INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY
ISSN Print: 1560–8530; ISSN Online: 1814–9596
10–584/AWB/2011/13–3–406–410
http://www.fspublishers.org

Full Length Article

Influence of Citrus and Guava Branch Architecture on Foliage Spider Fauna

ABDUL GHAFFAR[1], SHAKILA MUSTHAQ, SHAHNAZ AKHTER RANA AND KHALIL-UR-REHMAN†
Department of Zoology and Fisheries, University of Agriculture, Faisalabad, Pakistan
†*Department of Chemistry and Biochemistry, University of Agriculture, Faisalabad, Pakistan*
[1]Correspondence author's e-mail: zoologistag@yahoo.com

ABSTRACT

The effect of habitat structure on abundance of foliage spiders was investigated in citrus and guava trees. Several characteristics of spider habitats were measured viz. diameter of the branch, height of crown, branch length and number of branching angles. Maximum spider population was recorded from structurally more complex branch. Spider abundance was positively correlated with branch characteristics except to crown height, which was negatively correlated. Number of branching angles was the best predictors of spider abundance on individual branch, which accounted for 71 and 62% variation in total spider abundance in citrus and guava, respectively in both years. Selected habitat variables predicted the abundance of spiders in orchard. Results suggest that branch structure is the most important factor in determining the abundance of foliage spider in citrus and guava orchard. © 2011 Friends Science Publishers

Key Words: Foliage spider; Habitat architecture; Citrus; Guava trees; Faisalabad

INTRODUCTION

Habitat structure is a significant factor that influences spider diversity, abundance and distribution (Evans, 1997; Whitmore *et al*., 2002). Information obtained from both natural communities (Lubin, 1978; Robinson, 1981; Raizer & Ameral, 2001) and agricultural systems (Samu *et al*., 1999) shows that habitat structure and complexity are related to factors that include prey abundance, shelter against enemies and suitable microclimatic conditions (Gunnarsson, 1996; Halaj *et al*., 1998; Souza & Martins, 2004). The architecture of trees is changed by decreasing foliage density and branching angles, which makes the canopies and branches thinner. These changes affect tree living spider fauna indirectly as plant structures is important in providing dwelling space (Souza & Martins, 2004). Vegetation structure has been suggested as a major factor in determining abundance and diversity of spiders and the relationship between vegetation structure and spider community is well documented (Gunnarsson, 1990; Halaj *et al.*, 1998). Variation in plant height, foliage density, leaf surface area, number of leaves, branchlets, number and type of inflorescence can affect the abundance and distribution of foliage-dwelling spiders (Evans, 1997; Souza & Martins, 2005; Corcuera *et al*., 2008; Gontijo *et al*., 2010).

Large number of spiders is often present in orchards as reported in other studies (Mansour & Whitecomb, 1986; Van Den Berg *et al*., 1992). For instance in citrus orchards, sac spiders and related species have been reported among the dominant spiders (Breene *et al*., 1993). According to Amalin *et al.* (2003) various species of sac spiders contribute to the control of lepidopterous pests, mites and thrips in citrus orchards. It is hypothesized that spider abundance could be predicted by the availability and characteristics of their habitats. The aim of present study was to observe how branch architecture affects foliage spider abundance.

MATERIALS AND METHODS

This study was carried out in Horticulture Research Area located at western boundary of Agriculture University Campus, Faisalabad, Pakistan (Latitude =31° 26' 0" N, Longitude = 73° 6' 0" E, Altitude = 184 m). Faisalabad city is a central part of the province Punjab of Pakistan. The main criterion for site selection was the presence of a variety of cultivated and uncultivated plants, which form complex community for foliage spider. Two habitats chosen for this study were citrus and guava trees. Both types of trees in study area were sampled to test the effect of structural complexity on foliage spider's abundance.

The citrus and guava groves comprised 905 and 332 trees of various ages and sizes. Each plot was consisted of 12 trees arranged into four rows and columns about 5 m apart, trees ranged in their heights from 2 to 4 and 2.5 to 6 m, maximum crown diameter was recorded as 3 to 8 and 4 to 10 m, respectively and their branches intermingled at some places. Study period extended from Ist January, 2005

To cite this paper: Ghaffar, A., S. Musthaq, S.A. Rana and K.U. Rehman, 2011. Influence of citrus and guava branch architecture on foliage spider fauna. *Int. J. Agric. Biol.,* 13: 406–410

through 31st December, 2006 (2 years). Each year citrus trees received three application of Confidor (Methamidophos) in February, April and August. In both years, guava trees were sprayed with Cypermethrin in July and August.

