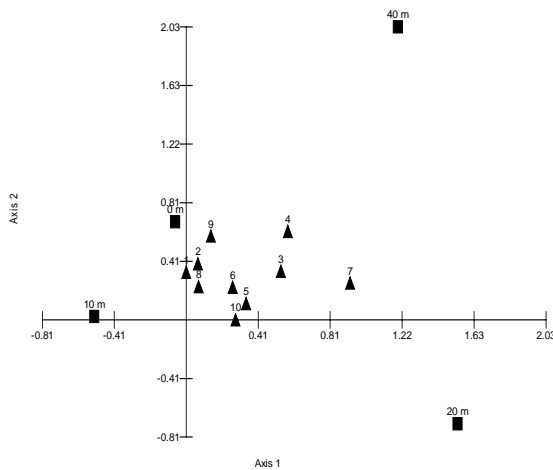


Fig. 4. Canonical correspondence analysis (CCA) biplot showing association of species with specific distance from field's margin.

1, *Lycosa terrestris*; 2, *Pardosa birmanica*; 3, *Binor albobimaculatus*; 4, *Hasarius adansoni*; 5, *Thomisus cherafunjeus*; 6, *Pardosa oakleyi*; 7, *Lycosa nigricans*; 8, *Plexippus paykulli*; 9, *Oxyopes javanus* and 10, *Hippasa* sp.

DISCUSSION

In total, 4645 spiders and 21 species were captured from four fields (four management practices) using pitfall traps. The group of dominant spiders species was same in all fields under investigation. However, abundance and spatial distribution of a particular species significantly depend on the type of management practice in the field. The data of the present study was mainly comprised of hunting spiders due to pitfall traps (Uetz, 1975; Collins *et al.*, 1996; Lang, 2000; Jogar *et al.*, 2004). However, few individuals of web-spinning spiders were also recorded. No doubt other sampling methods (*e.g.*, D-vac, sweep net, hand picking) yield additional species and individuals of

both hunter and web-spinner foraging guilds from the rice fields of Pakistan (Tahir and Butt, 2008). Spider densities also vary with phenology of crops. In general, the density of the spiders in the fields increase with the increase in plant size and complexity, thus smaller plants host fewer spiders than tall ones (Liu *et al.*, 2003). The higher spider densities in the present study in organic field suggested it favorable habitat for spiders (Schmidt *et al.*, 2005). It is argued that organic systems are more diverse, and therefore more stable, resulting in lower incidences of pest and disease problems and increased biodiversity (Lampkin, 1990).

ORF showed higher abundance and species richness than HTF or TLF in the present study. High abundance of spiders in the ORF might be due to rapid increase in the population of detritivores and plankton feeders after the addition of organic manure. These organisms serve as alternate prey for ground spiders in the absence of potential prey items in the fields (Settle *et al.*, 1996). ORFs also provide more diverse and complex habitat for spiders (especially lycosids) than conventionally farmed fields (Wisniewska and Prokopy, 1997; Feber *et al.*, 1998; Yardim and Edward, 1998; Schmidt *et al.*, 2005). Differences in the spider abundance and richness between organic fields, HTF and TLF have also been reported in other agroecosystems (Birnir *et al.*, 1998; Feber *et al.*, 1998).

Conventional management practices such as insecticide or herbicide application and tillage, have numerous indirect effects on the spider population. Herbicides can reduce populations of phytophagous insects, which result in less available prey for spiders (Amalin *et al.*, 2001). Reduction in plant complexity through herbicide applications or tillage can also lead to lower spider populations. Agroecosystems with more weed, more structural diversity, and higher plant community complexity offer more shelter and microhabitat for spiders. These fields also provide more prey species than conventional fields (Feber *et al.*, 1998; Huusela-Veistola, 1998, 1999; Holland *et al.*, 2000; Öberg and Ekblom, 2006). In the present study HTF showed higher abundance of spiders as compared to TLF. Higher abundance of spiders in HTF might be due to the reason that the residues of the plants (herbs) remains in the field after the treatment of the

herbicides, promoting environmental conditions conducive to the proliferation of robust soil fauna (House and Stinner, 1983). Results showed that residue of herbicide (Acetochlor) used in the present study did not cause high spider mortality in the field after one week. This hypothesis is also supported by results obtained by other researchers working in our laboratory (unpublished data).

