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Species richness of spiders in Sacred Mountain, Marawi City, Philippines

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Abstract

This study aims to determine the species richness and abundance of spiders in Sacred Mountain, Marawi City, Lanao del Sur, Philippines. Beat netting, vial tapping, and pitfall trapping methods were used to collect samples at elevations of 800, 900, and 1000 meters above sea level. Forty-three species belonging to 11 families were documented. Highest species richness was observed at 1000 meters above sea level. *Leucauge argentina* of family Tetragnathidae was the most abundant species. Family Salticidae had the highest number of species collected comprising 14 species. Overall spider collection was categorized into six guilds wherein the orb weavers occurred to be the most abundant. High diversity and more or less even distribution of spiders were observed in the area. Physico-chemical factors appear to affect the distribution of spider families Tetragnathidae and Theridiidae as shown by canonical correspondence analysis.

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Introduction

One of the most diverse groups of organisms in the Philippines is the spiders (Wankhade *et al.,* 2012) which serve as good biological control agents of prey population in farms and other agroecosystems (Symondson *et al.,* 2002). Spiders do an important role in the ecosystem by regulating insects but they are poorly studied (Russell-Smith, 1999).

Currently, more than 40, 000 spiders are known around the world (Braitberg and Segal, 2009). Spiders are categorized as the seventh most diverse order worldwide (Cardoso, 2012) and may be distributed in all continents except Antarctica (Sewlal and Cutler, 2003). About 517 species belonging to 225 genera and 38 families are recorded in the Philippines and the Philippines has the highest spider count in the entire Asian tropical rice fields (Barrion, 2001).

Besides their capacity to adapt, many spiders are indicator to minute changes in the environment (Wankhade *et al.,* 2012). Environment alterations may affect their distribution and (Bonte *et al.,* 2002) assemblages by variations of plant community structure, disturbance, and abiotic factors. Many spiders often rely on a unique environmental habitat complexity with respect to species-specific ecological demands (Uniyal *et al*., 2011)

Spiders in the temperate regions are well studied compared to tropical areas (Chen and Tso, 2004). Areas exposed to high disturbances and anthropological alterations have higher spider diversity indices and evenness values compared to pristine areas as observed in the study of Freitas *et al.* (2013). Maelfait and Hendrickx (1998) reported that spiders are also good bio-indicators for evaluating the effects of anthropogenic disturbance on natural ecosystems. Most spiders are as ecologically specialized as the prey groups they rely on (Mcdonald, 2007). Hence, different habitats supporting different prey groups affect spider richness and diversity. Spider communities can be described by the number of species found in an area and their relative abundance (Sørensen *et al.,* 2002). In Mindanao, the second largest Island in the Philippines (Knack, 2013), studies on arachnids include those of Ballentes *et al.* (2006) who reported 51 species of spiders in Mt. Malindang Range Natural Park. Enriquez and Nuñeza (2014) and Cabili and Nuñeza (2014) reported on the species richness and diversity of cave spiders in Mindanao. Meanwhile, Abrenica-Adamat *et al.* (2009) studied the stabilimenta of *Argiope luzona* in a banana plantation in selected Mindanao areas. Garciano *et al.* (2014) recorded 23 spider species in Mt. Matutum, South Cotabato and Dacanay *et al.* (2014) listed 37 species at Pulacan Falls, Zamboanga City.

Despite the recognized role of spiders as biological indicators, more surveys on spider diversity are still needed in the country. Far less research has been conducted on the processes influencing the diversity patterns of invertebrates and even less on spiders (Hore and Uniyal, 2009). Only limited literatures exist regarding the species composition and diversity of spiders in the country thus researchers and other spider enthusiasts cannot fully estimate the density of species population. Further exploration is necessary to fully document the species richness of spiders in the Philippines.

This study aims to determine the species richness of spiders found in Sacred Mountain, Marawi City, identify the guild structures and the spider families affected by abiotic factors, and to compare habitats through computed biodiversity indices.

Materials and methods

Sampling sites

Site 1 (8.0180 N and 124.3011 E) is at 800 meters above sea level (masl). Part of the area is utilized for agricultural purposes with its loam soil thus anthropogenic disturbance can be moderately observed. The common plants cultivated in the site are corn (*Zea mays)* and bananas (*Musa* sp.). Grasses and some shrubs were also observed nearby. The site is slightly parched especially during high noon because it is under direct sunlight exposure except the zone covered with big trees. There are few fallen logs present at the site which may be caused by storm. The covering canopy trees have few vines coiling in their trunks. Most of the ground cover are tree regenerants and the leaf litter depth measures about 4 centimetres.

