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Spiders of Agro-Ecosystems: A Review

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Abstract:

The large number of studies about the diversity, systematic and ecology of spiders carried out in last three decades in different types of ecosystems all over the world but the importance of spiders in agro-ecosystems as bio-control agents is still largely unknown. In this paper the literature about the study carried out in different agro-ecosystems is reviewed. Total 230 scientific papers published between year from 1804-2012, which are cited here. Several National and International studies have done in different agro-ecosystems like cotton, rice, wheat, maize, soybean, sugarcane, cereal fields, peanut, pea, apple orchards, lime orchards, citrus and banana fields. Significant reports of spider diversity reported from Cotton, Citrus and Banana agro-ecosystems from various parts of world given in Table.No.1.

Keywords: Biological Control, Spider, Agro-ecosystems

Introduction

International Studies:

Spiders play an important role in regulating insect pests in agriculture ecosystems (Nyffeler and Benz, 1987; Nyffeler *et al.*, 1994b; Sunderland, 1999a). Studies of Hamamura (1969); Sasaba *et al.* (1973); Gavarra and Raros (1973); Samal and Misra (1975); Kobayashi (1977); Chiu (1979); Holt *et al.* (1987) and Tanaka (1989) clearly described the role of spiders as predators in reducing insect pests in rice fields. They are ubiquitous in terrestrial ecosystems and abundant in both natural and agricultural habitats (Turnbull, 1973; Nyfeller and Benz, 1987). The distribution and diversity of spiders has drawn attention of naturalists in different parts of the world since the eighteenth century. Latreille (1804); Leach (1815); Koch (1836); Cambridge (1885, 1892 and 1897) and Simon (1887) prepared the early taxonomic records on spiders. According to the World Spider Catalog, Version 14.5 by Platnick (2014), the updated list documented 44540 species of spiders worldwide belonging to 3924 genera and 112 families.

Spiders can colonize fields early, feed on alternative prey until pest populations arrive, and target pests before they reach peak densities (Settle *et al.*, 1996; Landis and Van der Werf, 1997; Chang and Kareiva, 1999; Symondson *et al.*, 2002). They have a low metabolic rate that enables them to survive periods of starvation (Greenstone and Bennett, 1980). Understanding how spiders (Araneae) colonize agro-ecosystems is important since sustaining viable populations of generalist predators is a key attribute of effective integrated pest management (e.g. Snyder and Wise, 1999; Schmidt *et al.*, 2004). Dippenaar-Schoeman *et al.* (1999) studied spiders in South African cotton fields with respect to diversity and abundance (Arachnida: Araneae). Van den Berg *et al.* (1990) investigated the effect of pesticides on spiders in South African cotton fields.

Lycosid spiders are most effectively collected with pitfall traps and it has been shown that the number of linyphiid species caught is about the same in pitfall traps as in D-vac trapping (Dinter, 1995; Standen, 2000). Pitfall traps are also good to know the pattern of predators, and they have been shown to be suitable for monitoring activity (Bishop and Riechert, 1990). Population densities of spiders are low in the vegetation zone of meadows and cereals and high on the ground (Nyffeler and Benz, 1987). Spiders are generalist predators that can function as biological control agents within agroecosystems (Moulder and Reichle, 1972; Nyffeler and Benz, 1987; Riechert and Bishop, 1990; Young and Edwards, 1990; Kajak *et al.*, 1991; Kajak, 1997).

Spiders help in pest management. The spider families Linyphiidae, Dictynidae, Theridiidae, and Agelenidae consistently keep their webs standing which contribute to pest mortality (Nentwig, 1987;