Foliage spiders were collected from citrus and guava habitats by Jarring (Coddington, 1991; Mukhtar, 2004). First week with five consecutive days of each month was fixed for sampling. A total of 600 branches per year were jarred (50) and in this way 1200 branches were jarred from each habitat. Parameters related to branch complexity viz. length (cm) and diameter of the branches (cm), height of branch crown (cm) and number of branching angles (no) were recorded. All dislodged spiders were placed individually in polythene bags by direct hand picking and brought to laboratory for identification and preservation. Specimens were washed with xylene and each specimen was placed in 95% ethanol and glycerin solution following Butt (1996) and Mukhtar (2004). The relationship between spider abundance and branch variables was analyzed with the help of coefficient of correlation and linear regression (Ludwig *et al*., 1988).

RESULTS

A total of 3817 and 3554 spiders were recorded from 1200 branches of citrus and guava trees, respectively. These spiders belonged to 15 and 13 families, 36 and 35 genera and 81 and 80 species, respectively. However, most foliage spider's fauna of citrus during years 2005 and 2006 (5.71) colonized the branches with high branching angles (37.09), which indicate greater number of twigs with high foliage density in June (Table I). Other branch characters were diameter of the branch (14.62), length (220) and height of branch crown from ground (110.04). In guava habitat most foliage spider population during both years (5.52) colonized the branches with high branching angles (31.79) also in June (Table II). Other branch variables were diameter of the branch (12.33), length (305) and height of branch crown from ground (140.8).

Less number of spiders (1.97) was collected from citrus branches with less branching angles (28.7), diameter of branch from the point of bifurcation (13.63), length (191.1) and height of branch crown (115.4). Colonization trends of foliage spiders in two years of study followed the same pattern among citrus branches (Table I). In contrast to citrus trees, in guava habitat less number of spiders (1.23) was collected from branches with less branching angles (22.40), diameter of branch from the point of bifurcation (12.48), length (284.1) and height of branch crown (129.0). Colonization trends of foliage spiders in two years of study also followed the same pattern among guava branches (see Table II).

Correlation was used to detect potentially linear relationships between branch characteristics and foliage spider population. All branch characteristics had positive correlation with spider population except branch crown height from ground, which was negatively correlated with population in citrus and guava tress. Spiders abundance was positively correlated with number of branching angles ($r=0.842$, $P<0.01$), diameter ($r=0.689$, $P<0.01$) and length ($r=0.278$, $P<0.01$), whereas branch crown height ($r=-0.083$) were negatively correlated during the study year 2005 (Fig. 1).

Similar trends of correlation were observed in the year 2006 in citrus (Fig. 1). The abundance of spiders was linearly related to the number of branching angles ($r = 0.84$ & 0.85), diameter ($r = 0.69$ & $r = 0.67$) in 2005 and 2006 in citrus (Fig. 1). On the other hand in guava habitat, spiders abundance was positively correlated with number of branching angles ($r = 0.799$), diameter ($r = 0.111$) and length ($r = 0.111$), while branch crown height ($r = -0.079$) were negatively correlated during the year 2005 (Fig. 2). Similar trend of correlations was observed in the year 2006 in guava (Fig. 2). The abundance of spiders in guava as compared to citrus was also linearly related to the number of branching angles i.e., $r = 0.80$ and $r = 0.77$ in the both the years (Fig. 2).

Foliage spider richness/abundance was significantly associated with habitat variables of individual host trees. As much as 71% of variation in total abundance of foliage spiders on sampled citrus trees was related to the number of branching angels of branches, which form the branch more complex with high foliage density and wooden twigs. In contrast to citrus trees, 62% of variation in total abundance of spider on sampled guava trees was related to the number of branching angles of branch.

