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Effect of the vegetation density of some ornamental plants on the abundance and the diversity of spiders

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Abstract:

Diversity and spider community inhabiting foliage of two different categories of ornamental plants (Flowers and shrubs) was carried out in the Orman Garden. Collecting spiders by foliage beating on sweep nets, numbers of collecting spiders were pooled and analyzed for species diversity for the two categories using Shannon-Wiener and Simpson Indices and Sørensen Quotient of Similarity. Vegetation type influenced spider abundance; the flowers category received 130 individuals representing 10 families, 19 genera and 21 species; the most common species were *Thomisus spinifer* of the family Thomisidae, while the shrub category received 127 individuals representing 6 families, 13 genera and 13 species; the most frequent species were *Pulchellodromus glaucinus* of the family Philodromidae. The relative abundance of guilds (Based on numbers of individuals) varied greatly, which may reflect the availability of spiders within different hosts.

Introduction

The Orman Garden is a flat area covered with a great variety of ornamental plants, flowers, shrubs, trees and palm trees, flowering all year rounds and it provides water channels filled with water for long periods, therefore, this area is an excellent field for surviving many living organisms. The plant structural, the architectural arrangement of biomass in vegetation and in space has been recognized as one of the main factors that determine the diversity and abundance of plant dwelling spiders (Gunnarsson, 1990 and Halaj *et al*., 1998). A positive influence between plant architecture and spider abundance was demonstrated through the incidence of structural complexity, such as foliage density in big sage, *Artemisia* sp. (Hatley and McMahon, 1980), leaf surface area in different species of *Eucalyptus* (Evans, 1997) and density of needles in spruce *Picea abies* (Gunnarsson, 1990). Halaj *et al.* (2000) suggested that differences in the spider fauna in different plant species indicate the existence of spider associations for specific characteristics of the habitat.

It is clear from previous studies, that the difference in the density of vegetation, the surface or size of leaves or leaflets, the lack of increase of branches and their interlacing and the height and lower length of the plant, all affect the presence of spiders that use the plant as a shelter (Ghallab, 2013).

The objective of the work is to throw light on spider taxonomy, diversity and their distribution in different species of two ornamental categories (Six species of flower plants and four species of shrubs). The diversity analysis was based on Shannon-Wiener and Simpson "S" Indices quantify the community structures of spiders among the two categories mentioned before and to determine their similarities of spider composition.

Materials and methods

1. Study site, plant selected and sampling of spiders:

Orman Garden provides an excellent field for surviving many living organisms due to the presence of different ornamental plants all over the year. The flower category selected is of low elevation ranging between 0.75–1.5 m. Six species were selected included *Dimorphotheca pulvialis* L., *Salvia splendens* L., *Helichrysum bracteatum* (Vent.), *Tagetes erecta* L., *Chrysanthemum coronarium* L. and *Crinum asiaticum* L. While the shrubs selected are of high elevation ranging between 1-2.5m. They were *Acalypha macrophylla* Müll, *A. marginata* Müll, *A. hoffmanii* Müll and *Plumbago auriculata* Lam.

Spiders living on foliage were collected by shaking plants on the sweeping net with a mesh bag and each specimen was kept singly in a glass vial to prevent cannibalism. Samples were collected every two weeks from the previously mentioned hosts in the period between January and July 2020. All specimens were preserved in 70% ethyl alcohol and some droplets of glycerine and examined under a stereo-zoom microscope in the laboratory.

2. Identification of spiders:

The scientific names of the adult spiders' and their classification follows different specialized description keys and catalogues provided by Kaston (1978), Levi (2002), Oger (2002) and Proszynski (2003).

3. Data analysis:

3.1. The Shannon-Wiener "H" and Simpson "S" Indices:

The Shannon Index indicates the community stability under the balance of nature, while Simpson Index "S" is a measure of dominance (Nestle *et al.*, 1993). The typical values of Shannon diversity index generally range from 1 to 3 thus showing moderate species diversity with which values below 1 indicates low diversity and values more than 3 indicates high diversity. The two indices were calculated as described by Ludwig and Reynolds (1988).

Shannon Index $H' = -\sum (n_i/ n) \ln (n_i/ n)$

Simpson Index $S = \sum (n_i/n)^2$

Where n_i is the number of individuals belonging to the i^{th} of "S" taxa in the sample and "n" is the total number of individuals in the sample."

