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Rapid assessment of spider fauna in Marilog District, Davao City, Philippines

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Abstract

This study was conducted to determine the species richness and abundance of spiders in Barangay Baganihan, Marilog District, Davao City, Philippines. Sampling was conducted at three sites with elevations of 1000, 1100 and 1200 meters above sea level using conventional collection techniques like sweep netting, beat netting, and vial-tapping. One hundred seventy one spider species belonging to 25 families were recorded. Twenty four species are possibly new species and six species are new record in Mindanao. Highest species richness and the most diverse were recorded in site 2 at an elevation of 1100 meters above sea level. Family Araneidae had the highest species richness and abundance. Species diversity was low in the disturbed sites, sites 1 and 3. The possibly new species and new record for Mindanao in the study indicate that Barangay Baganihan, Marilog District is a species-rich area.

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Introduction

Arachnids are group of arthropods that contain about 43,678 described spiders in the world (Platnick, 2013). Spiders are very diverse, ubiquitous in terrestrial ecosystem, and abundant in both natural and agricultural habitats (Turnbull, 1973; Nyffeler and Benz, 1987). They vary in shapes, sizes, eye patterns, colors, behavioral tactics and tricks (Mascord, 1980), and feeding structures therefore named as “wonders of nature” (Barrion *et al*., 2012). Because of the high abundance and insectivorous foraging of spiders, they are considered as the major agent controlling insect communities in terrestrial ecosystem (Nyffeler, 2000). Studies have shown that spiders can discriminate among several environmental conditions, as habitat with distinct plant architecture or litter with differences in deep complexity (Rubio *et al*., 2008). They can display preferences for certain types of habitats (Hodge, 1987) and react to disturbances in the environment (Warui *et al*., 2005). Spiders fulfil the criteria to be a reliable ecological indicator assemblage to detect habitat disturbances by natural causes or by human intervention (Kremen *et al*., 1993). However, due to low mobility of mountain endemics such as spiders, they are not able to migrate northwards and are confined to restricted range. Additionally, they are threatened by habitat changes (Van Swaay *et al*., 2006) caused by human interference and climate change. Thus they face an exceptionally high risk of extinction (Thomas *et al*., 2004).

In the Philippines, there are about 517 species belonging to 225 genera and 38 families of spiders (Barrion, 2001) which make spiders ranked as the seventh most diverse order worldwide (Cardoso, 2012). Studies on spiders in Mindanao, the second largest island in the Philippines include those of Garciano *et al.* (2014) who studied species richness of spiders in Mt. Matutum, South Cotabato, Philippines; Enriquez and Nuñeza (2014) who reported on species richness and diversity of cave spiders in Mindanao; Ballentes *et al.* (2006) who studied 51 species of spiders in Mt. Malindang Range Natural Park; Abrenica-Adamat *et al.* (2009) who reported on the stabilimenta of *Argiope luzona* in banana plantation in Barangay Dalipuga, Iligan City; Dacanay *et al.* (2014) who did rapid assessment of spider fauna of Pulacan falls, Zamboanga del Sur, Philippines; Cabili and Nuñeza (2014) who reported on species diversity of cave-dwelling spiders on Siargao Island, and Chua *et al.* (2014) who conducted a rapid assessment of spider diversity in Kabigan Falls, Pagudpud, Ilocos Norte, Philippines. In these studies, the authors recommended for further biodiversity studies in the Philippines, particularly in Mindanao since numerous species may become extinct due to increased rates of habitat destruction and disturbance.

In the present study, the species richness of spiders was documented in Brgy. Baganihan, Marilog District, Davao City. This study also aimed to determine species diversity and distribution of the spiders in the sampling area. This research is significant as this will provide a baseline data of spider fauna in Brgy. Baganihan, Marilog District, Davao City and will also contribute to the existing information on spiders in the Philippines.

