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Diversity of Foliage Spiders in Two Contrasting Habitats in the Rain Forest Zone of Southwestern Nigeria

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ABSTRACT This study investigated and described the diversity and characteristics of spider families occurring in two contrasting natural habitats within a typical rainforest ecosystem in southwestern Nigeria. Standard sweep-nets were used to collect spiders from the under storey foliage in the Forest reserve of Biological Gardens and a nearby Tree Park in a band from ground level to approximately 1.5m height. Sampling was done in August, 2011 (Rain season) and January, 2012 (Dry season). The specimens were collected from two sets of 100 sweeps to give a total of 200 sweeps per day at each site. Collected data were analysed using Simpson's index of diversity. The Forest Reserve had greater species richness, abundance and diversity than the Tree Park. Only 14% of the species were common to both sites. The study suggests the possible effect of habitat characteristics on the occurrence and diversity of foliage spider species.

INTRODUCTION

Spiders are obligate carnivores and this makes them to be exceptional arthropods because of their complete dependence on predation as a trophic strategy. They have been reported to be the dominant predators and stabilizers of the invertebrate community in natural and agricultural ecosystems (Turnbull 1973; Uetz et al. 1999; Farzana et al. 2012). This attribute of spiders has made their community role to be of concern to the economic entomologists. Bristowe (1958) ranks spiders as first among the enemies of insects, with birds and other insectivorous creatures trailing far behind. Also, Andow (1991) and Uetz (1991) found spiders to be the most abundant and to apply the greatest pressure on insect prey species. Spiders have also been found to have good potential to serve as biological control agents against crop pests (Ferguson et al. 1984; Whitmore et al. 2002).

Spiders either hunt or trap their prey. The hunting types move very fast and often wander in search of prey, while the other species trap their prey in their webs, many spiders build silken traps suspended on vegetation to aid them in capturing and restraining their preys. These facts about spiders have enabled Araneologists to identify prey abundance and habitat structure as critical determinants of web spider distribution and density (Upamanyu and Uniyal 2008). However the relative importance of each of the two parameters appears to vary a great deal between the groups of spiders used in different studies (Rypstra 1983). Spiders, as predators, are not coupled to a particular plant species as a food source; vegetation structure may therefore be an important determinant of spider community attributes. However, there is paucity of data on diversities of spiders in Nigeria.

This study was therefore aimed at determining the species richness, abundance and diversity of the foliage spiders in a Forest reserve and a Tree park with a view to understanding the influence of vegetation structure on spider populations.

METHODOLOGY

Description of the Study Area

The study was carried out on the campus of Obafemi Awolowo University, Ile-Ife in Osun state, southwestern Nigeria. The University is in the lowland forest zone according to Keay (1959), semi-deciduous moist forest (Charter 1969) and what White (1983) described as Guinea-Congolian forest, drier type. The dry nature of the Ife forest is demonstrated by the fact that wherever the soil is shallow, as on the slopes of inselbergs, humid savanna vegetation develops (Adejuwon 1971).

The University campus occupies an area of 5600 hectares of which the built-up, central campus and the University farms occupy 3349 hectares. As at 1985, regrowth forest, most of it around two (Hills I and II) of the three inselbergs on the northwestern corner of the central campus, occupied an estimated 1234 hectares. The largest patch of forest is around Hill I and it is within it that the Biological Gardens, comprising a Zoo and a Botanical Garden are located. Most of the forest is no more than fifty years old except for the top of Hill I where shallow soils must have limited farming in the past (Isichei 1988).

The University area is underlain by metamorphic rocks of the Precambrian Basement Complex. The rocks consist of banded gneiss and migmatite quartzites, quartz, mica schists and related rocks (Smyth and Montgomery 1962). The soils are moderately to strongly leached and have low to medium humus content, weakly acid to neutral surface layers and moderately to strongly acid sub-soils (Smyth and Montgomery 1962).

The climate of the area is humid tropical with distinct dry and wet seasons. The wet season starts from around mid-March to late October and the rainfall pattern is bi-modal with peak periods in July and September. The dry season runs from November to March but a short dry spell usually occurs in August (Jeje and Agu 1982). The mean annual rainfall is about 1400mm. The mean maximum temperature of 33^0C is recorded between February and March while the mean minimum temperature (27^0C) is recorded between July and September .