While the species evenness "e" is a measure that indicate how evenly the total number of individuals (Abundance) is apportioned among species; i.e., the ratio of the actual H' value to the maximum value and thus it ranges from (0 to1), the closer to one the more homogeneous population.

Evenness "e" $=H' / H \max$. or $H'/\log(s)$ where "s" is the number of species.

3.2. Sørensen quotient of similarity (QS):

It was used to compare the community of spiders in vegetation of the two categories (Flowers and shrubs) and determine their similarity. Sørensen's quotient (Sørensen, 1948) was applied to the number of species and individuals of the two categories of the plant and ranges from (0-1).

Sørensen's formula "QS" = 2 C / A + B.

Where A and B are the number of species in samples A and B, respectively, and C is the number of species shared by the two samples.

3.3. Guild composition:

Spiders collected were divided into six guilds according to spider's web-building and prey-catching behaviors as described in the classification system proposed by Uetz *et al.* (1999).

Results and discussion

1. Species richness of true spiders inhabiting flowers category:

Over the seven months of study the true spiders were collected from 6 different types of flowers, Table (1) recorded a total of 130 individuals representing 10 families, 19 genera and 21 species. When ranked by abundance Figure (1), the most common families Thomisidae (38.5%), Salticidae (16.2%) and Theridiidae (15.4%) accounted for 70 % of all spiders sampled; the next two families, Philodromidae (11.5%) and Cheiracanthiidae (10.8%) contained another 22.3% and the least common five families Dictynidae, Araneidae, Linyphidae, Oxyopidae and Uloboridae comprising only 7.7%.

The most frequently encountered individuals were *Thomisus spinifer* (44 individuals) belonging to family Thomisidae then *Cheiracanthium isiacum* (14), *Pulchellodromus glaucinus* (12), *Thyene imperials* (12), *Kochiura aulica* (12) and *Theridion melanostictum* (8) of families Cheiracunthidae, Philodromidae, Salticidae, and Theridiidae, respectively.

As for preference of the plant structure and the spider abundance which showed in Figures (1 and 2), it is not yet known why the spider prefers the plant where it is endemic (By excluding the presence of pests), but it is hypothetical possibilities. The *Helichrysum* and *Chrysanthemum* flowers appeared to be a suitable dweller for foliage spiders, they recorded the highest collection of spiders of 33 and 29 individual respectively of the total 130 individuals included the most abundant species, *Thomisus spinifer* is very common in the garden for the abundance of flowers. This species belongs to the family Thomisidae, distributed different vegetation, *Helichrysum* 75.8%, *Dimorphotheca*(50%), *Tagetes* (42.8%) *Salvia* and *Chrysanthemum* 25 and 24.1% respectively, while it was absent in crinum plant.

Figure (1): Percentage of spider families inhabiting flowers.

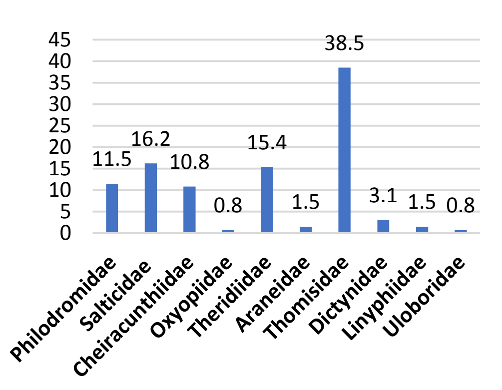


Figure (2): Population of spiders inhabiting different flowers.

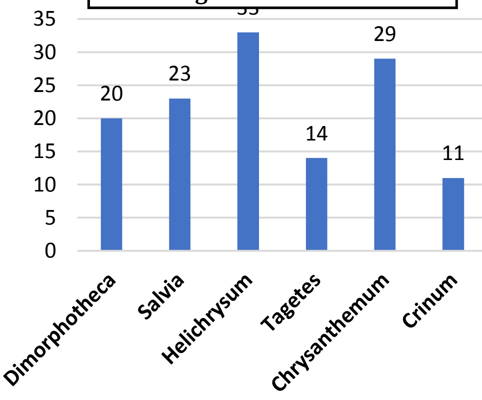


Table (1): Spiders inhabiting flowers between January to the end of July 2020.