DISCUSSION

Present work supports the hypothesis of branch complexity affecting the spider abundance on branches. During the field study it was observed that the more structurally complex branches with high foliage density sustained more spider population. The foliage spider abundance on simple branches with low foliage density was lower than on complex branches with high foliage density. This indicates that variations in foliage density can influence spider density in natural populations. The more diameter, length and high number of branching angles indicate the high foliage density and biomass and considered to be the more complex branches. Romero and Vasconcellos-Neto (2005) showed that leaf cutting negatively influenced the abundance of jumping spiders *Psecas chapoda.* The abundance of the foliage spiders was positively correlated with the branches variables such as diameter, length and number of branching angles. In this regard Souza and Martins (2005) concluded that the abundance of plant dwelling spiders was positively correlated with branches foliage density on which they occurred and branch architecture have significant effects on spiders abundance.

Table I: Comparison of means (± SE) of branch variables and spider abundance in Citrus habitat

Branch variables	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Diameter	2005	12.7±0.4	12.3±0.4	12.6±0.5	11.7±0.4	13.5±0.4	13.4±0.4	13.1±0.4	12.8±0.4	13.6±0.4	13.3±0.4	13.09±0.4	12.4±0.4	12.9±0.1
	2006	14.5±0.5	14.2±0.4	14.9±0.5	15.2±0.4	14.8±0.4	15.8±0.4	15.3±0.4	11.9±0.5	13.5±0.3	14.6±0.4	15.16±0.4	14.4±0.4	14.5±0.1
	Mean	13.6±0.3	13.2±0.3	13.7±0.3	13.5±0.3	14.1±0.3	14.6±0.3	14.2±0.3	12.3±0.3	13.5±0.2	13.9±0.3	14.13±0.3	13.4±0.3	13.7±0.1
Length	2005	188.6±5.7	165.4±6.3	166.0±5.7	177.5±6.7	206.2±6.6	225.3±8.1	192.9±6.8	204.7±10.0	199.6±6.1	175.6±6.5	172.4±5.4	170.1±5.0	187.0±2.0
	2006	193.5±7.2	185.7±6.0	186.9±6.4	217.3±6.2	214.0±6.7	214.7±6.8	199.7±6.5	170.3±5.8	197.0±6.9	228.8±6.7	236.0±8.2	219.1±9.0	205.2±2.1
	Mean	191.1±4.6	175.5±4.4	176.5±4.4	197.4±4.9	210.1±4.7	220.0±5.2	196.3±4.7	187.5±6.0	198.3±4.6	202.2±5.3	204.2±5.8	194.6±5.7	196.1±1.5
Branching Angles	2005	25.3±1.9	24.3±1.8	28.4±1.9	22.6±1.7	31.2±1.9	34.2±1.9	32.0±1.7	31.6±1.7	34.9±1.7	31.4±2.0	31.7±1.7	21.6±1.8	29.1±0.5
	2006	32.1±1.7	22.5±1.7	25.2±1.9	29.5±1.9	29.5±2.0	39.9±1.7	33.4±2.1	26.9±2.1	28.5±1.7	32.1±1.4	33.6±1.8	29.6±1.9	30.2±0.5
	Mean	28.7±1.3	23.4±1.2	26.8±1.4	26.1±1.3	30.3±1.4	37.0±1.3	32.7±1.3	29.3±1.4	31.7±1.2	31.7±1.2	32.7±1.2	25.6±1.4	29.7±0.4
Crown Height	2005	104.8±4.1	110.7±3.8	117.5±3.4	118.2±3.6	104.4±3.9	106.4±4.0	113.2±4.3	114.5.±3.6	113.5±4.5	113.5±3.3	112.7±3.6	122.1±3.9	112.6±1.1
	2006	126.1±3.8	130.7±3.3	128.3±3.5	113.5±5.1	108.1±4.6	114.3±4.1	111.2±6.0	105.5±4.1	96.2±4.1	99.5±3.4	102.7±3.7	114.0±4.2	112.5±1.2
	Mean	115.4±3.0	120.7±2.7	122.9.±2.5	115.8±3.1	106.2±3.0	110.4±2.9	112.2±3.6	110.0±2.7	104.8±3.1	106.5±2.5	107.7±2.6	118.1±2.9	112.6±0.8
Spider abundance	2005	2.14±03	3.7±0.5	4.7±0.6	4.4±0.6	4.24±0.55	5.5±0.5	3.4±0.5	2.8±0.4	1.8±0.2	2.0±0.4	2.7±0.4	3.1±0.5	3.4±0.1
	2006	1.80±0.3	1.7±0.3	3.2±0.4	2.6±0.4	2.72±0.42	5.9±0.7	2.6±0.5	2.4±0.4	2.1±0.3	2.46±0.3	4.0±0.4	3.6±0.4	2.9±0.1
	Mean	1.97±0.2	2.7±0.3	3.9±0.4	3.5±0.4	3.4±0.3	5.7±0.4	3.0±0.3	2.6±0.3	1.9±0.2	2.27±0.2	3.3±0.3	3.4±0.3	3.1±0.1