Reduced abundance and richness of spiders in TLF in present study might be due disturbance caused by tillage practice in this field. Reduced tillage cropping systems are favorable for the spiders because of rich habitat structure, high soil moisture, and proliferation of detritivores (Wardle, 1995; Sunderland and Samu, 2000). Rice plant and weed residues on the soil surface in untilled paddies before transplanting, possibly results in the early establishment, reproduction, and enhancement of some spiders (Takashi *et al.*, 2006). UTF also support more dipterans in rice paddies (Wardle, 1995), which are important prey for spiders (Settle *et al.*, 1996).

In the present study abundance of spiders (especially lycosids) captured from differently managed fields decreased as the distance from the field's margins increased. Higher densities of lycosids are also found at the field's margins in other agroecosystems as well (Alderweireldt, 1989; Holland *et al.*, 1999). Higher activity density and richness of spiders at field's margins suggests that field margin is an important habitat for spiders. Permanent grassy strips or weedy borders at field's margins provide shelter, over wintering sites, and alternate food source for spiders in frequently disturbed habitats such as conventional agricultural fields (Nentwig, 1987; Hussela-veistola, 1998; Clough *et al.*, 2005; Öberg, 2007).

Differences in the lycosid abundance and distribution among different fields, and distances from the field edges may be explained by characteristics associated with each microhabitat. The composition of plant communities and amount of litter may be especially important in explaining patterns in lycosid communities (Holland *et al.*, 1999; Martin and Major, 2001). Lycosid capture in conventional fields (HTF and TLF) was reduced following pesticide applications and tillage practice. It appears that herbicide application and tillage

activity had a direct effect on spiders (lycosid) populations. Herbicides disturb the spatial distribution of spiders and tillage activity destroy their habitat, and the edge zone of fields may be crucial for protection of and reinvasion of fields by these organisms (Holland *et al.*, 2000).

Indirect effect such as lower lycosid populations due to reduced weed cover, reduced spatial variability, or reduced prey availability should be investigated. More studies are needed to determine relationship between patterns in the distribution of spider species and management practices. Differences in the community compositions among different management practices should continue to be studied so that we may gain a better understanding of the environmental factors that are important in determining the spider inhabitants. Perhaps this knowledge can be use to manipulate agricultural habitats in order to enhance and maintain spider population for the use in integrated pest management

REFERENCES

- ALDERWEIRELDT, M., 1989. An ecological analysis of the spider fauna (Araneae) occurring in maize fields, Italian ryegrass fields and their edge zones, by means of different multivariate techniques. *Agric. Ecosyst. Environ.*, **27**: 293-306.
- AMALIN, D.M., PENA, J.E., MCSORLEY, R., BROWNING, H.W. AND CRANE, J.H., 2001. Comparison of different sampling methods and effect of pesticide application on spider population in lime orchards in south Florida. *Environ. Ent.*, **30**: 1021-1027.
- BARRION, A.T. AND LITSINGER, J.A., 1995. *Rice land spiders of South and Southeast Asia*. CAB Int. Wallingford, UK, pp. 700.
- BARR, R.G., BUNCE, H., CLARKE, R.T., FULLER, R. M., FURSE, M.T., GILLESPIE, M.K., GROOM, G.B., HALLAM, C.J., HORNUNG, M., HOWARD, D.C. AND NESS, M.J., 1993. *In: Countryside Survey 1990, Main Report*, Department of the Environment, London.
- BIRNIE, L., SHAW, K., PYE, B. AND DENHOL, M., 1998. Considerations with the use of multiple dose bioassays for assessing pesticide effects on non-target arthropods, *In: Proceedings, Brighton Crop protection Conference-Pest and diseases*. 16-19 November, Brighton, UK. pp. 291-296.
- CLAUSEN, I.H.S., 1990. Design of research work based on a pilot study dealing with the effect of pesticides on spiders in a sugar-beet field. *Acta zool. Fenn.*, **190**:69-

