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SPIDER FAUNA OF BETELVINE AGRO-ECOSYSTEM IN AATTUR, TUTICORI DISTRICT, TAMIL NADU, INDIA.

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Abstract: Spiders are the most diverse and abundant invertebrate predators in terrestrial ecosystems. This spider fauna of a betelvine agroecosyetem was surveyed monthly by Active searching, Pitfall trap method and Net sweeping in betelvine field. They employ a remarkable diversity of predation strategies, occupy a wide array of spatial and temporal riches, and are characterized by high within habitat taxonomic diversity, exhibit taxon and guild responses to environmental change, extremely sensitive to small changes in habitat structure, including vegetation complexity, litter depth and microclimate characteristics. The faunistic survey yields 21 species of spiders belonging to 21 genera and 9 families. Araneidae was the most dominant family recording 5 species belonging to 5genera. Guild structure analysis revealed five feeding guilds, namely orb weavers and ground runners were dominant feeding guilds of the total collection.

Keywords: Aranae, betelvine, spider fauna, natural enemies, guild structure, diversity.

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INTRODUCTION

The Betelvine (*Piper betel L.*) is a perennial climber with green heart shaped leaves which is used as a masticator and is popularly known as pan in India. In India it is grown over an area of 50,000 hectares, providing livelihood to hundreds and thousands of families engaged in its cultivation and trade. Number of entomologists has acknowledged the importance of spiders as one of the major predators in regulating the pest of different crops [1].Spiders has different habitats they may be found everywhere, on dry leaves on forest floor, tall grasses, and underground caves under bark, stones, and logs, near water source, mountainous areas and inside human habitats. Some spiders dig holes in the ground and make use of shallow holes for hiding. Many spiders prefer dark and shaded location with high humidity.

There are approximately 40,000 spider species that have been described worldwide belonging to 109 families. Orb-weaving spiders are strongly influenced by habitat type [2, 3]. Their abundance and species composition are affected by the structural complexity of vegetation, giving their site preferences for building their webs [4, 5, 6, 7, 8, 9]. Also, orb-weaving spiders are easily located due to the conspicuousness of their webs and their high abundance in ecosystems [10]. These features lead to consider this group as an appropriate model for biodiversity studies [10, 11].

All spiders (Araneae) are predators that feed primarily on insects and other arthropods [12]. Many studies have revealed that spiders are a large fraction of the predator fauna in agro ecosystems, both in terms of population density and in diversity of species [13] representing the most diversified group and, after the ants, the most abundant group of predators in betelvine ecosystem [14]. It was observed that spiders are more sensitive than their prey to pesticides: thus the absence of these predators can induce pest outbreaks [15]. Some cultural practices, as the use of pesticides, bring changes in spider composition [16].

Some of the most diverse spider families include the familiar hairy, big-eyed “Jumping spiders” (family Salticidae 4,400 species worldwide); the small “Sheet-web spiders” (Linyphiidae, 3,700 species); the “Orb weaving spiders” (Araneidae, 2,600 species); the “Cobweb spiders” (Theridiidae, 2,200 species); the non-web weaving “Wolf spiders” (Lycosidae, 2,200 species); and the “Crab Spiders” (Thomisidae, 2,000 species) [7]. In spite of this, they have not usually been treated as an important biological control agent, because there is so little information on the ecological role of spiders in pest control [17]. Studies on Indian spider fauna have been carried out by different workers [18, 19, 20, 21, 22] in different regions of the country and documented 1035 species belonging to 240 genera under 46 families from Indian sub continent. In this paper, we present the result of faunistic survey conducted to document the spider

diversity in Betel vine ecosystem, Aattur, Tuticorin District, Tamil Nadu, India.

MATERIALS AND METHODS

Survey for collection and population assessment of spiders was carried out in Aattur (Latitude 8^0 48' N 78^0 11' E Longitude) of, the taluk division of Tuticorin district in the state of Tamil Nadu, India. A survey of the study area was undertaken during June 2012 to November 2012. Sampling was performed following the concept of [23] from 7AM to 10AM and 5PM to 7PM summer and 7AM to 10AM and 4PM to 6PM during winter. Spiders were collected by adapting standard sampling procedures as described below.

Active Searching Methods:

Whenever spiders were encountered, they were carefully picked without injuring them and transferred to polythene bags into tubes containing alcohol. Small spiders were collected with the help of a brush dipped in alcohol. Sedentary spiders found on the leaf blades and those on the webs were caught in the jar by holding it open beneath them and by tapping the spiders into it with the lid.