Sampling Sites

Sampling was carried out in the Biological Gardens' Forest Reserve and Tree Park (behind the Biological sciences Building) of the Obafemi Awolowo University, Ile-Ife, Nigeria. Ile-Ife lies within latitude $7^0$31' N and longitude $4^0$33' E and is approximately 300m above sea level.

Sampling Site A – Forest Reserve of Biological Gardens

This site is covered by secondary regrowth forest. It is a reserved forest that forms a larger portion of Biological Gardens.

Sampling Site B – Tree Park

The Tree Park is situated behind the Biological Sciences Buildings of the University. The park is almost completely surrounded by other buildings, although to the north of it are the Biological Gardens which forms part of a forest reserve. The park itself was formerly part of the secondary forest on the campus but was later cleared of the under storey shrubs and climbers. Many of the forest trees are still left standing but they do not form a closed canopy. Although regularly slashed/mowed, however, quite often, the park is overgrown with herbaceous weeds and grasses.

Sampling Techniques

The sweep-net sampling technique that was employed in this study had been found satisfactory for arthropod sampling by several workers (Janzen 1973; Allan et al. 1975; Hatley and MacMahon 1980; Whitcomb 1980; Ferguson et al. 1984; Gunnarsson 1990; Patel et al. 2012).

Standard sweep-nets (38cm diameter) were used to collect spiders from the under storey foliage in the Forest reserve of Biological Gardens and the Tree Park in a band from ground level to approximately 1.5m height. Sampling was done in August, 2011 (Rain season) and January, 2012 (Dry season).

One sweep was a vigorous double motion to right and left. After each sweep, the contents of the net were emptied into a killing jar containing a few drops of ethyl acetate as a killing agent. Both study sites had pathways. The specimens were collected from two sets of 100 sweeps to give a total of 200 sweeps per day at each site. The collections were made between 8.30 am and 12 noon.

The spiders were first sorted into families and later separated by appearance into "morpho-species". This procedure is likely to underestimate rather than overestimate the number of true species (Allan et al. 1975). The number of species and the number of individuals in each were recorded as was the number of species common to both sites. The spider identification keys provided by Kaston (1953) and Dippenaar-Schoeman and Jocque (1997) were used as guides in species identification.

Diversity of spider species was calculated in two ways; the simple average number of individuals per species and Simpson's index, D. These were calculated for each spider family with more than one species. Simpson's index was preferred to the more complex and commonly used Shannon-Wiener Index as recent studies suggest that it is preferable for theoretical and practical reasons (Hubert 1971; May 1975). Simpson's index was calculated as $1-\Sigma P_i^2$ where Pi is the proportion of individuals in the i^{th} species.

RESULTS

The relationship between the number of species collected and sample size (number of sweeps) is shown in Figure 1 for four abundant spider families at each site. There is a tendency for the number of species collected to level off after 700 sweeps, suggesting that more than 800 sweeps would have produced very few or no additional species. For example, two additional species of Linyphiidae were obtained in the final 100 sweeps in the Tree Park; all other families had either one or no additional species.

Table 1 presents data on species richness, abundance and diversity for each spider family at each site. The overall species richness and abundance are clearly greater in the Forest reserve than in the Tree Park by 18% and 120% respectively. However, Salticidae and Tetragnathidae had more species in the Tree park (but only two-thirds the number of individuals) than in the Forest Reserve while Theriidae had more species and more individuals.

The diversity measures showed a similar pattern: average number of individuals per species is greater for all taxa in the Forest Reserve. Simpson's index showed only Tetragnathidae and Theriidae being more diverse in the Tree Park.

The number and the proportion of species common to both sites are also highlighted in Table 1. Salticidae had the highest number of species that are common to both sites, and it is followed by Linyphiidae. Families Theriidae, Mimetidae and Gnaphosidae had no species that are common to both sites.

The collected spider families were grouped into four species guilds based on their methods of obtaining prey. These are Ambushers, Hunters, Web-builders and Retreat builders.

(a) Ambushers- Thomisidae
(b) Hunters- Salticidae and Oxyopidae
(c) Web-builders- Therridae, Linyphiidae, Araneidae and Tetragnathidae.
(d) Retreat builders- Gnaphosidae, Clubionidae and Mimetidae.