Site 2 (8.0219 N and 124.2986 E) lies at 900 masl. This area is 40-50 meters away from the agricultural zone where corn (*Zea mays*), tomatoes, and kangkong (*Ipomea aquatica)* are planted. Ferns, allocacia (*Homalomena philippinensis* and *Schismatoglottis* sp.), and few rattans (*Calamus* sp.) serve as the understory plants. Leaf litters moderately cover the forest floor thus the ground in this site is considerably moist because of the decreased sunlight penetration due to the presence of big trees. Leaf litter depth is more than 4 centimetres.

Site 3 is located at 1000 masl elevation. This site is 60-80 meters away from the cultivated land area where corn (*Zea mays)* plants were grown. Thicker leaf litter can be observed in the area with denser canopy resulting in a moist ground. Rattan (*Calamus* sp.) and bamboos were also found in the area. Thicker leaf litter measuring about more than 5 centimetres covers the ground. Very rare on-site disturbance can be observed in this site since few local dwellers reach this far.

Sampling methods

Sampling was done for a total of 60-man hours on November 17 to November 20 and November 22 to 23, 2014 at 800 hours to 1200 hours and 1400 hours to 1600 hours. Sampling hours cannot be extended because of the rainy weather condition in the afternoon to night. The sampling site was limited to the lowland area not exceeding 1000 masl. Three transect points were made: the first point started at 800 masl; second point was at 900 masl; and the third point was at 1000 masl. Collection in every point was extended 10 m on each side perpendicular to the transect point to obtain extensive sampling. Microenvironments of spiders like fallen logs and leaf litters were examined for ground-dwelling spiders. Arboreal spiders were captured from visible webs and leaves of trees. Beat-netting, opportunistic sampling, aerial and ground hand collection, and pitfall trapping methods were done to collect samples. Captured samples were placed in plastic cups and vials to prevent escape of the motile spiders. Samples were then photographed. Voucher specimens were placed in vials with 75% ethanol. A habitat description form adapted from Heaney, as cited in HARIBON Foundation (2001) was used. Physico-chemical parameters of the area were also measured like the relative humidity and air temperature. The air temperature was measured using a field thermometer and the relative humidity was taken using a sling psychrometer.

Identification

Collected samples in the field were identified up to family and genus level when possible during the sampling period. The third author further identified the voucher specimens up to the species level.

Data analysis

Biodiversity indices were computed using Paleontological Statistics Software version 2.17 (PAST). Canonical Correspondence Analysis (CCA) was used to identify environmental variables that affect species composition.

Results and discussion

Forty three species belonging to 11 families under 31 genera were observed during the sampling period (Table 1). The number of individuals observed in the three sites was almost the same. Site one had 54 individuals while sites two and three had 52 individuals in each site. Site 3 with the highest elevation of 1000 masl had the most number of species (30) and families (9) of spiders. The family Tetragnathidae was the most abundant comprising 36% of the total number of individuals. Family Salticidae with 14 species had the highest species richness. *Leucauge argentina* (Fig. 1) of

Tetragnathidae emerged to be the most abundant spider species making up almost 20% of the total species observed. This orb web building spider was mostly found in site 1 with cultivated crops.

Chen and Tso (2004) also found this species to be dominant together with *Mesida gemma* (Tetragnathidae) in Orchid Island, Taiwan. The same genus (*Leucauge*) was found abundant in the study of Garciano *et al.* (2014) at 1200 masl in bushes, grasses, and agroecosytem. It was observed that the number of species increases along with the increase in elevation. Site 2 (900 masl) had higher number of species compared to site 1. Uniyal *et al.* (2011) reported that mid elevations (2500 masl to 3500 masl) are expected to have peak count of species richness. In this study, the highest number of species was recorded in site 3 at 1000 masl elevation. This result differed from the findings of Uniyal *et al.* (2011) and Garciano *et al.* (2014) wherein spider richness is negatively correlated with elevation ranging from 1100 masl to 4000 masl.

Table 1. Species richness and abundance of spiders in the sampling sites.