Pitfall traps Methods:

Ground-active spiders were collected by pitfall traps [24, 25, 26]. Each trap consisted of two coneshaped plastic (polyethylene) cups 9 cm wide at the mouth and 14 cm deep, one inside the other, buried to their rims. The three pitfall traps were laid on a line transect every 3 m. The inner cup of each trap was filled to a third of its volume with a 2% formaldehyde solution as a preservative. Traps were left open and emptied every second week. Where evaporation was high, refilling was done *ad hoc*. At the end of each fortnight, the contents were collected using an ordinary domestic sieve and emptied into appropriate containers for sorting in the laboratory.

Sweep-netting Methods:

Sweep-netting involved walking through the herb layer swinging a sweep net through the understorey vegetation for a standard number of times [27]. The net used for the current study was 40 cm in diameter and sweep-netting was done from knee height and below with little distraction from perennial shrubs since the vegetation of the study area was dominated by *Acacia drepanolobium* bushed grassland. In this study, one hundred sweeps were made along each transect. After every ten sweeps, samples were emptied on a plain sheet of cloth and all invertebrates collected with a pooter. The process was repeated every fortnight throughout the study period.

Identification:

Identification was done on the basis of morphometric characters of various body parts. They help was mainly taken from the keys and catalogues provided by [28, 29, 30, 31, 32, 33].

Diversity indices

The diversity, richness, and evenness indices of spider communities were calculated in a given habitat [34].

Species richness

Species richness was quantified using Margalef's index (d) [35].

d = (S-1) / log N

Where S is the total number of species and N is the total number of individuals.

Species diversity

This study adopted the Shannon-Wiener diversity index (H′) [36, 37] .

n

H′ = - Σ pi (log2pi),

i=1

Where n is the number of species and pi is the proportion of the total count arising from the *i*th species [38].

Evenness

The equitability (evenness) index used was Pielou's evenness index, J′, which expresses how evenly the individuals present are distributed among the different species. The index ranges between 0 and 1, with 1 representing even distribution. Lower values on the other hand represent dominance of individual taxa. The index is computed as follows:

J′= H′ (observed) / H′max

Where H′max is the maximum possible diversity, which would be achieved if all species were equally abundant. It reduces dependence on the sample size and is simple to compute [39].

RESULTS AND DISCUSSION

The spider fauna of India is represented by 1520 spider species belonging to 377 genera and 60 families [40]. During this study 138 specimens were collected from Aattur betelvine ecosystem during the study period of June 2012 to November 2012. Twenty two species were identifying belonging to 09 Families. Among the specimens most of the individuals were adult and few females were observed the family Araneidae represented 5 species; Gnaphosidae represented 3 species, Lycosidae 2 species, Miturgidae1species, Oxyopidae 2 species, Saltisidae 3 species, Sparassidae 1 species, Tetragnathidae 2 species, Thomisidae 2 species. (Table 1). [14] Documented a total of 1749 specimens representing to 5 families, 8 genera and 9 species of spiders in betelvine agroecosystem of Sholavanthan from the period of September 2008 to January 2009. The most frequently encountered species are Oxyopes sp. (Tikader), Pholcus phalangiiodes (Fuesslin), Araneus cucubitinus (Clerk), Uloborus bigibbosus (Simon), Crossopriza lyoni (Stoliczka), Argiope pulchella (Thorell) and Nephila kuhlii (Doleschall). [14] Reported a total of 1,024 specimens in the betelvine agroecosystem of Sholavandhan representing to the family Araneidae which includes 7 genera and 8 species of

spiders from the period of September 2008 to March 2009. The most frequently encountered species are Araneus cucubitinus (Clerk), Nephila maculate (Fabricius), Argiope pulchella (Thorell), Neoscona theis, (Walcknear), Neoscona nautical (L.Koch), Cyclosa bifida (Doeschall), Leucauge decorate (Blackwall) and Gasteracantha geminate (Fabricius)