Family names and species	A	%	B	%	C	%	D	%	E	%	F	%	Total	%
Philodromidae														
Pulchellodromus glaucinus (Simon)	**3**	15	**2**	8.7	**4**	12.1	-	0	**1**	13.8	**2**	18.2	**15**	11.5
Thanatus sp.							-		**3**					
Salticidae														
Thyene imperialis	-		**6**		**1**		**1**		**2**		**2**			
Plexippus paykulli	-	0		34.8	-	6.1	-	7.1	-	6.9	**3**	72.7	**21**	16.2
Alfraflacilla spiniger	-		**1**		-		-		-		-			
Hasarius adansoni	-				-		-		-		**2**			
Heliophanus sp.	-		**1**		**1**		-		-		**1**			
Cheiracunthiidae														
Cheiracunthium isiacum O.P.	-	0	**7**	30.4	**1**	3.03	**3**	21.4	**3**	10.3	-	-	**14**	10.8
Oxyopidae														
Oxyopies bilineatus O.P.	**1**	5	-	0	-	0	-	0	-	0	-	-	**1**	0.8
Theridiidae														
Theridion melanostictum O.P.	**5**	25		4.4	-	3.03	**1**	21.4	**2**	34.5	-	-	**20**	15.4
Kochiura aulica Koch	-		**1**		**1**		**2**		**8**		-	-		
Araneidae														
Neoscona sp.	**1**	5	-	0	-	0	-	0	-	3.5	-	-	**2**	1.5
Araneus sp.	-	-	-		-		-		**1**		-	--		
Thomisidae														
Thomisus spinifer O.P.	**9**		**2**		**25**		**3**		**5**		-			
Thomisus onustus Walckenaer	-	50	-	8.7	-	75.8	**3**	42.8	**2**	24.1	-	0	**50**	38.5
Thomisus sp.??	**1**		-		-		**0**		-		-			
Dictynidae														
Nigma sp.	-	0	**1**	4.4	-	0	-	7.1	**2**	6.9	-	-	**4**	3.1
Dictyna sp.	-		-		-		**1**		-		-	-		
Linyphidae														
Sengletus extricatus O.P.	-	0	**1**	8.7	**0**	-	**0**	-	-	-	-	-	**2**	1.5
Gnathonarium sp	-		**1**						-		-	-		
Uloboridae														
Uloborus sp.	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0	**1**	9.1	**1**	0.8
Total of alive individuals	**20**		**23**		**33**		**14**		**29**		**11**		**130**	

A: Dimorphotheca, **B:** Salvia, **C:** Helichrysum, **D:** Tagetes, **E:** Chrysanthemum, **F:** Crinum

The height of the two plants (Up to one meter) and the structure of leaves and dense vegetation might be a reason for spiders' abundance. This observation in accordance with that of (Corcuera *et al*., 2008), they indicate the high numbers of *P. viridans* correlated with a plant height of the shrub *Croton ciliatoglanduliferus*. Moreover, leaves of *Chrysanthemum* with glandular trichomes attracts different arthropods which represent available prey for spiders, this result agreed with (Vasconcelos-Neto *et al*., 2006).

In contrary, *Tagetes* and *Crinum* flowers recorded 14 and 11 individuals, respectively. Spiders distributed in *Tagetes* were *Cheiracunthium* and *K. aulica* (21.4 and 14.3%), respectively, followed by *T.spinifer* in their abundance. While *Crinum* plant recorded 4 species of Salticidae of 72.2 %. The low elevation of these two plants as well as the lack of poor branches, probably might be a reason to distribute species of Salticidae which were abundant in microhabitat and leaf litter beneath these two plants.

2. Species richness of true spiders inhabiting the shrubs category:

According to the true spiders collected from 4 species of shrubs Table (2), a total of 127 individuals representing 6 families, 13 genera and 13 species were obtained. When ranked by abundance Figure (3) the most common family was Salticidae (35.4%), followed by Philodromidae (20.5%) then Cheiracunthiidae (17.3%), those families accounted 73 % of all spiders sampled; the next two families, Thomisidae and Theridiidae contained another (24.4%) and the least common family was Araneidae comprising (2.4%).

The most frequently encountered individuals were *Pulchellodromus glaucinus* (24 individuals) of family Philodromidae, followed by *Cheiracanthium isiacum* and *Plexippus paykuli* (22 and 21 individuals, families Cheiracanthidae and Salticidae, respectively), then *Thomisus spinifer* and *Thyene imperials* (17 and 16) individuals, families Thomisidae and Salticidae, respectively) then *Theridion melanostictum* (10 individuals) belonging to Theridiidae .