Table II: Comparison of means (±SE) of branch variables and spider abundance in guava habitat

Branch Variables	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
Diameter	2005	11.6±0.5	11.9±0.5	11.6±0.4	11.6±0.4	11.4±0.4	11.8±0.4	13.6±0.4	13.6±0.5	13.6±0.5	14.8±0.4	13.5±0.4	11.9±0.5	12.6±0.1
	2006	12.2±0.5	13.0±0.5	12.7±0.5	12.3±0.5	12.9±0.5	12.8±0.4	13.1±0.4	12.3±0.5	13.5±0.4	15.3±0.4	13.4±0.3	3.5±0.4	13.1±0.1
	Mean	11.9±0.3	12.4±0.3	12.1±0.3	11.9±0.3	12.1±0.3	12.3±0.3	13.4±0.3	12.9±0.3	13.6±0.3	15.1±0.3	13.5±0.2	2.7±0.3	12.8±0.1
Length	2005	268.5±8.7	285.2±9.4	275.8±7.6	280.4±9.4	270.3±10.4	297.1±9.3	13.6±0.4	310.7±8.4	314.0±9.4	339.8±10.4	320.0±11.7	90.6±11.7	298.3±3.0
	2006	279.1±8.7	283.1±10.1	319.0±11.7	229.4±10.7	288.0±12.6	312.8±11.3	13.1±0.4	302.1±10.8	339.2±12.4	355.1±11.8	319.2±10.5	30.6±10.6	311.1±3.3
	Mean	273.8±6.1	284.1±6.8	297.4±7.2	289.9±7.1	279.2±8.2	305.0±7.3	13.4±0.3	306.4±6.8	326.6±7.8	347.4±7.8	319.6±7.8	10.6±8.1	304.7±2.2
Branching Angles	2005	20.0±1.2	24.5±1.5	32.7±1.8	26.4±1.7	26.2±1.7	33.8±1.7	14.1±1.7	27.5±1.8	24.4±1.72	26.8±2.0	26.0±1.9	25.2±1.6	26.7±0.5
	2006	19.0±1.6	20.2±1.4	28.1±2.1	27.7±1.8	22.3±1.6	29.7±1.9	14.2±1.6	20.2±1.0	27.5±1.5	30.1±1.4	27.7±1.4	27.6±1.4	25.3±0.4
	Mean	19.5±1.0	22.4±1.0	30.4±1.4	27.0±1.2	24.2±1.2	31.7±1.2	14.2±1.1	23.8±1.1	25.9±1.1	28.4±1.2	26.8±1.2	26.4±1.1	26.0±0.3
Crown Height	2005	132.1±4.3	132.7±4.2	133.3±2.6	128.9±3.5	140.8±4.7	144.8±3.6	26.7±1.5	147.5±3.7	142.9±3.9	146.6±3.8	139.6±3.8	137.2±4.0	138.8±1.1
	2006	128.2±3.7	125.4±4.7	143.8±3.8	141.0±3.6	137.9±4.0	136.9±4.1	23.7±1.5	141.6±3.5	136.8±3.4	130.7±3.9	126.6±3.8	134.4±3.2	135.1±1.1
	Mean	130.2±2.8	129.0±3.1	138.6±2.3	134.9±2.6	139.3±3.0	140.8±2.7	25.2±1.0	144.6±2.6	139.8±2.6	138.6±28.5	133.1±2.7	135.8±2.5	136.9±0.8
Spider Abundance	2005	1.6±0.2	1.7±0.3	6.7±0.9	3.0±0.4	2.6±0.4	5.5±0.7	139.0±3.9	3.3±0.4	1.8±0.3	2.3±0.3	3.5±0.6	1.9±0.3	3.1±0.1
	2006	1.1±0.3	0.7±0.1	3.7±0.4	4.0±0.4	2.9±0.4	5.4±0.5	137.8±3.6	3.8±0.9	2.1±0.4	2.2±0.3	2.6±0.5	1.2±0.2	2.7±0.1
	Mean	1.4±0.2	1.2±0.1	5.2±0.5	3.5±0.3	2.8±0.3	5.5±0.4	138.4±2.7	3.6±0.5	2.0±0.2	2.3±0.2	3.1±0.4	1.6±0.2	2.9±0.1