Species	Site 1 (800 masl)	Site 2 (900 masl)	Site 3 (1000 masl)	Total	RA (%)
Araneidae (orb weavers)					
Anepsion sp.	2	4	3	9	5.7
Cyclosa insulana (Barrion & Litsinger, 1995)	1	0	0	1	0.63
Cyclosa sp.	1	0	1	2	1.27
Eriovixia laglaizei (Simon, 1877)	0	1	0	1	0.63
Eriovixia sp.	0	1	0	1	0.63
Gasteracantha doriae (Simon, 1877)	2	4	0	6	3.8
Gea subarmata (Thorell, 1890)	5	3	0	8	5.06
Neoscona punctigera (Doleschall, 1857)	0	0	2	2	1.27
Neoscona sp.	0	0	1	1	0.63
Linyphiidae (sheet web weavers)					
Neriene sp.	2	0	3	5	3.16
Lycosidae (wolf spiders)					
Pardosa birmanica (Simon, 1884)	0	0	1	1	0.63
Nephilidae (Orb weaver)					
Nephila sp.	0	0	1	1	0.63
Pholcidae (cellar spider/ daddy long legs)					
**Pholcus* sp.	0	1	0	1	0.63
Pisauridae (nursery web spider)					
Hygropoda sp.	0	0	1	1	0.63
Salticidae (jumping spider)					
Bavia sexpunctata (Doleschall, 1859)	0	2	0	2	1.27
Bavia sp.	0	2	0	2	1.27
Carrhotus sp.	0	0	1	1	0.63
Chalcotropis sp.	1	0	2	3	1.9
Orthrus sp.	0	0	1	1	0.63
Palpelius beccarii (Thorell, 1881)	3	0	1	4	2.53
Palpelius sp.	1	0	2	3	1.9
Pancorius sp.	4	1	2	7	4.43
Phintella bunyiae (Barrion & Litsinger, 1995)	0	0	2	2	1.27
Sarvaea sp.	0	2	0	2	1.27
Telamonia sp.	3	2	3	8	5.06
Telamonia vlijmi (Proszynski, 1984)	0	0	3	3	1.9
Thiania sp.	1	0	0	1	0.63
Thiania viscaensis (Barrion & Litsinger, 1995)	0	0	1	1	0.63
Sparassidae (huntsman)					
Heteropoda sp.	3	6	3	12	7.59
Heteropoda garciai (Barrion & Litsinger, 1995)	0	0	1	1	0.63
Tetragnathidae (long-jawed orb weavers)					
Leucauge argentina (Hasselt, 1882)	8	7	3	18	11.39
Leucauge decorata (White, 1841)	5	5	0	10	6.33
Leucauge fastigiata (Simon, 1905)	6	4	0	10	6.33
Leucauge sp.	0	2	4	6	3.8
Leucauge tessellata (Thorell, 1887)	4	2	1	7	4.43
Meta sp.	0	0	1	1	0.63

Tetragnatha sp.	0	0	2	2	1.27
Tylorida striata (Thorell, 1877)	1	1	1	3	1.9
Theridiidae (cobweb/tangle-web)					
Achaearanea sp.	0	1	1	2	1.27
Chrysso trimaculata (Zhu, Zhang & Xu, 1991)	0	0	2	2	1.27
Episimus sp.	1	1	0	2	1.27
Theridion sp.	0	0	1	1	0.63
Thomisidae (crab spiders)					
Borboropactus sp.	0	0	1	1	0.63
Total no. of individuals	54	52	52	158	100
Total no. of species	19	20	30		
Total no. of Families	6	6	10		

Legend: RA (relative abundance); * (possible new species).

This high species richness at 1000 masl can be attributed to its elevation since it is still part of the lowland area with adjacent agricultural ecosystem. This site also had thicker leaf litter. According to Uetz *et al.* (1999), presence of some species may be facilitated by leaf litter size which increases essential surface area for some foraging species. Low count of species in site 1 (800 masl) may be attributed to the presence of nearby anthropogenic disturbance. Mcdonald (2007) also observed that more disturbances in grasslands manifested by common land uses affect the spider richness. In this study, the spider count can be affected by pesticides and other forms of pest control used by farmers to protect their crops. Natural environment of the area may be altered which may reduce spider diversity since spiders are very sensitive to any minute environmental change (Sudhikumar *et al.*, 2005; Uniyal *et al.*, 2011).

Table 2. Total number of spiders in each family and their relative abundance (RA).