DISCUSSION

No analysis of the physical environment, vegetation or biology of the spiders was made and thus the differences in fauna of the two sites can only be accounted for by the general effects of the contrasting forest management practices. Due to the close proximity of the two sites, it is assumed that their spider fauna would be similar if the management was the same.

Four species guilds of spider were recorded in this study, based on their methods of obtaining prey. Species guilds, defined by Root (1967) as "a group of species that exploit the same class of environmental resources in a similar way" can be used to identify functional roles present in a

Table 1: Comparison of the foliage-dwelling spiders of Biological Garden Forest reserve with that of a nearby Tree park on the University Campus, Ile-Ife

Spider Family	*Biological garden*				*Tree park*				*Species common to both sites*	
	No of species (s)	*No of individual (N) N/S*	*Diversity NS*	*Diversity D*	*No of species (s)*	*No of individual*	*Diversity NS*	*Diversity D*	*Number*	*Proportion*
Thomisidae	24	115	4.8	0.934	16	42	2.6	0.832	4	0.10
Linyphiidae	17	155	9.1	0.883	13	44	3.4	0.873	6	0.20
Theriidae	6	43	7.2	0.777	15	61	4.1	0.798	0	0.00
Oxyopidae	11	59	5.4	0.862	9	20	2.2	0.810	2	0.10
Salticidae	16	137	8.6	0.896	19	95	5.0	0.812	7	0.20
Araneidae	13	105	8.1	0.872	7	28	4.0	0.764	3	0.15
Tetragnathidae	6	34	5.7	0.789	7	20	2.9	0.805	3	0.23
Mimetidae	1	1	-	-	0	0	-	-	0	-
Clubionidae	15	83	5.5	0.883	7	23	3.3	0.737	3	0.14
Gnaphosidae	1	1	-	-	0	0	-	-	0	-
Total	110	735	AV 6.8	0.862	93	333	AV 3.4	0.804		AV 0.14