- 74.
- 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.
- COLLINS, A.J, JENNINGS D.T. AND FORSYTHE, Y.H., 1996. Effects of cultural practices on the spider fauna of lowbush blueberry fields in Washington county, Maine. *J. Arachnol.*, **24**:43-57.
- DYAL, S., 1935. Fauna of Lahore: Spiders of Lahore. *Bull. Zool. Punjab Univ.*, **1**: 119-252.
- FEBER, R. E., BELL, J., JOHNSON, P.J., FIRBANK, L.G. AND MACDONALD. W.D., 1998. Effect of organic farming on surface active spider (Araneae) assemblages in wheat in southern England, UK. *J. Arachnol.*, **26**: 190-202.
- FULLER, R.M., 1987. The changing extent and conservation interest of lowland grasslands in England and Wales: a review of grassland surveys 1930–84. *Biol. Conserv.*, **40**: 281–300.
- GIBBONS, D.W., REID, B.J. AND CHAPMAN, A.R., 1993. *New atlas of breeding birds in Britain and Ireland : 1988-1991*. A.D Poyser, London.
- HASKINS, M.F. AND SHADDY, J.H., 1986. The ecological effects of burning, mowing, and plowing on ground-inhabiting spiders (Araneae) in an old-field ecosystem. *J. Arachnol.*, **14**: 1–13.
- HOLLAND, J.M., PERRY, J.N. AND WINDER, L., 1999. The within-field spatial and temporal distribution of arthropods in winter wheat. *Bull. entomol. Res.*, **89**: 499–513.
- HOLLAND, J. M., WINDER, L. AND PERRY, N.J., 2000. The impact of dimethoate on the special distribution of beneficial arthropods in winter wheat. *Ann. appl. Biol.*, **136**: 93-105.
- HOUSE, G.J. AND STINNER, B. R., 1983. Arthropods in no tillage soybean agroecosystem: Community composition and ecosystem interactions. *Environ. Manag.*, **7**: 23-28.
- HUUSELA-VEISTOLA, E., 1998. Effects of perennial grass strips on spiders (Araneae) in cereal fields and impact on pesticide side effects. *J appl. Ent.*, **122**: 575-583.
- JOGAR, K, METSPALU, L AND HIIESAAR, K., 2004. Abundance and dynamics of wolf spiders (Lacosidae) in different plant communities. *Agron. Res.*, **2**: 145-152.
- LAMPKIN, N., 1990. *Organic farming*. Farming Press Books. Ipswich, pp. 701.
- LANG, A., 2000. The pitfall traps: a comparison of pitfall catches and absolute density estimates of epigeal invertebrate predators in arable land. *J. Pestic. Sci.*, **73**: 99-106.
- LEMKE, A. AND POEHLING, H.M., 2002. Sown weed strips in cereal fields: overwintering site and “source” habitat for *Oedothorax apicatus* (Blackwall) and *Erigone atra* (Blackwall) (Araneae: Erigonidae), *Agric. Ecosyst. Environ.*, **90**: 67–80.
- LIU, W.X., HOU, M.L., WAN, F.H. AND WANG, F.L., 2003. Temporal and spatial niche dynamics of spiders and their control effects on cotton bollworms in transgenic Bt cotton fields. *Entomol. Know.*, **40**:160-163.
- LUDWIG, J.A. AND REYNOLDS, F.J., 1988. *Statistical ecology: A primer on methods in computing*. John Wiley and Sons, New York. Pp. 337.
- MARTIN, T.J. AND MAJOR, R.E., 2001. Changes in wolf spider (Araneae) assemblages across woodland- pasture boundaries in the central wheat belt of new South Wales, Australia. *Austral. Ecol.*, **26**: 264-274.
- MARSHALL, E.J.P. AND MOONEN, A.C., 2002. Field margins in the northern Europe: their functions and interactions with agriculture. *Agric. Ecosyst. Environ.*, **89**: 5-21.
- NENTWIG, W., 1987. The prey of spiders. In: *Ecophysiology of spiders* (ed. W. Nentwig.). Springer-Verlag, Berlin, pp. 249-263.
- NEWTON, I. AND WYLLIE, I., 1992. Recovery of sparrow hawk population in relation to declining pesticide contamination. *J. appl. Ecol.*, **29**: 476-484.
- NYFFELER, M., 2000a. Ecological impact of spider predation: a critical assessment of Bristowe’s and Turnbull’s estimates. *Bull. Br. Arachnol. Soc.*, **11**: 367–373.
- NYFFELER, M., 2000b. Killing power of the orb-weaving spider *Argiope bruennichi* (Scopoli, 1772) during a mass occurrence. *Newslett. Br. Arachnol. Soc.*, **89**: 11–12.
- NYFFELER, M. AND BENZ, G., 1987. Spiders in natural pest control: a review. *J. appl. Ent.*, **103**: 321–339.
- ÖBERG, S., 2007. Diversity of spiders after spring sowing-influence of farming system and habitat type. *J. appl. Ent.*, **13**: 524-531.
- ÖBERG, S. AND EKBOM, B., 2006. Recolonisation and distribution of spiders and carabids in cereal fields after spring sowing, *Ann. appl. Biol.*, **149**: 203–211.
- ÖSTMAN, Ö., EKBOM, B. AND BENGTTSSON, J., 2003. Yield increase attributable to aphid predation by ground-living polyphagous natural enemies in spring barley in Sweden. *Ecol. Econ.*, **45**:149–158.
- PIFFNER, L. AND WYSS, E., 2004. Sown wildflower strips to enhance natural enemies of agricultural pests in annual and perennial cropping system. In: *Ecological engineering for pest management: advances in habitat manipulation for arthropods* (eds. G. M. Gurr, S. D. Wratten and M. A. Altier), CSIRO Press, Collingwood, pp. 165-186.
- PLATNICK, N.I., 2007. *The world spider catalogue*, version 8.0, The American Museum of Natural History. "http://research.amnh.org/entomology/spiders/catalog/
- PROSZYNSKI, J., 2003. *Key for identification of salticidae*.

