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Composition and Diversity of Spiders in the Lian-huo Highway (Shangqiu Section) Shelter Forest and Campus Habitat of Henan Province, China

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ABSTRACT

Background: Spider assemblages, which are easily sampled, are useful indicators that can be used to compare the biodiversity of various environments and assess the effects of disturbances on diversity. Because spiders are generally found in forests in high abundance, they form some good model taxa for biodiversity studies.

Methods: The present study compares the composition and diversity of spiders in the Lian-Huo highway (Shangqiu section) shelter forest (HS) and campus habitat (CH) of Henan province, China. Sampling were collected from April to June 2018 and fourth time a month, a total of twenty-four samples were collected. Within each habitat type there were eight sites surveyed which represented a wide geographical spread of the habitats.

Result: A total of 3725 individual spiders were collected from the two sites, representing 14 families and 23 species. Guild structure analysis of the collected spiders revealed 4 feeding guilds *viz*, web weavers, Sheet web weavers, Foliage hunter's spider and Ambush hunters. The abundance of spiders in the campus habitat is significantly higher than that in Lian-Huo highway (Shangqiu section) shelter forestand the Shannon-Wiener index (H') (HS=3.3827, CH=2.2007), Simpson index (D) (HS=0.8710, CH=0.7391), Evenness index (J) (HS=2.8391, CH=1.7088) and Richness index (E) (HS=0.7462, CH=0.6362) are significantly higher in the campus habitat than in the Lian-Huo highway (Shangqiu section) shelter forest. These results suggest that increasing the complexity of habitat structure and reducing anthropogenic disturbance is a meaningful way to conserve and restore Spiders diversity.

Key words: Campus habitat; Guild structure, Highway shelter forest, Spiders diversity.

INTRODUCATION

Biodiversity can be simply defined as the variety of all types of living organism (Hofer and Bresvovit, 2001). Spider assemblages, which are easily sampled, are useful indicators that can be used to compare the biodiversity of various environments and assess the effects of disturbances on diversity (Churchill, 1998). Because spiders are generally found in forests in high abundance, they form a good model taxon for biodiversity studies (Ren *et al.,* 2016). In addition, their distributions and abundances are linked to the structural attributes of their habitat (Hore and Uniyal, 2008). Spider assemblages are highly influenced by variations in plant community structure, ecosystem dynamics such as disturbance and abiotic factors such as soil and ambient humidity and temperature (Bonte *et al.*, 2003). They play key functional roles in ecosystems and their abundance, richness and community structure in tree canopies are associated with the complexity of the ecosystem's vegetative structure (Bultman and Uetz, 1982).

Spiders comprise a group known to measure changes in habitat structure, habitat type, wind and temperature exposure and play key ecological roles as predators (Riechert and Bishop, 1990; Nyffeler, 2000; Deka *et al.,* 2022). Spiders have co-evolved with insects (main prey) to exploit nearly all terrestrial habitats from the Arctic Circle to the southern most reaches of terrestrial ecosystems, excluding Antarctica (Dunlop *et al.,* 2010; Tahir *et al.,* 2018). Higher trophic levels have been repeatedly found to be especially sensitive to environmental change (Oxbrough *et al.,* 2005). For example, Zhou *et al.,* (2019) found that functional diversity is one of the most important parameters used to explain how ecosystems work and adapt to change. Studying functional groups can be useful to investigate assemblage response to climate change and habitat disturbance (Wu *et al.,* 2017).

In order to evaluate the potential species loss or gain caused by afforestation it is first necessary to establish what species are present in a given habitat (Nyffeler, 2000). The use of biodiversity indicators in habitat quality assessments

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have gained increasing importance in recent years, with the recognition that for most groups of animals and plants the resources are not available to carry out complete inventories of the species present (Churchill,1998). Species richness is certainly not investigated as an indicator of the ecosystem health, but more as an indicator of the degree of stress in the ecosystem and of the natural value in function of conservation investment (Marc and Canard, 1997). Spiders have been used as indicators of invertebrate diversity (Zhou *et al.,* 2019), probably because of their predatory position in food webs and their relationship with vegetation structure, which can be linked to changes in environmental conditions (Marc *et al.,* 1999).

The spider composition could be influenced by the special situation of the highway, especially the vegetation diversity and heavy metal contaminant emitted from automobile exhaust in the highway forest. In this study, we compared the spider assemblage between highway shelter forest and Campus habitat. Our objectives were 1) investigated spider assemblage in different habitat; 2) explore the main factors affected spider guild structure and abundance. Though the study of spiders from highway shelter forest is still far from complete, the present study forms a basis for further investigations on this group.