Table 1

Spiders collected from Aattur area

S.no	Family	Spider fauna species
1.	ARANEIDAE (Simon,1895)	Argiope Pulchella (Thorell,1881) Gastercantha sp. (Fabricius, 1798) Argiope Sp.(Anasuja) Cytrophora Cicatrosa (Doleschall,1857) Collinus Sp. (Kulczynski, 1898)
2	GNAPHOSIDAE	Herpyllus. Sp. (Blackwall) Zelotes (Kulczynski, 1897) Drassyllus (Chamberlin, 1922)
3.	LYCOSIDAE (Sundevall, 1833)	Lycosa. Sp.(Gravely) Paradosa (Walkenaer, 1802)
4.	MITURGIDAE	Cheiracanthium (C.L.Koch, 1839)
5.	OXYOPIDAE (Thorell, 1870)	Peucetia (Stoliczka) Oxyopes (Tickader)
6.	SALTICIDAE (Blackwell, 1841)	Aelurillus. Sp. (Latreille, 1817) Plexippus (Karsch, 1878) Salticus (Tikader)
7.	SPARASSIDAE (Bertkau, 1872)	Olios. Sp. (Walckenaer, 1837)
8.	TETRAGNATHIDAE	Nephila Sp. (Doleschall, 1859) Leucause decorate (Blackwall)
9.	THOMISIDAE	Thomisus (Blackwall, 1850) Pistius (Simon, 1875)

In a similar study, [41] reported a total of 1225 specimens from kumbakarai falls during the period of March 2009 to August 2010 representing 3 genera and 4

species of Heteropoda.This area have very rich floral diversity this attributes to the high diversity of spider fauna. Abundance of different spider families in respects to their individuals number which prominently reflects Araneidae(26) individuals followed by Miturgidae (22), Gnaposidae (20), Salticidae (18) and Sparrasidae (17) had more abundant through less diverse family in comparison to Lycisidae (12), oxyopidae (09),Tetragnathidae(08) and Thomisidae(06) (Table 2).

Table 2

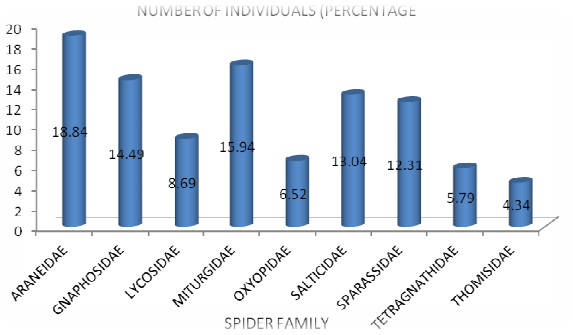
Total Number of spider fauna belonging to different families and functional guild

S.No	Spider family	Abundance	Guild
1.	Araneidae	26	Orb web weavers
2.	Gnaphosidae	20	Ground runner
3.	Lycosidae	12	Ground runner
4.	Miturgidae	22	Foliage hunter
5.	Oxyopidae	09	Stalkers
6.	Saltisidae	18	Stalkers
7.	Sparassidae	17	Foliage hunter
8.	Tetragnathidae	08	Orb web weavers
9.	Thomisidae	06	Ambushers

The total number of species per family is shown in Graph1. The families with the highest number of individual's percentage were the Araneidae with 18.84% followed by Miturgidae 15.94%, Gnaposidae 14.49%, Salticidae 13.04%, Sparrasidae 12.31%, Lycosidae 8.69%, oxyopidae 6.52%, Tetragnathidae 5.79% and Thomisidae with 4.38%.

Graph 1

Abundance of Individuals/family

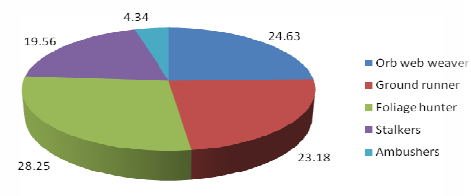


The moist climatic conditions of this area give way to dense vegetation in the betelvine ecosystem which in turn helps web building spiders to build their webs in the climber foliages. This may be one of the possible reasons that we collect the web builders in abundance from this area. Different families of spider (Graph 2) of which 24.63% were orb web weaver, 23.18% ground runner, 28.25% foliage hunter, 19.56% stalkers, and 4.34% ambushers. The spiders were found to be living in different types of habitats the spiders belonging to Families Araneidae, Gnaphosidae and Salticidae were mainly found in betelvine ecosystem. Spiders living in the corners of the rivers and semiterrestial area included those belonging to family Salticidae, Araneidae, Uloboridae. Most spiders were found living on the ground under the stones or in vegetation exhibiting some kind of colorations for cosmofuge. Coloration in spiders varies extensively among the species due to different environmental effects which also is due to different behavioural pattern observed on them [41, 42, 43, 44, 45, 46, 47, 48] . No exceptionally poisonous spiders were found among the species recorded in the betelvine ecosystem

.