- Museum and Institute of Zoology, Polish Academy of Sciences. UL. Wilcza 64, 00-679. Warszawa, Poland
- ROBERTSON, L. N., KETTLE, B.A. AND SIMPSON, G.B., 1994. The influence of tillage practices on soil macrofauna in a semi-arid agroecosystem in northeastern Australia. *Agric. Ecosyst. Environ.*, **48**: 149–156.
- SAMU, F. AND SZINETAR, C., 2002. On the nature of agrobiont spiders. *J. Arachnol.*, **30**:389-402.
- SCHMIDT, M.H, ROSCHEWITZ, I., THIES, C. AND TSCHARNTKE, T., 2005. Differential effect of landscape and management on diversity and density of ground dwelling farmland spiders. The role of perennial habitats for Central European farmland spiders, *J. appl. Ecol.*, **42**:281–287.
- SCHMIDT, M.H AND TSCHARNTKE, T., 2005a Landscape context of sheetweb spider (Araneae: Linyphiidae) abundance in cereal fields. *J. Biogeogr.*, **32**: 467–473.
- SCHMIDT, M.H AND TSCHARNTKE, T., 2005b. The role of perennial habitats for Central European farmland spiders, *Agric. Ecosyst. Environ.*, **105**:235–242.
- 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., M. 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.
- SEBASTIAN, A.P., MATHEW, J.M., PATHUMMALB, S., JOSEPH, J. AND BIJU, R.C., 2005. The spider fauna of the irrigated rice ecosystem in the central Kerala, India. *J. Arachnol.*, **33**:247-255.
- SETTLE, W.H., ARIAWAN, H., ASTUTI, T.E., CAHYANA, W., HAKIM, L.A., HINDAYANA, D. AND LESTARI, S.A., 1996. Managing tropical rice pests through conservation of generalist natural enemies and alternative prey. *Ecology*, **77**: 1975–1988.
- SUNDERLAND, K. AND SAMU, F., 2000. Effects of agricultural diversification on the abundance, distribution, and pest control potential of spiders: a review. *Ent. exp. Appl.*, **95**: 1–13.
- 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. AND BUTT, A., 2008. Activities of spiders in rice fields of central Punjab, Pakistan. *Acta zool. Sin.* **54**: 701-711.
- TAKASHI, M., CHIKARA, I., MOTONORI, T., MIHOKO, M.T., AYAME, T., KAZUMASA, H. AND YASUHISA, K., 2006. Effects of tillage practices on spider assemblage in rice paddy fields. *Appl. J. Ent.*, **41**: 371-381.
- THOMAS, C.F.G. AND MARSHALL, E.J.P., 1999. Arthropod abundance and diversity in differently vegetated margins of arable fields. *Agric. Ecosyst. Environ.*, **72**: 131–144.
- TIKADER, B.K., 1987. *Handbook of Indian spiders*. Zoological Survey of India, Calcutta, India. pp. 251.
- TIKADER, B. K. AND MALHOTRA, M.S., 1980. *The fauna of India*. Zoological Survey of India, Calcutta, India, vol. 1, pp. 272-439.
- UETZ, G., 1975. Temporal and spatial variation in species diversity of wandering spiders (Araneae) in deciduous forest litter. *Environ. Ent.*, **4**:719-724.
- WARDLE, D. A., 1995. Impacts of disturbance on detritus food webs in agro-ecosystems of contrasting tillage and weed management practices. *Adv. ecol. Res.*, **26**: 105–185.
- WEBB, N.R., 1990. Changes on the heathlands of Dorset, England between 1978 and 1987. *Biol. Conserv.*, **51**: 273-286.
- WISNIEWSKA, J. AND PROKOPY, R.J., 1997. Pesticide effect on faunal composition, abundance, and body length of spiders (Araneae) in apple orchards. *Environ. Ent.*, **26**:763–776.
- YARDIM, E.N. AND EDWARDS, C.A., 1998. The influence of chemical management of pests, diseases and weeds on pest and predatory arthropods associated with tomatoes. *Agric. Ecosyst. Environ.*, **7**:342-356.