Sunderland *et al.*, 1986a,b). Grasshoppers exhibited reduced feeding on grass in the presence of the spider *Pisurina mira* (Walckenaer) (Araneae: Pisauridae). Similarly, the presence of spiders deterred Japanese beetles, *Popilliae japonica* (Newman) (Coleoptera: Scarabaeidae), from feeding on soybean leaves. Spiders have effectively reduced pest populations in agroecosystems (Riechert, 1999; Johnson *et al.*, 2000; Whitehouse and Lawrence, 2001). Predation is most effective when spiders are present early in the growing season when the predator to prey ratio is high (Edwards *et al*., 1979; Ekbom and Wiktelius, 1985; Chiverton, 1986; Birkhofer *et al.*, 2008). Halaj and Wise (2001) performed a meta-analysis of terrestrial food webs in agricultural systems and discovered that spiders exhibited strong top-down effects on plants. Presence of spider populations resulted into reduced larval populations of the moth *Spodoptera littoralis* (Boisduval) (Lepidoptera: Noctuidae) and decreased populations of Cicadellidae (Hemiptera), Thripidae (Thysanoptera), as well as decreased populations of Aphididae (Hemiptera) in southern Bavaria (Lang *et al*., 1999). Riechert and Bishop (1990) found prey densities and plant damage to be lower in garden test systems with augmented spider densities. *Araneus quadratus* Clerck (Araneae: Araneidae) indirectly reduced plant damage by preying on grasshoppers (Andrzejewska *et al.*, 1967). Sea grape leaf damage was significantly reduced when spiders preyed upon gall midges (Spiller and Schoener, 1990). Spiders fed on herbivores, increasing the dry biomass of the plant species *Solidago rugosa* (Schmitz, 2003). The spider *Anyphaena celer* (Hentz) (Araneae: Anyphaenidae) increased mortality of the hemipteran herbivore *Stephanitis pyrioides* (Scott) (Shrewsbury and Raupp, 2006). In soybean, plant damage was reduced when spiders were added (Rypstra and Carter, 1995). Additionally, composted plots had less soybean leaf and pod damage when more spiders were present and non-crop plants had reduced damage as *Argiope trifasciata* (Forskål) (Araneae: Araneidae) had eaten more leaf-chewing insects (Rypstra and Marshall, 2005). Spider predation on pests has been further demonstrated in several other agroecosystems by Riechert and Lockley (1984).

Spiders are especially useful for reducing aphid densities (Sunderland *et al.*, 1986a, *Collins et al.*, 2002). Aphids (Hemiptera: Aphididae) represented approximately 14% of the prey captured by spiders (Nyffeler *et al.*, 1994b). Linyphiid spiders (Araneae: Linyphiidae) killed 31 *Sitobion avenae* (F.) (Hemiptera: Aphididae)/m2/day in winter wheat (Sunderland *et al*., 1986b). In Europe, experimentally manipulated increases in ground predator densities resulted in aphid reduction in maize (Lang *et al.*, 1999), barley (Chiverton, 1986; Ekbom *et al.*, 1992; Ostman *et al.*, 2003), and wheat (Edwards *et al.*, 1979; Chiverton, 1986; Mansour and Heimbach, 1993; Collins *et al.*, 2002; Lang, 2003; Schmidt *et al.*, 2004, von Berg *et al.*, 2009). In addition, presence of spider populations exhibited decreased damage by the greenbug, *Schizaphis graminum* (Rondani) (Hemiptera: Aphididae) (Muniappan and Chada, 1970; Mansour *et al.*, 1981).

It has been suggested that spiders in agro-ecosystems take refuge in surrounding natural landscapes during periods of cultivation and disturbance (e.g., Halley *et al.*, 1996; Wissinger, 1997). Spiders common to agro-ecosystems have been found to move from weed strips to cereal fields in the spring (Lemke and Poehling, 2002) and the proportion of spider webs in cereal fields correlates with the proportion of surrounding non-crop habitat (Schmidt and Tscharntke, 2005a). Differences in spider assemblage patterns in natural landscapes such as woodland and old-fields adjacent to cultivated land was observed (Riechert and Bishop, 1990; Samu and Szinetar, 2002) showing the importance of such landscapes as spider reservoirs. Assemblage differences, however, can fluctuate depending on the time of year. For instance, dominant arable species have been found to be more abundant in permanent grassland in early spring indicating a dependence on natural habitat (Schmidt and Tscharntke, 2005b). Spider colonization of agro-ecosystems occur more commonly *via* long distance colonization events (i.e., ballooning) rather than short distance methods (cursorial) (Riechert and Bishop, 1990; Schmidt and Tscharntke, 2005b). Conservation biological control has also been promoted as a method for increasing populations of spiders in agro-ecosystems (Halaj *et al.*, 2000).