Study site

Shangqiu city is located at the eastern of Henan Province, China (114°82'-116°45'E, 33°98' -34°80' N), the climate of Shangqiu is clearly divided into Spring (March-May), Summer (June-August), Autumn (September-November) and Winter (December -February) seasons with an annual average temperature of 14.2°C and an annual average rainfall of 623 mm. The natural vegetation where this study was conducted is classified as deciduous broad-leaved forest.

Lian-huo highway is the longest highway in China, which connecting Lianyungang City in Jiangsu Province and Horgos City in Xinjiang Province and the total length is 4395 Km. The construction of highway not only alleviates traffic and transportation tension, but also brings adverse effects to the environment, such as interference, noisy, pollution, *etc*. The coverage area of Shqngiu normal university is 2.0 ×103 ha and the student in our campus have been formed good habits to protect insect. The dominate plant are *Populus tomentosa* and *Ligustrum lucidum*and the frequent animal are *Pica pica*0and *Cyanopica cyana* in the Lian-Huo highway (Shangqiu section) shelter forest; however, the dominate plant in campus habitat are *Platanus acerifolia* and *Salix babylonica*and the frequent animal are *Pica pica*0 *Sturnus cineraceus* and *Cyanopica cyana* in Campus habitat.

MATERIALS AND METHODS

Spider sampling

Sampling were collected from April to June 2018 and fourth time a month, a total of twenty-four samples were collected. Within each habitat type there were eight sites surveyed which represented a wide geographical spread of the habitats (Including forest, shrub, grass, ground, wetland *etc*). Spiders were sampled using pitfall traps that consisted of a plastic cup 7 cm in diameter by 9 cm in depth. A bulb corer was used to make a hole in the ground for the plastic cup, which was placed so that the rim of the cup was flush with the grounds' surface. In the sites which were heavily grazed (mostly improved grass land) a section of plastic piping (7 cm diameter by 10 cm depth), was inserted into the groundand the plastic cup then inserted within this ring to protect it from trampling. Each plastic cup had two drainage slits cut 1 cm from the rim of the cup and were filled to 1 cm depth with ethylene glycol.

Pitfall samples were stored in 70% alcohol and the spiders were sorted from the catch. Identification of spiders to species level was carried out using a × 50 magnification microscope and nomenclature follows (Dunlop *et al.,* 2010). All species were assigned unique codes and stored in the zoological Museum of Shangqiu normal university.

Families of adult spiders were grouped into guilds according to their web-building and prey-catching behaviors. Orb web weavers: Araneidae, Nephilidae, Symphytognathidae, Tetragnathidae, Uloboridae, Platoridae; Sheet web weavers: Agelenidae, Linyphiidae, Ochyroceratidae, Pisauridae, Tetrablemmidae; Foliage hunters: Corinnidae, Gnaphosidae, Lipcranidae, Clubionidae, Ctenidae, Miturgidae, Oxyopidae, Salticidae, Scytodidae, Sparassidae, Theridiosomatidae; Ambush hunters: Deinopidae, Selenopidae,Thomisidae, Oonopidae;

Statistical analyses

Several indices of species diversity are used in the large amount of literature on biological diversity and ecological monitoring. A commonly used index is that referred to as 'Shannon's Index' or 'H'.

The formula are

Shannon-Wiener Index: $H' = -\sum P_i \ln P_i$;

Simpson Index: $D = 1 - 1 - \sum P_i^2$;

Margalef richness index:

$$E = \frac{(S-1)}{\ln N}$$

Pielou eveness index:

$$J = \frac{H'}{\ln S}$$

Where,

n= Number of species quantity.

pi = ski/Sk.

ski = Number of single species.

sk = Total number of species.

The number of family was estimated using the programme EstimatesS, species richness eatimators of Chao 1 was used. One-way ANOVA and Bonferroni correction comparison were used to compare the relative abundance of various spiders guilds among the two site. Homogeneity of variances was tested using levene's test.

Data were checked for normally distribution using Kolmogorov-Smirnov test. All data were calculated and analyzed with Spss 21.0 computer program.

RESULTS AND DISCUSSION

Spider assemblage composition

A total of 3725 individual spiders were collected from the two sites, representing 14 families and 23 species. From sampling of Lian-Huo highway (Shangqiu section) shelter forest, 12 families and 21 species were identified, in which the most abundant species were *Menemerus confusus, Menemerus confusus* and *Araneus ventricosus*; from sampling of campus habitat, 14 families and 23 species were identified, in which the most abundant species were *Tegenaria domestica, Hylyphantes graminicola* and *Araneus ventricosus* (Table 1).