The positive relationship between the number of spiders and branch characteristics is usually explained by the fact that patches with higher structural complexity attract a large number of spiders because they provide more hiding places and milder microclimates to spiders (Gunnarsson, 1996; Evans, 1997; Henschell & Lubin, 1997). The web-builder spiders are indicators of the dense, complex vegetation structure of undisturbed sand forest (Haddad *et al*., 2010). The influence of branch structural complexity on the abundance of spiders has been demonstrated in the literature (Hatley & MacMahon, 1980; Gunnarsoon, 1990 & 1992). Scheidler (1990) and later Halaj *et al*. (1998) recommended that difference in spider population on different plant species indicate the existence of spider associations for specific characteristics of the habitat. The response of animal communities to habitat quality may vary depending on microhabitat associations of species. Herrmann *et al*. (2010) investigated effects of local and landscape factors on spider communities in different microhabitats within Swiss apple orchards. They expected a stronger negative effect of woody habitat fragmentation on spiders inhabiting tree canopies compared to spiders living in the meadow.

The variation in total abundance of foliage spiders was related significantly to number of branching angles and length of branch, which indicated the foliage density and wooden twigs. It was also observed that the spider abundance on branches was affected by foliage density in itself. A high foliage density resulted in high spider abundance than thin foliage branches (Souza & Martins, 2005). Earlier studies support the hypothesis of needle density affecting the spider abundance on spruce branches (Gunnarsson, 1996). He suggested that the spider colonization on spruce branches was affected by the needle density. A high needle density resulted in a higher spider density than on needle-thinned spruce branches (Gunnarsson, 1990).

The foliage spiders in the present study maintained high abundance almost throughout the year and especially during the period extending from March through July.

Fig. 1: The best prediction model for the total abundance of spiders in samples pooled from citrus grove in 2005 and 2006

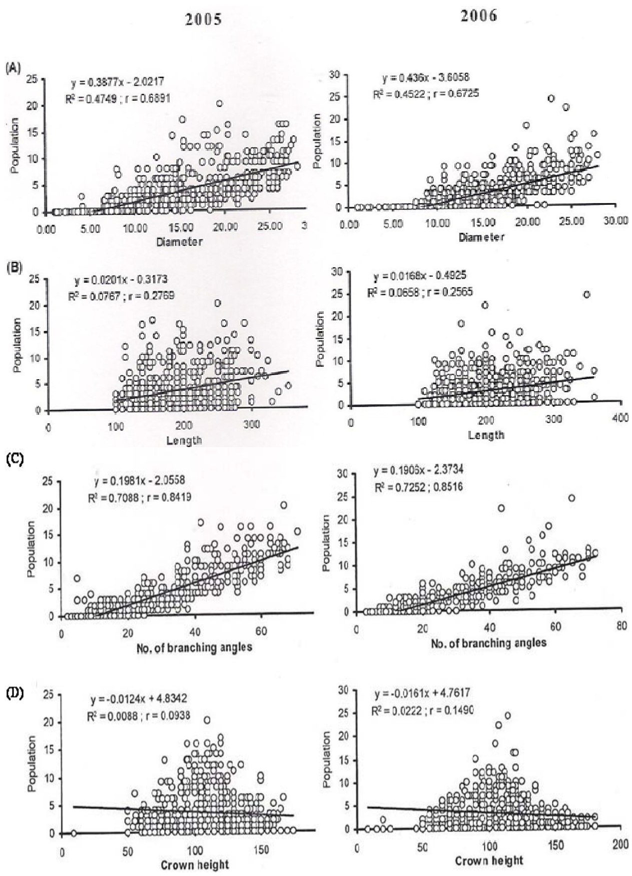
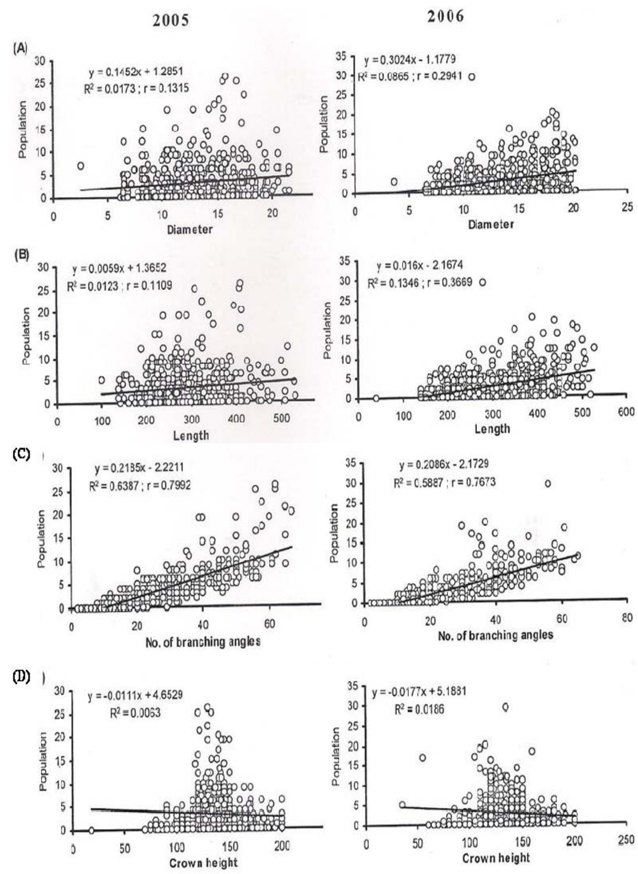