Mellet, *et al.* (2006) investigated the effect of Bt-cotton cultivation on spider populations in Marble Hall, South Africa. According to them neither Bt-cotton nor the application of endosulfan had apparent negative effects on ground or plant dwelling spiders in the field. Spiders should therefore be able to continue playing a role in pest control in Bt-cotton fields. Danisman, *et al.* (2007) Investigated spider fauna of Cereal Fields in Antalya (Araneae). A total of 629 spiders were recorded from wheat, oats and maize fields belonging to 41 species from to 34 genera and 16 families.

Hibbert and Buddle (2008) assessed the dispersal of spiders within agricultural fields and an adjacent mature forest in Canada. They carried out manipulative experiment in corn fields and their adjacent forests using enclosures that restricted access to ground-dwelling spiders. Enclosures were either closed from the adjacent habitat but open to ballooning and ground-dwelling spiders or were open plots. This allowed them to test the role of ballooning compared to cursorial dispersal of ground-dwelling spiders within these habitats. Ninety species were collected using visual surveys and with pitfall traps. More species were collected in cornfields, and more individuals were collected in litter-addition plots. Tahir (2009) investigated diversity and predatory efficacy of spiders inhabiting the rice fields of Central Punjab, Pakistan.

Ghavami *et al.* (2007) investigated the spider fauna of cotton fields in Iran. Spider samples were collected by them from different cotton field localities by pitfall trap and insect net. They classified a total of 632 specimens in 45 species and 59 genera belonging to 19 families. *Cheiracanthium pennyi*, *Neoscona adianta*, *Aulonia albimana* and *Thanatus formicinus* were the most abundant species in cotton fields. Most species belonged to Thomisidae and Araneidae families and the fewest species were from Gnaphosidae, Linyphiidae and Pisauridae families.

Species composition, population densities, and vertical distribution of spiders in Soyabean agro-ecosystem are documented by several arachnologists from different countries (Barry, 1973; LeSar and Unzicker, 1978; Culin and Rust, 1980; Culin and Yeargan, 1982; House and Stinner, 1983; Ferguson *et al.*, 1984; Gregory *et al.*,1989; Carter and Rypstra, 1995; Balfour and Rypstra, 1998; Marshall *et al.*, 2002; Vichitbandha and Wise, 2002; Hlivko and Rypstra, 2003; Pearce *et al.*, 2005; Beltramo *et al.*, 2006; Gonzalez *et al.*, 2009).

Throughout the world, diversity, habitat use and prey preferences by spiders in the rice agro-ecosystem has been extensively investigated by number of authors indicating role of spiders in Integrated Pest Management to control insect pests (Woods and Harrel, 1976; Barrion and Litsinger, 1984; Heiss and Meisch, 1985; Shepard *et al.*, 1987; Xu, *et al.*, 1987; Ye and Wang, 1987; Oraze *et. al.*, 1988; Oraze *et al.*, 1989; Bastidas *et al.*, 1993; Im and Kim, 1996; Kumar and Velusamy, 1997; Barrion, 1999; Im and Kim, 1999; Bamdaradeniya and Edirisinghe, 2001; Bambaradeniya and Edirisinghe, 2008; Tahir and Butt, 2008; Everton, 2009; Tahir and Butt, 2009; Tahir, *et al.*, 2009; Tahir, 2009).

The species composition and frequency of spiders occurring in wheat crop is studied by (Doane and Dondale, 1979; Sunderland *et al.*, 1980; Nyffeler and Benz, 1988c; Nyffeler and Benz, 1988b; Basedow, 1998; Feber *et al.*, 1998; Toth and Kiss, 1999; Basedow *et al.*, 2000; Greenstone, 2001; Harwood, 2001; Pluess *et al.*, 2008). Predatory role of spiders in Maize crop is documented by several authors (Everly, 1938; Sharma and Sarup, 1980; Plagens, 1986; Alderweireldt and Desender, 1990; Peterson *et al.*, 2010). Costall and Death (2009) studied population structure and habitat use by the spider *Latrodectus katipo* along the Manawatu-Wanganui coastline.