As for preference of the shrub structure and the spider abundance which showed in Figures (3 and 4). The three common species selected of *Acalypha* were of dense vegetation as well as broad leaves, the abundance of spiders in the three plants species was close, recorded 28, 27 and 25 for species *macrophylla*, *marginata* and *hoffmanii*, respectively. The *A. macrophylla* had 10 sp. three of them were common in the four shrubs, they were *Pulchellodromus* (24 individuals of total 26) followed by *Cheiracunthium* (22) then *Thyene* (16). The shrub, *A. marginata* recorded the most common abundance of Salticid spiders, which was *Plexippus paykullii*, (66.7%); while the 3rd shrub *A. hoffmanii* comprised 7 species two of them were common, *Cheiracunthium* (40%) and *Plexippus paykullii* (36%).

The 4th shrub, *Plumbago* distinguished by loose branchlets with small leaves. It invaded by 47 individuals, including 8species of 6 families; the most abundant species was *Pulchellodromus glaucinus* (14 individuals). This result is in conformity with that of (Ghallab, 2013) which proved that foliage runner spiders were the dominant on *Lantana* shrubs which had few branches, and De Souza and Martins (2005) who proved that foliage-runners constituted the dominant spiders on *Desmanthus virgatus* and *Banksia gardneri*, which have few branches; and they suggest that branch architecture is the most important factor determining the abundance of plant-dwelling spiders in the study area independently of branch biomass, leaf surface area or texture; in addition, Evans (1997) found that social crab spiders preferred *Eucalyptus* species with smaller leaves.

Table (2): Spiders inhabiting shrubs between January to the end of July 2020.

Family names and species	*A. macrophylla*	%	*A. marginata*	%	*A. hoffmanii*	%	*P. auriculata*	%	Grand total	%
Philodromidae										
Pulchellodromus glaucinus	6	28.6	2	7.4	2	8	14	29.8	26	20.5
Philodromus blankei	1		-		-		-			
Thanatus sp.	1		-		-		-			
Salticidae										
Thyene imperialis	4	28.6	5	66.7	1	36	6	21.3	45	35.4
Plexippus paykulli	1		12		8		-			
Bianor	3		-		-		-			
Heliophanus sp.	-		1		-		4			
Cheiracunthiidae										
Cheiracunthium isiacum O.P.	5	17.8	6	22.2	10	40	1	2.1	22	17.3
Theridiidae										
Theridion melanostictum O.P.	2	14.3	-	0	2	12	6	14.9	14	11
Kochiura aulica Koch	2		-		1		1			
Araneidae										
Neoscona sp.	-	0	-	0	1	4	-	4.3	3	2.4
Araneus sp.	-		-				2			
Thomisidae										
Thomisus spinifer O.P.	3	10.7	1	3.7	0	0	13	27.7	17	13.4
Total of alive individuals	28		27		25		47		127	

Figure (3): Percentage of spider families inhabiting shrubs.

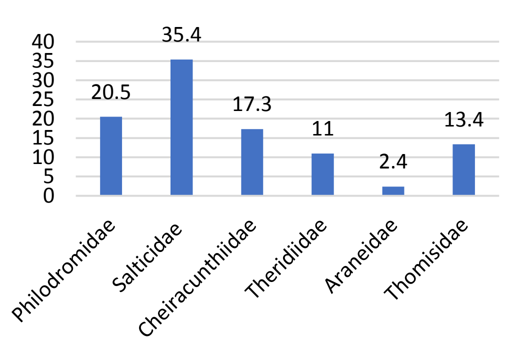
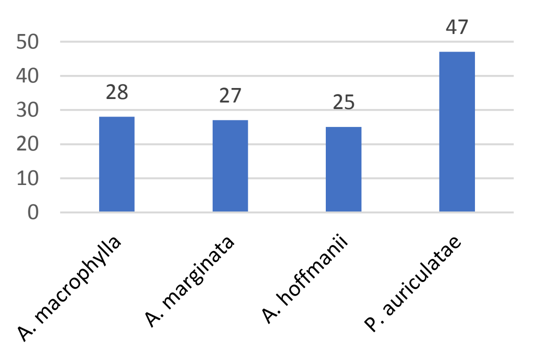


Figure (4): Population of spiders inhabiting different shrubs.