	Site 1 (800 masl)	Site 2 (900 masl)	Site 3 (1000 masl)	Total no. of Individuals	RA (%)	Total no. of Species
Araneidae	11	13	7	31	19.62	9
Linyphiidae	2	0	3	5	3.16	1
Lycosidae	0	0	1	1	0.63	1
Nephilidae	0	0	1	1	0.63	1
Pholcidae	0	1	0	1	0.63	1
Pisauridae	0	0	1	1	0.63	1
Salticidae	13	9	18	40	25.32	14
Sparassidae	3	6	4	13	8.23	2
Tetragnathidae	24	21	12	57	36.08	8
Theridiidae	1	2	4	7	4.43	4
Thomisidae	0	0	1	1	0.63	1
Total				158	100	43

Eleven families were recorded to be present in the sampling area. Among these families, Tetragnathidae comprised more than 36% of the overall population as shown in Table 2. This was followed by family Salticidae with more than 25% of the total spider count. The highest species richness was also under this family. Chen and Tso (2004) found 19 spider families and the orb weavers (Araneidae, Tetragnathidae Uloboridae) occurred to be the most abundant comprising 70% of their total collected specimens. They were mostly found in the undisturbed bushes and shrubs which supported their webs. In this study, web building spiders are expected to be abundant because of the presence of bushes especially in the forest edge.

Among the six guilds found in the sampling sites, orb weavers were the most ubiquitous guild constituting 42% of the distribution in the area (Fig. 2). This was composed of families Tetragnathidae, Araneidae, and Nephilidae which were mostly collected near the cultivated areas and near the bushes, mostly in site 1, which provided wider expanse for web building. The foliage runners of Salticidae family were commonly found above or beneath leaves and constituted 33% of the guild distribution. Orb weavers were also found dominant in the study of Sudhikumar *et al.* (2005) and Garciano *et al.* (2014) and were also collected in an agroecosytem. Uniyal *et al.* (2011) also recorded a high count of family Araneidae in their study conducted along different altitudinal gradients. Dacanay *et al.* (2014) documented an abundant number of orb weavers in Pulacan Falls, Zamboanga del Sur.

Table 3. Tabulated biodiversity indices of the three sites.

Indices	Site 1 (800 masl)	Site 2 (900 masl)	Site 3 (1000 masl)
No. of Species	19	20	30
Shannon (H')	2.718	2.785	3.278
Evenness	0.7976	0.8096	0.8838

The presence of this guild may be explained by the type of vegetation in the area which could provide adequate area of varying extent for web building. Space builders (Theridiidae and Pholcidae) have 12%, foliage runners (Sparassidae) and ground runners (Lycosidae) 7%, ambushers (Thomisidae and Pisauridae) have 5% and sheet web weavers (Linyphiidae) have 2% of the guild distribution. Aerial and ground collection and opportunistic sampling methods generated the most number of collected spiders in this study.

Fig. 1. *Leucauge argentina*, the most abundant spider species in the Sacred Mountain, Marawi City.

The composition of flora in the area where many shrubs and bushes were found appears to favor diversity of spiders. These plants provide more space for weavers for them to build web which is why the dominant guild documented in this study is the orb weavers. Food availability and web building capacity of web builders and wanderers, and the survivability of other spider guilds are mostly affected by vegetation structure (Sudhikumar *et al.*, 2005; Mcdonald, 2007).

Fig. 3 shows the relationship of the environmental factors (altitude, air temperature, and relative humidity) to the presence of spiders in each site. The canonical correspondence analysis (CCA) showed that families Tetragnathidae and Theridiidae were affected by the environmental factors. Family Tetragnathidae was influenced by the difference of air temperature and relative humidity while family Theridiidae was affected by altitude. The rest of the eight families were not directly associated with environmental factors. Uniyal *et al.* (2011) reported that there are some spider families which live on the ground and are not directly affected by the shift of vegetation structure. Other families are reliant on the type of their habitat associated with their foraging manner thus vegetation affects their population. For example, Lycosidae which can tolerate severe environments is not affected by the variables (air temperature, altitude, relative humidity) used in this study. Other factors such as web support, shading, prey availability, presence of threat, and predation among guilds may affect the occurrence of certain families (Pinkus *et al.*, 2006; Freitas *et al.,* 2013).