Agnew *et al.* (1985) and Agnew and Smith (1989) studied spider diversity in peanut agro-ecosystem with respect to Ecology and habitat use in Texas. Distribution and importance of spiders as predator in sugarcane crop is well studied by Ali and Reagan (1985) and Rinaldi *et al.* (2002). Diversity, population density and effect of pesticides on the occurance of spiders in apple orchards was studied earlier in different countries by (Dondale, 1956; Dondale, 1958; Dondale, *et al.*, 1979; Bostanian, *et al.*, 1984; Wyss, *et al.*, 1995; Wisniewska and Prokopy, 1997; Bogya and Marko, 1999; Miliczky *et al.*, 2000; Pekar and Kocoukek, 2004;). Mansour and Whitcomb (1986); Amalin *et al.* (2001a;b); Ghavami and Ghanadamooz (2008) investigated diversity and habitat use by spiders in citrus ecosystem in Israel, Florida and Iran respectively.

Ntonifor *et al.* (2012) conducted a study to elucidate the frequent occurrences of the tropical vagrant huntsman spider, *Heteropoda venatoria* in bananas, for which, the spider habitats, temporal abundance, distribution and dynamics were studied in banana agro-ecosystems in Cameroon. They concluded that the tropical huntsman spider prefers close fitting sites and crevices as habitats due to its flattened body and long flexible legs. The banana-agroecosystem and plant architecture provides many of such suitable hideouts including litter spots/mulches, loose pseudostem leaf sheaths, leaf petioles, spaces between flower bracts and clusters and between fingers of bunches. During the rains, most of the spiders could migrate into these more sheltered habitats.

Many farmers use chemical pesticides to help control pests. An ideal biological control agent, therefore, would be one that is tolerant to synthetic insecticides. Although spiders are more sensitive to insecticides than insects, some spiders show tolerance, perhaps even resistance, to some pesticides. Spiders are less affected by fungicides and herbicides than by insecticides (Yardim and Edwards, 1998). Spiders such as the wolf spiders *P. pseudoannulata* are highly tolerant to botanical insecticides such as Neem-based chemicals (Theiling and Croft, 1998; Markandeya and Divakar, 1999). They are also generally more tolerant to organophosphates and carbamates than of pyrethroids, organochlorines, and various acaricides. This tolerance may be due to genetic resistance bred over a period of continuous exposure (Theiling and Croft, 1998; Wisniewska and Prokopy, 1997; Yardim and Edwards, 1998; Marc *et al.*, 1999; Tanaka *et al.*, 2000). *P. pseudoannulata* (Lycosidae), *Tetragnatha maxillosa* (Tetragnathidae), *Ummeliata insecticeps* and *Gnathonarium exsiccatum* (Linyphiidae) were highly sensitive to the pyrethroid deltamethrin, but very tolerant of the organophosphate diazinon and the carbamate carbaryl (Tanaka *et al.*, 2000).

Studies on Spiders of Agro-ecosystems from India:

In India, studies on the population and abundance of the spider assemblages in agricultural crops are few. Some basic studies were carried out by Pathak and Saha (1999) and Bhattacharya (2000). Banerji, *et al.* (1993) and Anbalagan and Narayanaswamy (1999) analyzed the population fluctuation of spiders in paddy fields. However, these studies were mostly limited to the identification of spiders and investigation of the dominant spider species.