Graph 2

Guild structure of spiders collected from Aattur area



There are many environmental factors that affect species diversity. However, when spiders were divided according to their functional group there was a significant effect of habitat on the diversity of these groups. The web building and foliage running spiders rely on vegetation for some part of their lives, either for finding food, building retreats or for web building. The structure of the vegetation is therefore expected to influence the diversity of spiders found in the habitat. Studies have demonstrated that a correlation exists between the structural complexity of habitats and species diversity [49]. Diversity generally increases when a greater variety of habitats types are present [50]. [3] Suggest that structurally more complex shrubs can support a more diverse spider community.

Table 3

Overall diversity results of spider recorded in betelvine ecosystem.

D = Margalef's richness index, H′ = Shannon-Wiener diversity index.

Familly	D	H′	E
Araneidae	1.23	0.30	0.19
Gnaphosidae	0.67	0.24	0.32
Lycosidae	0.81	0.34	0.50
Miturgidae	-	-	-
Oxyopidae	0.45	0.32	0.46
Saltisidae	0.69	0.30	0.27
Sparassidae	-	-	-
Tetragnathidae	0.48	0.34	0.49
Thomisidae	0.56	0.35	0.51

Table 3. Shows overall diversity results of spiders recorded in betelvine ecosystem. Typically, the value of the index ranges from 0.24 to 0.35 (H′) and 0.19 to 0.51(E) it indicate low species richness and evenness. From this results that the

diversity and evenness in this site from the undisturbed habitat are much higher than in the site from the highly disturbed habitat. The betelvine ecosystem not only has a greater number of species present, but the individuals in the community are distributed more equitably among these species. [51] and [52] have demonstrated that spiders are extremely sensitive to small changes in the habitat structure; including habitats complexity, litter depth and microclimate characteristics. Spiders generally have humidity and temperature preferences that limit them to areas within the range of their "physiological tolerances" which make them ideal candidates for land conservation studies [53]. Therefore, documenting spider diversity patterns in this ecosystem can provide important information to justify the conservation of this ecosystem. In relation to spider studies, sweep-netting is one of the best methods of capturing actively hunting spiders and small web-building species [54]. It helps to sample arthropods fast and is not expensive. The pitfall trapping survey sample has higher species diversity than the sweep-netting sample. This might be due to the fact that the pitfall traps were constantly in operation whereas sweep-netting was only carried out for a few hours fortnightly. It was also probable there were more species inhabiting the ground layer than the herb layer. It provides qualitative data important that might give more information about distribution [55] of spider in the betelvine ecosystem.

CONCLUSION

This study shows that the betelvine ecosystem eventhough has low spider richness and abundance. It suggests that this arachno fauna is sufficiently rich that it might be useful for biological monitoring work e.g. as indicators of habitat change in these area. This presence limits the habitats open to insect pests. Spiders threaten insect pests with various foraging strategies. As well as consuming large numbers of insect pests as prey, they have the trait of killing all insects living in their territory. For this reason, spiders are a favorable biological control agent in the betelvine ecosystem. Other ecological and biological characteristics of spiders also need to understand. [41] Suggested that it takes longer for spiders to rebuild their population densities after the application of insecticide than plant hoppers and leafhoppers, because spider has a longer generation interval. Also, the development of selective insecticides, the effect of insecticides on spiders, and appropriate timing and quantities of insecticide applications, should all be considered.

REFERENCE

1. Patel BH, Pillai GK. Studies on spider fauna of Groundnut fields in Gujarat. India. J Bio control, 1988; 2(2): 83-88.

2. Hurd LE. Fagan WF. Cursorial spiders and succession-ageor habitat structure. Oecologia. 1992; 92: 215-221.

3. Uetz GW. Habitat structure and spider foraging. In: Bell SS, McCoy ED, Mushinsky HR (eds) Habitat structure: the physical arrangement of objects in space. Chapman and Hall. London.1991. 325–348

4. Hatley CL and MacMahon JA. Spider community organization: Seasonal variation and the role of vegetation architecture. Environ Entomol. 1980; 9: 632-639.

5. New TR. Untangling the web: spiders and the challenges of invertebrate conservation. Journal of Insect Conservation. 1999; 3:251–256.