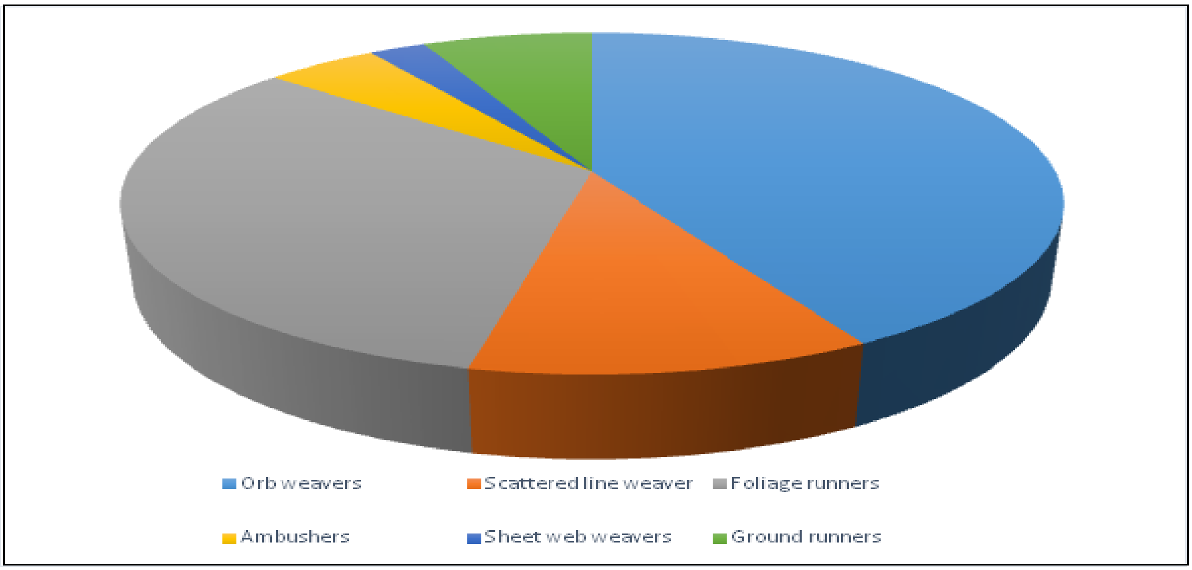

Fig. 2. Distribution of guild structures in the sampling area.

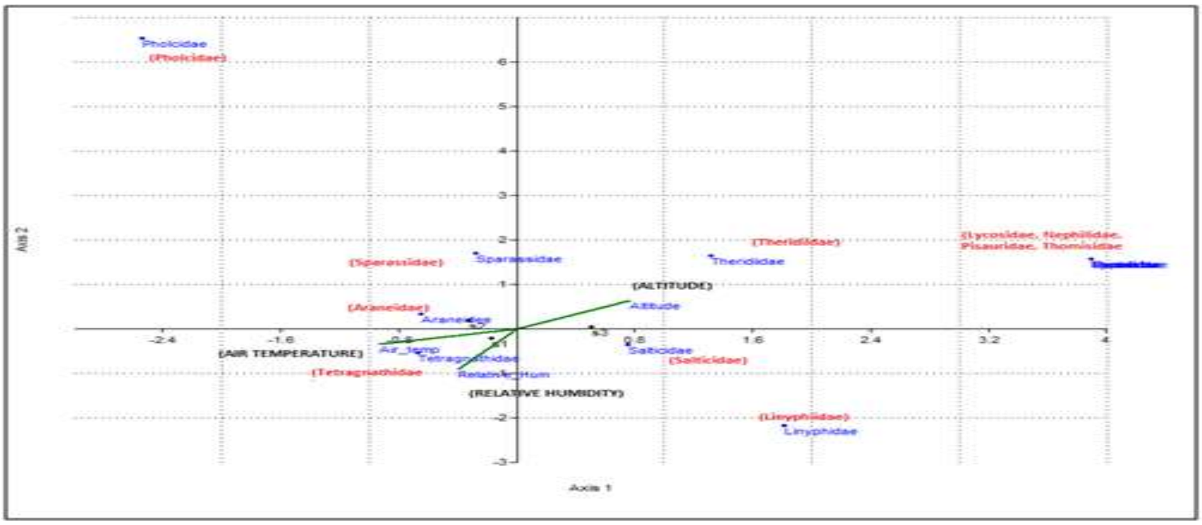

Fig. 3. Canonical Correspondence Analysis (CCA) of spider families found in the sites.

Table 3 shows the biodiversity indices of the three sites in Sacred Mountain. High diversity and almost even species distribution were observed in all sites although site 3 had the highest diversity and evenness. This indicates that the highest elevation in the area is a good habitat for several spider species not found in other sites. This can also indicate that different elevations in the lowland area can provide favorable environment for various spider species. The pattern of species diversity can considerably be affected by the vegetation structure, landscape, and environmental conditions which may result to absence of some less tolerant or fragile species (Uniyal *et al*., 2011).

Conclusion

Sacred Mountain has 43 species of spiders and high species diversity index with more or less even distribution. Family Tetragnathidae was the most abundant family while family Salticidae had the highest species richness. Of the six guilds recorded, orb weavers were the most distributed, being found in all sites. Families Tetragnathidae and Theridiidae were affected by the altitude, relative humidity, and air temperature.

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