Trivedi (2009) carried out an ecological study to determine the quantitative and qualitative community structure and population of spiders in Groundnut crop fields. Spiders were collected at random following a quadrant method (each quadrant of 1 sq. m taken per visit, total count 25 quadrants), 25 visits every week, during the crop season from july to November, 2002, at Munjka village of Rajkot, Gujarat state. A total of 809 spiders, belonging to 37 species under 22 genera and 10 families were collected. They were classified into three guilds based on their predatory behavior ashunting, ambushing and web building; the per cent of spiders within active groups were 68.48, 14.83, and 16.69 respectively. The largest numbers of individuals collected belonged to the families Salticidae (27.69%), Oxyopidae (11.25%), and Philodromidae (11.13%). The most abundant genera were *Marpissa, Pardosa, Oxyopes and Theridion*. The most abundant Salticid and Lycosid identified to species were *Plexippus paykulli* (4.94%) and *Pardosa pseudoannulata* (4.94%) respectively. Maximum density of spiders was observed during the flowering stage of the crop in September, thereafter it decreased, and evenness index (e) was almost higher (3.0) in Groundnut crop-ecosystem. These results indicated that an increased diversity index (H') was correlated with crop growth and it ranked as October- 3.94 > September – 3.89> August- 2.73>Nov-0.99> July-0.0.

Siliwal Manju and Dolly Kumar (2002, 2003a,b) reported *Harmochirus brachiatus (Thorell), Dinopis goalparaensis, Triaeris manii* and *Triaeris poonaensis* spiders from banana agroecosystems of Baroda, Gujarat. Similarly they have also sighted *Latrodectus hasseltii indicus* Simon (Araneae: Theridiidae) in a cotton field in Baroda district, Gujarat during 2001.Dollykumar and Shiva Kumar (2004, 2006) investigated the seasonal abundance of spiders in rice and pigeon pea agroecosystems of Vadodara Gujarat, with special emphasis on Bio-control aspect.

Sebastian, *et al.* (2005) studied spider fauna of the irrigated rice ecosystem in central Kerala. A survey of spiders associated with the irrigated rice ecosystem in central Kerala, India was conducted by them across different elevation ranges. Spiders were collected from rice fields of high ranges, midland and low land areas in two cropping seasons viz., June–September 2002 (Kanni Krishy) and October 2002–February 2003 (Makara Krishy) with a total of 144 hours of sampling time distributed across the two seasons. The sampling areas constituted Adimali and Marayoor of Idukki district (high range), Vannappuram of Idukki district and Kothamangalam of Ernakulam district (midland) and Parakkadavu and

Piravom of Ernakulam district (lowland). Visual searching methods were used to sample the spider fauna

Agro-ecosystem	**Country**	**Reference**	**Major observations**

from quadrats. A total of 1130 individuals belonging to 92 species, 47 genera and 16 families were recorded during the study period. Araneidae and Tetragnathidae were the dominant families and *Tetragnatha mandibulata* (Family Tetragnathidae) the most abundant species. Various diversity indices, as well as richness and Chao I estimator were used to analyze the possible effect of elevation on species occurrence; the results showed that species richness and diversity were the highest in Parakkadavu, which is a lowland area. In a cluster analysis the localities belonging to the same elevation were found to form separate groups. Orb weavers were dominant at all study sites. Most of the spider diversity in agro-ecosystem is studied by several researchers in rice fields from different states of India (Sellammal and Chelliah, 1982; Krishnaswami *et al.*, 1984; Gupta *et al.*, 1986; Rajendran, 1987; Nirmala, 1990; Ansari and Pawar, 1992; Banerji *et al.* (1993); Mishra and Shrivastava, 1993; Kumar, 1994; Thakur *et al.*, 1995; Ganeshkumar and Velusamy, 1996; Sahu, *et al.*, 1996; Samiyyan and Chandrasekaran, 1998; Venkateshalu *et al.*, 1998; Anbalagan and Narayanaswamy, 1999; Pathak and Saha, 1999; Bhattacharya, 2000; Vanitha, 2000; Mathirajan, 2001; Shenhmar *et al.*, 2001; Zhimomi *et al.*, 2001; Jose, *et al.*, 2002; Satpathi, 2004; Patel *et al.*, 2004 and 2005; Sebastian *et al.*, 2005; Sudhikumar, *et al.*, 2005; Devarassou and Adiroubane, 2006; Diraviam *et al.*, 2006; Kumar and Shivakumar, 2006; Manisegaran *et al.*, 2006; Manu and Bai, 2006; Venturino, *et al.*, 2008; Chatterjee, *et al.*, 2009 and Jayakumar and Sankari, 2010).