3. Foraging guild of analysis:

The analysis of functional groups (Foraging guild) of the collected spiders composed of six functional groups based on their foraging behavior in the field (Uetz *et al*., 1999), they are stalkers, ambushers, foliage runners, orb web, space weavers and wandering sheets Figures (5 and 6).

Figure (5): Guilds of spider inhabiting flora plants.

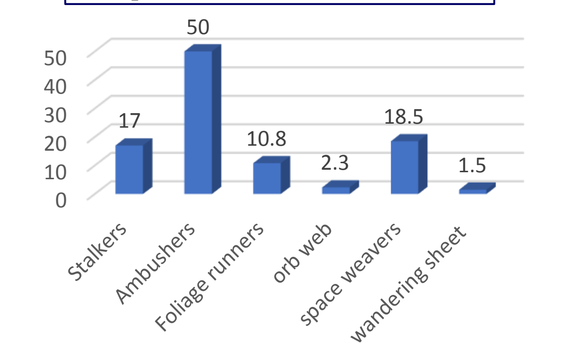
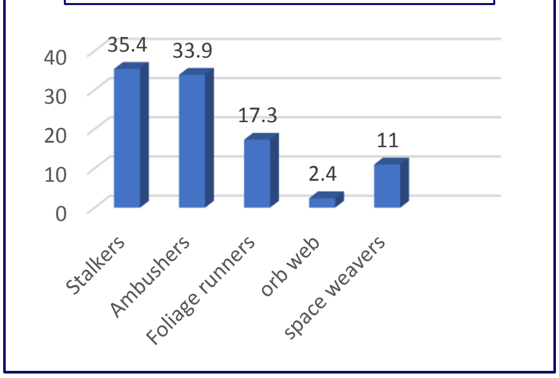


Figure (6): Guilds of spider inhabiting shrubs.



In the floral, plants (Table 1 and Figure 5), the ambushers and space weavers were the dominant feeding guilds on flora. The ambushers (Thomisidae (38.5%) and Philodromidae (11.5%)), comprised 50 % of the total spider collected; Thomisidae recorded the high frequency in *Helichrysum* (75.8%) followed by *Dimorphotheca* and *Tagetes* 50 and 42.8 %, respectively. This observation is in accordance with (Nentwig, 1993 and De Souza and Módena (2004) who indicated that the high frequency of ambushers was expected in flowering branches, because spiders from this guild belong to the Thomisidae family, typical of inflorescences. While Philodromidae recorded the high frequency in Crinum (18.2%) followed by Dimorphotheca (15%). The space weavers (Thrediidae and Dictynidae) comprised 18.5 % of the total spider collected of high frequency in Tagetes 34.5% then Dimorphotheca 25%.

According to shrub category (Table 2 and Figure 6), the stalkers (Salticidae) was predominant (35.4%) of the total spider collected; recorded the high frequency in *A. marginate* (66.7) and *A. hoffmanii* 36%; this result was in accordance with Labanon *et al.* (2020) where they proved in their studies that Salticids or jumping spiders can be abundantly found in all ecosystems with a broad range of microhabitats from beneath leaf litter to the forest canopy. The Salticidae followed by the Philodromidae (20.5) and Thomisidae (13.4) which constitute together, the ambushers, of total frequency (33.9); both families have recorded the high frequency in *P. auriculate* (29.8 and 27.7%, respectively) then *A. macrophylla* (28.6 and 10.7%, respectively).

Orb weaver guild was the least frequent in both flora and shrubs categories, recording 2.3 and 2.4 %, respectively, (Figures 5 and 6), space weavers was absent in shrubs and comprised 1.5% in flora. The foliage running spiders (Cheiracanthidae) depend on vegetation for finding food; they recorded 10.8 and 17.3% in flora and shrubs, respectively.

The flora recorded the highest species richness (21 species) while shrubs recorded (13 species). The guild composition in the different species of flora and shrubs were definitely different which indicates the high difference between their habitats. This result may be the best indicator that some factor is interfering in the spider community.

4. Spider's diversity:

By using Shannon-Wiener Index, we can describe the diversity of the spider communities in different flower plant (Spider dwellers) (Table 3).

Table (3): Biodiversity of spider species in the different flowers.