Spider guild structure

The number of Orb web weavers spider in Campus habitat was higher than those in Lian-Huo highway (Shangqiu section) shelter forest (Mann-whitney U = 7.00, P<0.01) ; the number of Sheet web weavers spider in Campus habitat was higher than those in Lian-Huo highway (Shangqiu section) shelter forest (Mann-Whitney U = 21. 50, P< 0.01); the number of Foliage hunters spider in Campus habitat was higher than those in Lian-Huo highway (Shangqiu section) shelter forest (Mann-Whitney U=0.5, P<0.01); however, the number of Ambush hunters spider in Campus habitat was lower than those in Lian-Huo highway (Shangqiu section) shelter forest (F= 0. 29, P= 0.39) (Table 2).

Spider abundance

The abundance of spiders in the campus habitat is significantly higher than that in Lian-Huo highway (Shangqiu section) shelter forestand the Shannon-Wiener index(H') (HS=3.3827, CH=2.2007), Simpson index (D) (HS=0.8710, CH=0.7391), Evenness index(J) (HS=2.8391, CH=1.7088) and Richness index(E) (HS=0.7462, CH=0.6362) are significantly higher in the campus habitat than in the Lian-Huo highway (Shangqiu section) shelter forest (Table 3).

Spider assemblage composition

The spider diversity probably reflects differences in management regime (*i.e.* grazing and mowing intensity, chemical application, management history) and habitat factors (*i.e.* cover of vegetation, soil type and soil moist) (Dunlop *et al.,* 2010). In this field work, we investigate species composition patterns of spiders in Lian-Huo highway (Shangqiu section) shelter forest and campus habitat. The

Table 1: The number and proportion of spiders in the campus habitat and the Lian-Huo highway (Shangqiu section) shelter forest.

Families	Species name	Total abundance of Lian-Huo highway (Shangqiu section) shelter forest	Relative abundance %	Total abundance of Campus habitat	Relative abundance %
Salticidae	*Phintella melloteei*	10	0.71	19	0.82
	Menemerus confusus	307	21.83	10	0.43
	Menemerus bivittatus	10	0.71	10	0.43
	Hasarius adansoni	10	0.71	26	1.12
	Plexippus setipet Karsch	10	0.71	134	5.78
	Menemerus confusus	521	37.06	97	4.18
	Myrmarachne joblotii	10	0.71	50	2.16
Araneidae	*Araneus ventricosus*	64	4.55	163	7.03
Agelenidae	*Tegenaria domestica*	8	0.57	314	13.54
Linyphiidae	*Hylyphantes graminicola*	103	7.33	555	23.93
Oecobiidae	*Oecobius cellariorum*	10	0.71	71	3.06
Tetragnathidae	*etragnatha squamata*	0	0	31	1.34
Sicariidae	*Scytodes thoracica*	26	1.49	3	0.13
	Scytodes nigrolineata	13	0.92	8	0.34
Pholcidae	*Pholcus affinis Schenkel*	15	1.07	152	6.55
Thomisidae	*Misumenops tricuspidatus*	10	0.71	12	0.52
	Oxytate striatipes	3	0.21	6	0.26
Heteropodidae	*Heteropoda venatoria*	10	0.71	126	5.43
Theridiidae	*Steatoda triangulosa*	13	0.92	128	5.52
	Achaearanea tepidariorum	137	9.67	410	17.68
Selenopidae	*Selenops henanensis*	7	0.50	10	0.43
Lycosidae	*Lycosa sinensis*	109	7.75	10	0.43
Platoridae	*Plator inslens*	0	0	10	0.43
Total	23	1406	100	2319	10

result showed that the most abundant species were *Menemerus confusus, Menemerus confusus* and *Araneus ventricosus* in Lian-Huo highway (Shangqiu section) shelter forestand the most abundant species were *Tegenaria domestica, Hylyphantes graminicola* and *Araneus ventricosus* in campus, respectively, which was much lower than the observed richness in many tropical lowland forests (Oxbrough *et al.,* 2005). The spider assemblages were differentiated among the habitats investigated. Considering the influence of vegetation structure on ground dwelling spider assemblages it is unsurprising that the spider fauna differed among different site (Hore and Uniyal, 2008). The dominant vegetation was *Populus tomentosa* in Lian-Huo highway (Shangqiu section) shelter forest and most of them were artificial planting, the single habitat leads to lower spider number diversity. Our result agreed with previous reported that conversion of forest to plantation and other man-induced disturbances lead to reduction in the diversity of invertebrates, both in species richness and in the taxonomic and bibliographical quality (Ren *et al.,* 2016; Deka *et al.,* 2022).