The mean populations of spiders in cotton fields from three different places like Thayilpatti, Madathuppatti and Vembakkottai, Virudhunagar district, Tamil Nadu, India were studied by Jeyaparvathy *et al.* (2012). In these areas, twenty common species of spiders belonging to six families from these three selected areas were collected and identified. The collected spiders were belonging to the families, Salticidae, Oxyopidae, Araneidae, Lycosidae, Gnaphosidae and Sparassidae. In this study, two types of spiders were observed, one is web weaver and another one is non-web weaver. The web weaving spiders were belonging to the family Araneidae and Lycosidae. The non-web weaving spiders were belonging to the family Salticidae, Oxyopidae, Gnaphosidae, Lycosidae and Sparassidae. *P. viridana, O. birmanicus, O. hindostanicus, P. latikae and A. anasuja* were dominant predator recorded in these three selected areas. The population dynamics of the individual spider species in different months showed that the population of spider species mainly *P. vridana, O. birmanicus, O. hindostanicus, A. anasuja, N. lugubris, P. latikae, C. cicatrosa* and *L. pseudoannulata* were very high throughout the study period. The increase in the spider density suggested that the spider density is influenced by the increase in prey density.

Jeyaparvathi *et al.* (2013) also investigated the biological control potential of spiders on the selected cotton pests and found that the four species of spiders like (*Peucetia viridana Oxyopes birmanicus* (Thorell) and *Peucetia latikae* were predominant in the cotton fields of Achamthavirthan, Virudhunagar district, Tamil Nadu, India.

Table 1: Significant Reports of Spider Diversity Reported from Cotton, Citrus and Banana Agro-Ecosystems from Various Parts of World

Cotton	Texas	Dean *et al*., 1982	1. Reported 97 species from 71 genera and 18 families. 2. Orb weavers as dominant species mostly inhabiting middle of the plant and ambushing spiders occupied top of the plant.
Cotton		Dean *et al*., 1987	1. Hunting spiders *Phidippus audax*, *Metaphidippus galathea* and *Misunenops celer* were observed predating on the cotton fleahopper, *Pseudatomoscelis seriatus*.
Cotton	Israel	Mansour, 1987	1. Spiders from 18 and 13 families were recorded from pesticide unsprayed and sprayed fields respectively. 2. Spiders suppress pest populations and delay pest outbreaks.
Cotton	Texas	Nyffeler *et al*., 1987b	1. Cotton fields were dominated by generalist predator, *Oxyopes salticus.* 2. 0.12 million prey might have been killed by them per ha cotton land per week.
Cotton	Texas	Nyffeler *et al*., 1987a	1. Green lynx spider, *P. viridans* feeds both diurnally and nocturnally. 2. *P. viridans* was observed feeding on insects of orders Diptera, Hymenoptera, Heteroptera, Homoptera, Coleoptera, Lepidoptera, Neuroptera, and Odonata.
Cotton	Texas	Nyffeler *et al*., 1987c	1. *A. aurantia* was found to be a predator of the cotton fleahopper (about 1 % of the spiders'diet).
Cotton	Texas	Nyffeler *et al*., 1988a	1. Web-building spiders *Dictyna segregata*, *Theridion australe*, *Tidarren haemorrhoidale* and *Frontinella pyramitela* found to prey on Aphids and cotton fleahoppers.
Cotton	Texas	Nyffeler *et al*., 1988b	1. Black widow spider, *Latrodectus mactans* preyed on red fire ant, *Solenopsis invicta*, which constituted 75 % of the prey.
Cotton	Texas	Nyffeler *et al*., 1989	1. Orb weavers as dominant groups in cotton field. 2. Prey selection by spiders is determined by web location, web inclination, and web strength.
Cotton	Texas	Breene, 1989	1. Recorded 18 species of spiders from 11 families Preying on cotton fleahopper.
Cotton	Mississip pi	Hayes and Lockley, 1990	1. Coleoptera and Diptera are important preys of wolf spiders during night.
Cotton	South Africa	Van Den Berg *et al*., 1990	1. 76 species from 61 genera and 18 familes were identified. Lycosidae (41.9 %) as dominant family.
		Breene *et al*., 1990	1. *O. salticus*, *P. audax*, and *M. celer* controlled cotton fleahoppers almost 42 %, 66 % and 32 % respectively.
Cotton	Texas	Nyffeler *et al*., 1992	1.Cotton fleahoppers composed almost 25% of the total prey of *O.*