Type of Index	Spider diversity in flowers					
	Dimorphotheca	***Salvia***	***Helichrysum***	***Tagetes***	***Chrysanthemum***	***Crinum***
Shannon–Wiener (H')	1.3	1.6	0.8	1.4	1.7	0.7
Species evenness	1	1.2	0.5	1.2	1.1	0.7
Simpson Index (S)	0.34	0.24	0.59	0.22	0.21	0.57

5. Biodiversity of spider species in the different flowers:

Table (3) showed the comparison of the biodiversity of spider species in the different structures of flowers. The biodiversity index calculation **(H')** indicated that the bigger number is more diverse, where the values (1.7 and1.6) which recorded in the flowers *Chrysanthemum and Salvia*, respectively, were the most diverse and both recorded 10 species belonging to 7 families and evenness 1.1 and 1.2, respectively. Next comes plants *Tagetes* and *Dimorphotheca* of values 1.4 and 1.3, respectively, they included 6 and 7 species belonged both to 5 families, while the species evenness was 1.2 and 1, respectively. The lowest spider diverse was observed in *Helichrysum* and *Crinum* flowers of values 0.8 and 0.7 and both of 6 species belonged to 5 and 3 families and species evenness were 0.5 and 0.7, respectively.

According to Simpson Index, which is a measure of dominance, it was found that *Helichrysum* included the highest number of dominant species recorded the value (0.59) which was 75.8% of the species *Thomisus spinifer* (Table 1).

6. Biodiversity of spider species in the different shrubs:

Table (4) showed the comparison of the biodiversity of spider species in the structures of four different species of shrubs. *Acalypha macrophylla* and *Plumbago auriculata* were the most plants that dwelled by spiders, the values of diversity recorded the biggest values, 1.5 for both shrubs which indicates the most diverse; the *A. macrophylla* comprised 10 species belongs to 5 families where *Plumbago* includes 8 species of 6 families; while the species evenness was 1 and 0.9. , respectively. The lowest spider diverse was observed in *A. marginata* of value 0.9 and species evenness was 0.6 comprised 6 species belong to 4 families.

According to Simpson Index, *A. marginata* shrub included the highest number of dominant species (0.5), it was for members of Salticidae and Cheiracunthidae 66.7% and 22.2% , respectively.

Table (4): Biodiversity of spider species in the different shrubs.

Type of Index	Spider diversity in shrubs			
	A.macrophylla	***A. marginata***	***A. hoffmanii***	***P. auriculata***
Shannon–Wiener (H')	1.5	0.9	1.3	1.5
Species evenness	1	0.6	0.9	0.9
Simpson Index (S)	0.22	0.5	0.3	0.2

7. Faunal similarity of spiders:

In relation to the flowers, the *Helichrysum* plant was the most highly collected spider recording a total of 33 individuals belonging to five families, while the number of spider species was (6) followed by *Chrysanthemum* and *Salvia* of 29 and 23 individuals, respectively, belonging both to seven families and 10 species, then the remaining plants *Dimorphotheca* and *Crinum*, recorded 20 and 11 individuals, belonging to 5 and 3 families, respectively and 6 species both. The total species of flower plants were 21 species. According to the shrubs, the Plumbago was the most highly collected spider recording a total of 47 individuals belonging to 6 families 8 species followed by *A. macrophylla* and *A. marginata* of 28 and 27 individuals belonging to 5 and 4 families and 10 and 6 species, respectively, the last shrub was *A. hoffmanii* recorded 25 individuals, belonging to 5 families and 7 species. The total species of shrub plants was 13 species, the number of common species by the two communities flowers and shrubs was 11. To allow a comparison of similarity between the habitats of the flowers and the shrubs, the Sørensen's quotient of similarity (QS) was calculated. It is concluded that the two communities were semi-similar as they recorded 65% of similarity.

This research is one of series research that have been studied on the diversity of spider fauna in the Orman Botanical Garden. The objective was to make initial observations of how habitat structure influence foliage spiders by determined the association between selected habitat of several hosts plants to the abundance and diversity of spider fauna. It is concluded that, habitat structure and species richness caused by the dependence of spiders on the vegetation of their habitat due to a way of life and foraging, and these factors predict the abundance and diversity of spiders which plays a significant role in shaping these communities. Ried and Miller (1989) suggested that diversity increased in presence of a greater varieties of habitat types, while Uetz (1991) and Labanon and Nuñeza (2020) proposed the complex structure of shrubs can support a more diverse spider community, as the vegetation matures, becoming denser and more stratified, more spider species become available, thus further supporting the hypothesis that structural complexity of plants influences spider species richness. While the view of Wise (1993) is the environmental structure may or may not impact spider composition. In terms of microhabitat preference, spiders generally do not have a strong association with the plants on which they live, however, spiders are known to be selective of their microhabitats and foraging sites, increasing their survivorship and reproductive success (Labanon and Nuñeza, 2020).