The high floral diversity sustains a high faunal diversity by providing diverse micro-habitat especially for invertebrates (Jocqué and Alderweireldt, 2005). The high species diversity of spiders in can be attributed to the high diversity of plants and insects (7500 spp., 65 spp. of butterflies) (Oxbrough *et al.,* 2005). Dunlop *et al.* (2010) pointed that *Tegenaria domestica* and *Hylyphantes graminicola* suitable dwell in complexity and low interference habitat, although there is amount of student in campus, the diversity habitat can accommodate more spiders (Russell-Smith, 2002; Tahir *et al.,* 2018). This is consistent with one hypothesis suggests that intermediate disturbance supports higher species diversity than higher or lower levels of disturbance (Marc and Canard, 1997). Pianka (1994) gives an overview of 10 hypothetical mechanisms, determining species diversity and richness. Most important are ecological time, evolutionary time, habitat and climatic stability, productivity, spatial heterogeneity, competition, predation and disturbance.

Table 2: Abundance (means±SE) of various spider guilds in per sampling plot between habitats.

Spider guilds	Lian-Huo highway (Shangqiu section) shelter forest	Campus habitat
Orb web weavers	21.4±3.6	4.09±0.7
Sheet web weavers	3.91±0.5	7.3±0.87
Foliage hunters	29.7±3.2	8.4±0.73
Ambush hunters	1.2±0.71	1.4±0.4

Spider guild structure

Guild structure analysis of the collected spiders revealed 4 feeding guilds *viz.*, web weavers, Sheet web weavers, Foliage hunter's spider and Ambush hunters. However, when spiders were divided according to their functional group there was a significant effect of habitat on the diversity of these groups (Hofer and Bresvovit, 2001). The density and diversity of the spider community has been closely tied to the structural complexity of the local environment (Tsai *et al.,* 2006). As litter depth increased, there were significant changes in prey species richness, litter complexityand microclimate. For instance, soil dwelling spiders increase dramatically when the litter layer is enhanced because there are more retreats and hiding places and because temperature and humidity extremes are moderated. Web-building spiders are directly linked to the configuration of the Vegetation because of specific web attachment requirements. Both correlative and experimental data support a tight relationship between spider density and habitat structure (Tsai *et al.,* 2006).

The spider fauna of leaf litter may be divided into various guilds, based on methods of prey capture and utilization of similar prey resources (Zhou *et al.,* 2019). Resource partitioning among spiders is also influenced by the presence of web building spiders as they display higher territorial behavior in order to protect energetically costly webs (Wu *et al.,* 2017). 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 (Wise, 2004). 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 (Xie *et al.,* 2022).

Wu *et al.* (2017) have demonstrated that spiders are extremely sensitive to small changes in the habitat structure, including habitat 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 (Zhou *et al.,* 2019). Therefore, documenting spider diversity patterns in this ecosystem can provide important information to justify the conservation of this ecosystem.

Spider abundance

Species richness is in our case not highest at high or intermediate levels of disturbance, but at low levels (Bultman and Uetz, 1982; Longkumer *et al.,* 2024). However, habitat structure does influence their density and richness and more

Table 3: Shannon-Weiner (H'), Simpson (D) Richness (E) and Evenness index (J) of sampling plots in two sites.

Habitat	Smipson index D	Shannon-Wiener index H	Richness E	Evenness J
Lian-Huo highway (Shangqiu section) shelter forest	0.7391	2.2007	1.7088	0.6362
Campus habitat	0.8710	3.3827	2.8391	0.7462

complex habitats can be expected to be more diverse. It has been showed that the richness and abundance of spiders vary to microhabitat qualities (Zhou *et al.,* 2019). Bonte *et al.* (2003) found that the richness of xerothermic species was influenced by patch size. This relationship is probably the result of a higher variation in micro-environmental conditions, which positively influence the presence of a more diverse species composition. There are many environmental factors that affect species diversity. Factors at the micro-habitat scale, especially heavy metal contaminant emitted from automobile exhaust in highway shelter forest, which may be important in influencing the diversity, need to be investigated.

CONCLUSION

Comparison of spiders between studies is difficult because of possible seasonal variation and the largely unknown effect of vegetation type and structure on the community structure. This study serves as a baseline for future study of spiders in scholarship ecosystems. Such studies can build upon this one by using additional collecting methods and/or collecting in different seasons (Sudhikumar *et al.,* 2005). Future studies can build upon this checklist and continue to catalogue the poorly documented spider fauna and perhaps discover new species along the way. This indicates that information on the management of a site will be a more useful indicator of biodiversity value than a survey of the vegetation structure present.

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Ethics

Our experimental procedures complied with the current laws on animal welfare and research in Chinaand were approved by the Animal Research Ethics Committee of Shangqiu Normal unisersity (SQNU007).

Authors' contributions

All authors conceived and designed the study. Bao-dong Yuan conducted the experiments, analyzed the data and wrote the paper. All authors contributed to manuscript revisions. All authors approved the final version of the manuscript and agree to be held accountable for the content therein.

Conflict of interest

We have no conflict of interests.

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