(Received 28 October 2008, revised 11 December 2008)

Table I.- Relative abundance of spiders at each of four distances from field edge at four different management practices.

Families	Species	Reduced Input Field				Organic Field				Herbicide Treated Field				Tilled Field			
		0 m	10 m	20m	40 m	0 m	10 m	20 m	40 m	0 m	10 m	20 m	40 m	0 m	10 m	20 m	40 m
Araneidae																	
	<i>Argiope pradhani</i> Sinha 1951	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
	<i>Neoscona theis</i> (Walckenaer 1842)	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Gnaphosidae																	
	<i>Gnaphosa</i> sp.1	-	2	-	-	-	-	-	-	-	-	-	-	-	1	-	-
	<i>Gnaphosa</i> sp.2	-	-	-	-	1	2	-	-	-	-	-	-	-	-	-	-
Lycosidae																	
	<i>Evipa</i> sp	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	<i>Hippasa</i> sp	6	3	1	-	7	-	4	-	11	3	3	-	3	5	2	-
	<i>Lycosa maculata</i> Butt, Anwar & Tahir 2006	4	3	2	1	3	1	1	1	3	1	-	-	1	-	-	-
	<i>Lycosa nigricans</i> Butt, Anwar & Tahir 2006	-	3	2	2	3	5	9	4	4	7	2	0	3	5	1	0
	<i>Lycosa terrestris</i> Butt, Anwar & Tahir 2006	402	210	121	79	435	291	98	77	278	74	60	37	294	90	43	21
	<i>Pardosa birmanica</i> Siman 1884	141	82	53	29	241	167	61	65	98	43	31	13	85	30	35	21
	<i>Pardosa oakleyi</i> Gravely 1924	6	7	4	4	8	6	5	2	-	-	0	-	8	6	2	1
Oxyopidae																	
	<i>Oxyopes javanus</i>	2	4	-	-	6	3	1	3	8	3	4	-	-	-	-	-
Salticidae																	
	<i>Bianor albobimaculatus</i> Lucas 1846	11	19	12	9	19	22	24	14	9	16	12	8	6	11	8	8
	<i>Hasarius adansoni</i> (Audouin 1826)	14	17	19	14	12	22	16	19	8	21	15	7	9	12	8	9
	<i>Phidippus</i> sp	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
	<i>Plexippus paykulli</i> (Audouin 1826)	9	6	3	4	8	6	3	3	7	5	3	1	-	-	-	-
	<i>Thyenes imperialis</i> Rossi 1846	2	3	-	-	1	3	2	1	0	2	-	-	-	-	-	-
Tetragnathidae																	
	<i>Tetragnatha javana</i> (Thorell 1890)	3	2	-	-	4	3	1	1	1	2	-	-	2	1	-	-
Thomisidae																	
	<i>Runcinia</i> sp	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-
	<i>Thomisus cheraupunjeus</i> Stoliczka 1869	5	11	7	2	7	8	8	-	1	7	2	1	3	6	2	-
	<i>Thomisus pugilis</i> Stoliczka 1869	1	2	1	-	2	4	2	-	-	2	1	-	1	2	2	-
	Total	608	377	227	144	757	545	235	190	426	188	134	67	414	170	103	60