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References

Corcuera, P.; Jimenez, M. L. and Valverde, P.L. (2008): Does the microarchitecture of Mexican dry forest foliage influence spider distribution?. Journal of Arachnology , 36(3): 552-556.

De Souza, A.L.T. and Martins, R.P. (2005): Foliage density of branches and distribution of plant-dwelling spiders. Biotropica: The Journal of Biology and Conservation, 37(3):416-420.

De Souza, A.L.T. and Módena, Es. (2004): Distribution of spiders on different types of inflorescences in the Brazilian Pantanal. The Journal of Arachnology, 32(2): 345-348.

Evans, T. A. (1997): Distribution of social crab spiders in eucalypt forests. Aust. J. Ecol., 22: 107–111.

Ghallab, M. M. (2013): Preliminary study of the spiders inhabiting ornamental plants in Orman Garden. Serket , 13(1/2), pp. 8.

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

Halaj, J.; Ross, D.W. and Moldenke, A.R. (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– 220.

Halaj, J.; Ross, D.W. and Moldenke,A.R. (2000): Importance of habitat structure to the arthropod food-web in Douglas-fir canopies. Oikos, 90: 139–152.

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

Kaston, B.J. (1978): How to know spiders, 272 pp, 3rd edit. Wm. C Brown company Publishers.

Labanon, K.K. O. and Nuñeza, O. M. (2020): Species Diversity of Salticid Spiders (Araneae: Salticidae) according to Elevation and Vegetation Type in Western Mindanao State University. Experimental Forest Area, Upper La Paz, Zamboanga City, Philippines, Bull. Env. Pharmacol. Life Sci., 9(5):53-64

Levi, H.W. (2002): Keys to the genera of araneid orb weavers (Araneae, Araneidae) of the Americas. Journal of Arachnology, 30 (3): 527-562.

Ludwig, J.A. and Reynolds, J.F. (1988): Statistical Ecology: A primer on methods in computing. New-York, John Wiley & Sons, pp.337.

Nentwig, W. (1993): Spiders of Panama. Biogeography, investigation, phenology, check list, key and bibliography of a tropical spider fauna. Fauna and Flora Handbook no. 12. Gainesville, USA: Sandhill Crane Press, pp. 247.

Nestle, D. ; Dickschen, F. and Altieri, M.A. (1993): Diversity patterns of soil macro-Coleoptera in Mexican shaded and unshaded coffee agro-ecosystems in indication of habitat perturbation . Biodiversity and Conservation , 2 : 70 – 78.

Oger, P. (2002): Les Araignées de Belgique et de France on line at http://arachno.piwigo.com/index.php?/categories

Press, Cambridge, England.

Proszynski, J. (2003): Salticidae genera of levant (Israel and Neighboring Countries) http://salticidae.org/salticid/diagnost/keys-sal/levant.htm

Ried, W.V. and Miller, K. R. (1989): Keeping options alive: A scientific basis for conserving biodiversity. Washington D.C., World Resources Institute.

Sørensen, T. (1948): A method of establishing groups of equal amplitude in plant sociology based on similarity of species and its application to analyses of the vegetation on Danish commons. Biologiske Skrifter/Kongelige Danske Videnskabernes Selskab, 5:1-34.

Uetz, G. W. (1991): Habitat structure and spider foraging. { In: Bell, S. S., Mc Coy, E. D. and Mushinsky, H. R. (eds), Habitat structure: the physical arrangement of objects in space. Chapman and Hall : 325-348.

Uetz, G. W.; Halaj, J. and Cady, A. B. (1999): Guild structure of spiders in major crops. Journal of Arachnology, 27: 270-280.

Vasconcelos-Neto, J.; Romero, G.Q. and Santos A.J. (2006): Association of spiders in the genus Peucelia (Oxyopidae) with plant bearing glandular hairs. Biotropica, 39: 221-226.

Wise, D. H. (1993): Spiders in ecological webs, 328 p. Cambridge University