6. Whitmore C, Slotow R, Crouch TE and Dippenaar-Schoeman AS. Diversity of spiders (Araneae) in a savanna reserve,Northern Province. South Africa, J Arachnol. 2002; 30: 344-356.

7. Tews J, Brose U, Grimm V, Tielbölger K, Wichmann M.C. Schwager M, Jeltsch F. Animal species diversity driven by habitat heterogeneity/diversity: the importance of keystone structures. J Biogeogr. 2004; 31: 79-92.

8. Tsai ZI, Huang PS, Tso IM. Habitat management by aboriginals promotes high spider diversity on an Asian tropical island. Ecography. 2006; 29: 84-94.

9. Jiménez-Valverde A, Lobo JM. Determinants of local spider (Araneidae and Thomisidae) species richness on a regional scale: climate and altitude vs. habitat structure. Ecol Entomol. 2007; 32: 113-122.

10. Blanco-Vargas E, Amat-García GD, Flórez-Daza E. Araneofauna orbitelar (Araneae: Orbiculariae) de los Andes de Colombia: comunidades en habitats bajo regeneración. Rev IberAracnol. 2003; 7: 189-203.

11. Coddington JA, Levi HW. Systematics and evolution of spiders (Araneae). Annu Rev Ecol Syst. 1991; 22: 565-592.

12. D.H.Wise. Spider in ecological webs. Cambridge University Press. Cambridge.1993.

13. Ghavami S. Abundance of spiders (Arachnida: Araneae) in olive orchards in Northern part of Iran. Pakistan Journal of Biological Science. 2006; (5): 795-799.

14. Shunmugavelu M, Saravanakumar P. Biodiversity of spiders in the betelvine agro ecosystem of Sholavanthan. National Seminar on 'Conserve the mother earth need of the hour'. Jayaraj Annapackiam Colleage for Women (Autonomous). Periyakulam. 9th and 10th March. 2009; Abstracts P 21.

15. Maloney D, Drummond FA and Alford R. Spider predation in agroecosystems: can spiders effectively control pest populations? MAFES Technical Bulletin. 2003; 190: 1-32.

16. Santos SAP, Pereira JA, Torres LM, and Nogueira AJA. Evaluation of the effect, on canopy arthropods, of two agricultural management systems to control pests in olive groves from north-east of Portugal. Chemosphere. 2007; 67,131-139.

17. Riechert SE and Lockley T, Spiders as biological control agents. Annual Rev Entomol. 1984; 29:299-320.

18. Tikader BK. Fauna of India. Spiders (Thomsidae) I, 1980; (1): 1-247.

19. Sanyal AK and Tandon SK. Arachnida Faunal diversity in India. Zoolo surv India. 1998; 349-356.

20. Biswas B and Biswas K. Araneae: Spiders, state fauna series 3: Fauna of west Bengal 3. Zool Surv of India. Kolkata. 1992; 357- 500.

21. Patel BH. A Preliminary list of Spiders with description of three new species from Parambikulam wildlife Sanctuary. Kerala. Zoos print Journal. 2002; 18(10): 1207-1212.

22. Gojbe P. Spiders of Jabalpur. MadyaPradesh (Arachnida: Araneae) Zoological survey of India. Kolkata. 2004; 1-154.

23. Ritu Chautan, Vijay Sihag , Singh NP. Distribution and Biocontrol potential of chosen spiders. Journal of Biopesticides . 2009; 2(2): 151-155.

24. Greenslade PJM. Pitfall trapping as a method for studying populations of Carabidae. Journal of Animal Ecology. 1964; 33: 301-310.

25. Uetz GW and Unzicker JD. Pitfall trapping in ecological studies of wandering spiders. Journal of Arachnology. 1976; 3: 101-111.

26. Sutherland SW. Ecological census techniques. A handbook. Cambridge. Cambridge University Press. 1996.

27. Harris C. Collecting techniques. 09 June 2003,[On line at <http://www.marion.ohio-state.edu/spiderweb/collectingtechniques.htm. 2000.

28. Kaston BJ. Spiders of Connecticut. Geological Natural History Survey. Bulletin No. 70. State Department of Environmental Protection. Hartford.1981.

29. Tikader BK and Biswas B. Spider fauna of Calcutta and vicinity: Part I. - Records of Zoo-logical Survey of India. Occasional Papers. 1981; 30: 1-149.

30. Tikader BK. The fauna of Indian Araneae. 1982; 2 (1):1- 293.

31. Gajbe UA. A new scopodes spider from India (Araneae: Gnaphosidae) bulletin of the zoological survey of India. 1987; 8:285-287.