			salticus during June and July.
Cotton	Texas	Nyffeler *et al.*, 1992	1.Lynx spiders were the dominant predators feeding predominantly on Heteropteran, Hymenopteran, and Dipteran pests.
Cotton	Texas	Breene *et al.*, 1993	1. Spiders were observed feeding upon every major and most minor, secondary, or occasional insect pests of Texas cotton. They act as ecological indicators.
Cotton	China	Zhao, J. Z., 1993	1. 204 species of spiders inhabited cotton fields in China, belonging to 21 families and 88 genera. These species accounted for >50% of the total population of predators of cotton insect pests.
Cotton	South Africa	Dippenaar-Schoeman *et al.*,1999	1. 127 species from 92 genera and 31 families were reported. Their occurance was in the order Thomisidae > Araneidae >Theridiidae.
Cotton	Pakistan	Ghafoor, 2002	1. 64 species belonging to 8 families were recorded from cotton fields and the dominance was in the order of Lycosidae > Gnaphosidae > Salticidae > Araneidae.
Cotton	India	Sebastian *et al.*, 2004	1. *Oxyopes chittrae* was observed as actively hunting spider in cotton.
Cotton	Central Kenya	Warui *et al.*, 2004	1. 132 species belonging to 30 families were recorded from cotton fields from central Kenya and they were in the order of Salticidae > Gnaphosidae > Araneidae > Lycosidae >Theridiidae >Thomisidae >Zodariidae.
Cotton	New Mexico	Bundy, 2005	1. 42 genera from 19 families were identified which were in the order of Lycosidae > Linyphiidae > Thomisidae as abundant families.
Cotton	Iran	Ghavami, 2008	1. Spiders act as biological control agents of insect pests in agro-ecosystems.
Cotton	Iran	Ghavami, 2008a	1. 76 species from 59 genera and 19 families were reported from cotton fields from Iran. 2. *Thanatus formicinus, Cheiracanthium pennyi, Aulonia albimana, neoscona adianta* were dominant species.
Citrus	Florida	Muma, 1975	1. Cribellate spiders were abundant in the citrus grove.
Citrus	California	Carroll, 1980	1. Reported spider as a major predator in citrus canopy as well as in the litter.
Citrus	Israel	Mansour and Whitcomb, 1986	1. Spiders act as a biocontrol agent for *Ceroplastes floridensis* (Homoptera: Coccidae).
Citrus	South Africa	Van Den Berg *et al.*, 1992	1. 3054 spiders from 21 families were sampled in an unsprayed citrus orchards. 2. Order of dominance was family Salticidae > Theridiidae > Thomisidae > Araneidae > Clubionidae > Tetragnathidae.
Citrus	Texas	Breene *et al.*, 1993	1. 33 species from 13 families of spiders were reported their occurance was in the order Araneidae >

			Theridiidae > Thomisidae > Salticidae > Lycosidae > Tetragnathidae > Gnaphosidae > Uloboridae > clubionidae > Anyphaenidae.
Banana	Panama	Harrison, 1968	1. Vertical distribution of spiders was studied in the banana field. 2. Member of family Argiopidae represented by largest number.
Banana	Cameroo n	Ntonifor *et al*., 2012	1. *H. venatoria* inhabited the soil litter /mulches, loose leaf sheats (barks) of pseudostems and stumps, leaf petioles, spaces between banana flower bracts and clusters.

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