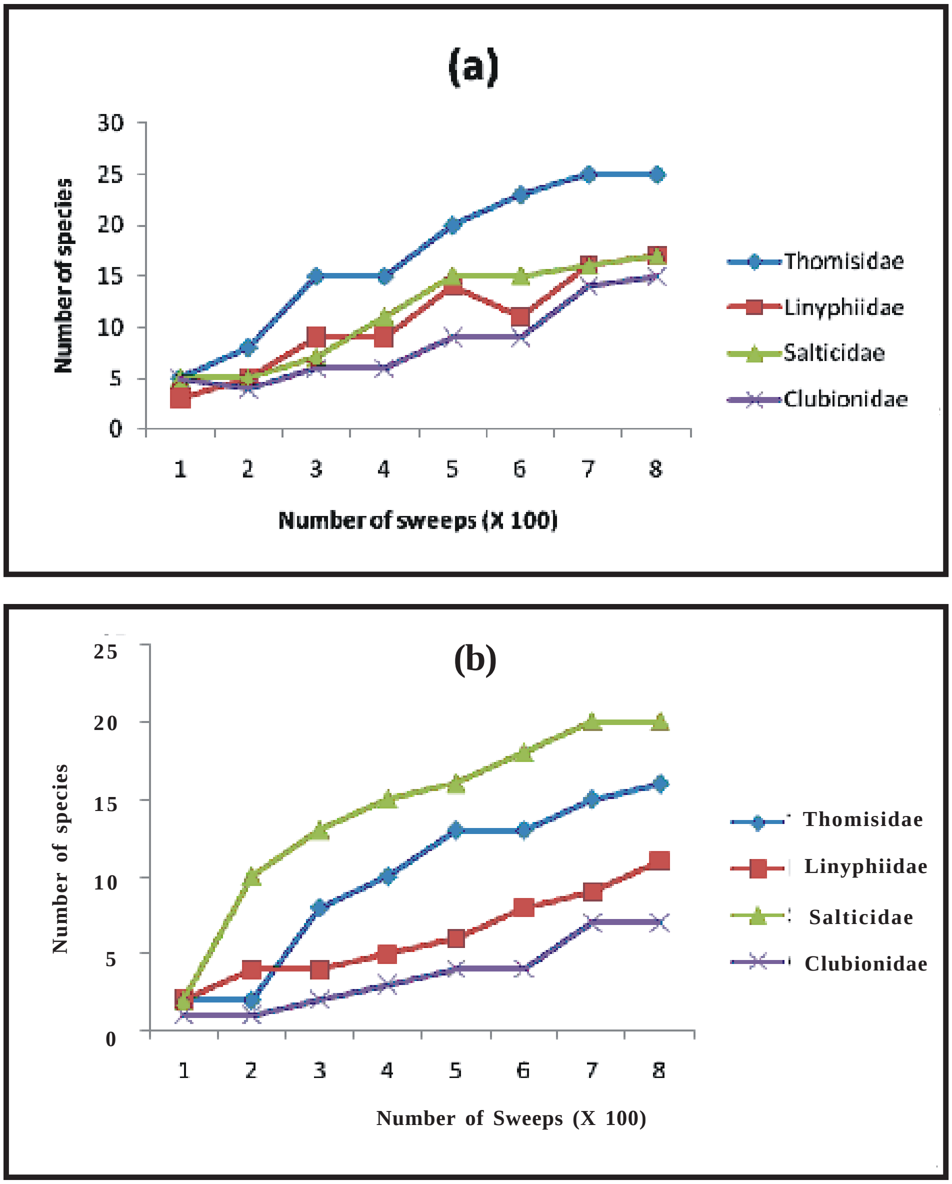

Fig. 1. The relationship between number of sweep-net samples taken and the cumulative number of species collected for four taxa in a (a) Forest reserve of biological gardens, (b) Tree park

system. This approach considers sympatric organisms as a unit, involved in a competitive interaction, regardless of taxonomic relationships. Functional organization can then be considered independent of the individualistic response a single species may make to local conditions. Functional analysis of community organization has been used in studies of plant-arthropod associations (Root 1973), and wandering spider communities (Uetz 1975; Batary et al. 2012).

The transformation from indigenous forest to Tree Park reduced the species diversity of foliage spider fauna and equally changed the numbers present. Vegetation provides varying types of substrates or microhabitats which are differentially suitable for spider species. The type of substrate on which a species occurs may influence the preys available to it and also dictate the method by which they are obtained. Spiders, as predators, are not coupled to a particular plant species as a food source; vegetation structure may therefore be an important determinant of spider community attributes. Hatley and Macmahon (1980) reported that architectural properties of habitats may be an important determinant of the distribution and species diversity of predatory invertebrates. Spider distribution has been reported to be affected by substrate structure (Halaj et al. 2000; Sorensen et al. 2002). Bulan and Barrett (1971) found that arachnid density decreased in oak fields after mowing and remained lower in subsequently burned fields than in unburned fields. The structure of spider communities has been found to change with plant succession through changes in spider species density and population density. In general, the proportion of web-builders to hunting spiders has been observed to increase during succession. deSouza et al. (2004) noted a correlation between the presence and abundance of spiders and the level of shrub development. He also found a horizontal separation of several shrub-dwelling species that preferred specific desert shrub species.

The results of disturbance of natural patterns on biodiversity are various and complex. It has been observed that human activities tend to create gradients of disturbance with accompanying changes in community structure (Gunnarsson 1990). There is an increasing interest in the use of 'indicator' groups of invertebrates for assessing and monitoring ecological changes associated with forest management practices (Spellerberg 1993; Williams 1993; Kapoor 2008; Batary et al. 2012). The traditional practice for such monitoring has focused on vascular plants and vertebrates, but there is growing acknowledgment that this taxa provide a limited view of the state of an ecosystem after disturbance. A more reliable indication of an ecosystem health is likely to be provided by invertebrates (Spellerberg 1993; Williams 1993; Dippener-Schoeman et al. 1999; Whitmore et al. 2002; Farzana et al. 2012; Patel et al. 2012).

CONCLUSION

The Forest Reserve had greater species richness, abundance and diversity than the Tree Park. Four species guilds were observed in the two habitats: Ambushers, Hunters, Web-builders and Retreat builders. This study suggests that differences in habitat vegetation structure may be responsible for differences in spider species diversity in the study areas.

RECOMMENDATIONS

Further studies need to be conducted which will compare several different habitats in different ecological zones of Nigeria. This will enable us to confirm the effects of different forest management practices on spider populations.

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