32. Biswas B and Biswas K. Araneae: spiders, In: state Fauna Series-3: Fauna of West Bengal. Part 3.Zoological Survey of India Publication. 1992; 357-500.

33. Barrion AT and Litsinge JA. Rice land spiders of South and South East Asia. CAB International. Wallingford England. 1995; 736.

34. Ludwig JA, Reynolds JF. Statistical Ecology: A primer on methods in computing, John Wiley & Sons. New York. 1988.

35. R. Margalef. Temporal succession and spatial heterogeneity in phytoplankton. In: Perspectives in Marine biology. Buzzati Traverso (eds.). Univ Calif Press. Berkeley. 1958; pp. 323-347.

36. Clarke KR and Warwick RM. A taxonomic distinctness index and its statistical properties. J App Ecol. 1998; 35: 523-531.

37. Clarke KR and Gorley RN. PRIMER v5: User manual/tutorial, Plymouth Marine Laboratory. Plymouth .2001.

38. Pielou EC. The measurement of diversity in different types of biological collections, J Theoret Biol, 1966; 13: 131-144.

39. Sebestian PA and Peters KV. Spiders of India. University Press Publication. 2009.

40. Shunmugavelu M and Karthikeyan R. Estimating the Diversity of Spider Assemblages (Araneae: Sparassidae) in of Kumbakarai falls. Theni District. Tamil Nadu. South India. International Conference on Bioresource Technology (ICBRT-2010) on October 7-8 2010 by Department of Botany. Nirmala College for Women. 2010; (41).

41. Oxford GS and Gillespie RG. Evolution and ecology of spider coloration, Annu Rev Ento-mol. 1998;28:337–364.

42. Craig CL and Ebert K. Colour and pattern in predator-prey interactions: the bright body colors and patterns of a tropical orb spinning spider attract flower-seeking prey. Funct Ecol. 1994; 8:616–620.

43. Hauber ME. Conspicuous coloration attracts prey to a stationary predator. Ecol Entomol. 2002; 27:686–691.

44. Tso IM, Huang JP and Liao JP. Nocturnal hunting of a brightly coloured sit-and-wait predator. Anim Behav. 2007; 74:787–793.

45. Tso IM, Liao CP, Huang R and Yang EC. Function of being colourful in web spiders: at-tracting prey or camouflaging oneself. Behav Ecol. 2006; 17:606–613.

46.Tso IM, Lin CW, and Yang EC. Colourful orb-weaving spiders and web decorations through a bee's eyes. J Exp Biol. 2004; 207:2631–2637.

47. Hoese FJ, Law EAJ, Rao D and Herberstein ME. Distinctive yellow bands on a sit-and-wait predator prey attractant or camouflage. Behaviour. 2006;143:763–781.

48. Vaclav R and Prokop P. Does the appearance of Orb weaving spiders attract prey. Ann Zool. 2006; Fennici 43:65-71.

49. DL Hawksworth and MT Kalin Arroyo. Magnitude and distribution of biodiversity. In: VH Heywood (eds.), Global Biodiversity Assessment. United Nations Environment Programme. London. Cambridge University press. 1995; pp.107-191.

50. Ried WV and Miller KR. Keeping options alive: A scientific basis for conserving biodiversity. DC Washington . World Resources Institute. 1989.

51. Downiel S, Wilson WL, Abernethy VJ, Mccracken D I, Foster GN, Ribera I and Murphy KJ. A Water-House. The impact of different agriculture land-use on epigeal spider diversity in Scotland. Journal of Insect Conservation. 1999; 3:273-286.

52. SE Riechert and RG Gillespie. Habitat choice and utilization in web-building spiders.-In: W.B. Shear (eds.). Spiders: Webs, Behavior and Evolution. Stanford. Stanford University Press. 1986; pp. 23-48.

53. GW Uetz. Habitat structure and spider foraging. In SS Bell, ED McCoy, HR Mushinsky (eds). Habitat structure: the physical arrangement of objects in space. Chapman & Hall.London.

54. Coddington JA,Young LH ,Coyle FA, Estimating spiders species richness in a Southern Appalachian cove hardwood forest. Journal of Arachnology. 1996; 24: 111-128.

55. Whittaker RH. A study of summer foliage insect communities in the great Smoky Mountains. Ecological Monographs. 1952; 22: 1-44.