Fig. 2: The best prediction model for the abundance of spiders in samples pooled from guava grove in 2005 and 2006



But, maximum abundance was generally observed from March through August in both citrus and guava habitats. This pattern of abundance of the foliage spiders is very different from those, which inhibit the ground surface. Studies of Butt (1996) and Ijaz (2000) indicated that ground surface spiders become scanty during colder months of the year. But in this case the foliage spider abundance was high and good number of spiders was captured during colder months. Therefore, it is quite possible that in colder months foliage spiders persist in this habitat because foliage density provide more hiding places to spiders (Gunnarsson, 1996).

In conclusion, significant association existed between the branch structure and foliage spider abundance. Branch structures directly reflected the availability of habitat to plant dwelling-spiders. Branch complexity increases with the increase of branching angels. More complex the branch structure, more abundant the spiders it has and better opportunity to avoid the stress of ecological factors. The abundance of plant dwelling spiders was positively correlated with the branch characteristics. More experimental work is needed to determine the significance of specific features of spider habitat.

REFERENCES

Amalin, D.M., J. Pena and R. McSorley, 2003. Development of three SAC spiders occurring on lime orchards at Homestead, Florida. *Proc. Florida State Hort. Soc*., 116: 44–46

Breene, G.R., D.A. Dean and R.L. Meagher, 1993. Spiders and ants of Texas citrus groves. *Florida Entomol*., 76: 168–170

Butt, A., 1996. Taxonomy and ecology of wandering spiders of citrus and guava orchards and vineyard. *Ph.D. Thesis*, Dept. Zool. and Fish., University of Agriculture, Faisalabad, Pakistan

Coddington, J.A., 1991. Designing and testing sampling protocols to estimate biodiversity in tropical system: The unity of evolutionary biology. *Proc. IV Int. Cong. System Atics Evol. Biol. Discorides, Poortland*

Corcuera, M., L. Jime´nez and P.L. Valverde, 2008. Does the microarchitecture of Mexican dry forest foliage influence spider distribution? *J. Arachnol*., 36: 552–556

Evans, T.A., 1997. Distribution of social crab spiders in Eucalyptus Forests. *Australian J. Ecol.*, 22: 107–111

Gontijo, L.M., D.C. Margolies, J.R. Nechols and R.A. Cloyd, 2010. Plant architecture, prey distribution and predator release strategy interact to affect foraging efficiency of the predatory mite *Phytoseiulus persimilis* (Acari: Phytoseiidae) on cucumber. *Biol. Cont*., 53: 136–141

Gunnarsson, B., 1990. Vegetation structure and the abundance and size distribution of spruce living spiders. *J. Anim. Ecol.*, 59: 743–752

Gunnarsson, B., 1996. Bird predation and vegetation structure affecting spurce living arthropids in a temperate forest. *J. Anim. Ecol*., 65: 389–397

Haddad, C.R., A.S. Honiball, A.S. Dippenaar-Schoeman, R. Slotow and B.J.V. Rensburg, 2010. Spiders as potential indicators of elephant-induced habitat changes in endemic sand forest, Maputaland, South Africa. *African J. Ecol*., 48: 446–460

Halaj, J., D.W. Ross and A.R. Moldenke, 1998. Habitat structure and prey availability as predictors of the abundance and community organization of spiders in Western Oregon Forest canopies. *J. Arachnol.*, 26: 203–20

Hatley, C.L. and J.A. MacMahon, 1980. Spider community organization: seasonal variation and the role of vegetation architecture. *Environ. Entomol*., 9: 632–639

Henschell, J.R. and Y.D. Lubin, 1997. A test of habitat selection at two spatial scales in a sit and wait predator: A web spider in the Naimb Desert Dunes. *J. Anim. Ecol*., 66: 401–413

Herrmann, J.D., D. Bailey, G. Hofer, F. Herzog and M.H. Schmidt-Entling, 2010. Spiders associated with the meadow and tree canopies of orchards respond differently to habitat fragmentation. *Landscape Ecol*., 25: 1375–1384

Ijaz, Z., 2000. Diversity and relative abundance of spider species occurring on ground surface of citrus orchard at Summandari, Distt. Faisalabad. *M.Sc. Thesis*, Department of Zoology and Fisheries, University of Agriculture, Faisalabad, Pakistan

Lubin, Y.D., 1978. Seasonal abundance and diversity of web-building spiders in relation to habitat structure on Barro Colorado Island, Panama. *J. Arachnol*., 6: 31–51

Ludwig, J.A. and J.F. Reynolds, 1988. *Statistical Ecology: A Primer on Methods and Computing*. John Wiley and Sons, New York

Mansour, F. and W.H. Whitecomb, 1986. The spiders of a citrus grove in Israel and their role as biocontrol agents of *Caroplastes floridensis* (Homoptera: Coccidae). *Entomophology*, 31: 269–276

Mukhtar, M.K., 2004. Taxonomic studies on the foliage spider fauna of Punjab. *Ph.D. Thesis*, Dept. Zoology and Fisheries, University of Agriculture, Faisalabad, Pakistan

Raizer, J. and M.E.C. Ameral, 2001. Does the structural complexity of aquatic macrophytes explain the diversity of associated spider assemblages? *J. Arachnol*., 29: 227–237

Robinson, J.V., 1981. The effect of architectural variation in habitat on a spider community: an experimental field study. *Ecology*, 62: 73–80

Romero, G.Q. and J. Vasconcellos-Neto, 2005. The effects of plant structure on the spatial and micrspatial distribution of a bromeliad living jumping spider (Salticidae). *J. Anim. Ecol.*, 74: 12–21

Samu, F., K.D. Sunderland & C. Szinetar, 1999. Scale-dependant dispersal and distribution patterns of spiders in agricultural systems: a review. *J. Arachnol.*, 27: 325–332

Scheidler, M., 1990. Influence of habitat structure and vegetation architecture on spiders. *Zool. Anz.*, 225: 333–340

Souza, A.L.T. and E.S. Modena, 2004. Distribution of spiders on different types of inflorescences in the Brazilian Pantanal. *J. Arachnol*., 32: 345–348

Souza, A.L.T. and R.P. Martins, 2005. Foliage density of branches and distribution of plant dwelling spiders. *Biotropica*, 37: 416–420

Van Den Berg, M.A., A.S.D. Shoeman, V.E. Deacon and S.H. Anderson, 1992. Interactions between citrus Psylla, *Trioza erytreae* (Hem. Triozidae) and spiders in an unsprayed citrus orchard in the transvall lowveld. *Entomophlogy*, 37: 599–608

Whitmore, C., R. Slotow, T.E. Crouch and A.S. Dippenaar-Schoeman, 2002. Diversity of spiders (Araneae) in a savanna reserve, Northern Province, South Africa. *J. Arachnol*., 30: 344–356

(Received 06 November 2010; Accepted 24 December 2010)