Materials and methods

Sampling site description

The study area was located at Marilog District, Davao City, Philippines in the mountainous area of Barangay Baganihan, homeland of the Matigsalug tribe. It is adjacent to Bukidnon and North Cotabato provinces. Barangay Baganihan, Marilog District, Philippines is situated at latitude (7.524850) and longtitude (125.224655) on the map of the Philippines. Baganihan is approximately 53 km. away or 41 minutes drive from Davao City. Three sampling sites (Table 1) with different elevations and vegetation type were established in the study area.

Sampling methods

Field sampling was done on December 3-5, 2014 for a total of 18- man hours in the three study sites of Brgy. Baganihan, Marilog District, Davao City. A gratuitous permit (GP) was obtained from the Department of Environment and Natural Resources-DAVAO region for collection of samples. Three sites with 1km transect were established at different elevation: site 1 at 1000 masl, site 2 at 1100 masl and site 3 at 1200 masl. In addition, spiders were searched up to 10m to the left and to the right of the transect line to provide extensive area for sampling. The sampling methods include visual searching for the spiders as far as distinct vision is possible. Ground search was done under leaf litter and on fallen or dry wood. Sweep netting was done to collect foliage dwelling spiders. Beat netting was done using a beat net placed under the tree to catch the spiders which fall upon beating the branches of the tree. Vial tapping was done by tapping the spider into the bottle with 70% ethyl alcohol and covering the bottle with a lid. Web pattern and habitat type were recorded with every encounter. Samples when captured were put in solid containers such as large jars while sampling, making them easier to contain, as spiders are highly motile. The specimens were temporarily placed in zip-lock plastic bags for capturing live images then transferred to individual vials with 70% ethanol. The collection date, compartment name, and habitat were recorded on each vial. Description of the general habitat of these spiders based on disturbance was also noted. All specimens were identified by the second author at the University of the Philippines Los Baños Museum of Natural History.

Statistical analysis

Biodiversity indices which include species richness, relative abundance, Shanon-Weiner Diversity Index, and Pielou's evenness were calculated using Paleontological Statistics Software Package (PAST). A dendrogram based on Bray-Curtis distances for clustering was done to determine the similarity of study sites (Hammer *et al.,* 2001). Furthermore, correspondence analysis was also performed to show the distribution of spiders according to elevation.

Results and discussion

Species richness and abundance

A total of 481 individuals from 171 species, 83 genera, and 25 families were sampled in Barangay Baganihan, Marilog District, Davao City during the study period. Table 2 is a summary of the species composition. The total spider collections formed a mixture of young individuals and adults. Among the adults, the females (147) were more numerous than males (42). The species richness is relatively high compared to the spider fauna in Mt. Matutum (Garciano *et al.*, 2014), Mt. Malindang Range Natural Park (Ballentes *et al.,* 2006), cave spiders in Mindanao (Cabili and Nuñeza, 2014) and Siargao Island (Enriquez and Nuñeza, 2014). However this is relatively low compared to the spider fauna in Philippine rice fields

Table 1. Graphical location and habitat description of the three sampling sites.

Site	Graphical Location (GPS) and elevation	Habitat Description
1	Lat: 7.43826, Long: 125.22604 1000 masl	Flat slope. This sampling site has an agricultural type of vegetation where bananas are cultivated. There was an anthropogenic clearing 30m from the sampling site.
2	Lat: 7.45626, Long: 125.23904 1100 masl	Undulating slope with secondary vegetation. Emergent trees found are *Swietenia mahogani* (mahogany) and some *Gmelina*, surrounded by understory plants like *Alocacia* and ground cover plants such as ferns and mosses. Bamboo and some flowering plants were also found in the area.
3	Lat: 7.46962, Long: 125.24515 1200 masl	Mountainous slope with primary vegetation type of forest. There were epiphytes like ferns and some vines found on the trees. Forest floor is covered with leaf litters and fallen logs, which are common microhabitats of ground-dwelling spiders.

(Barrion, 2001) which consists of 337 species under 28 families. Results showed that the number of species increased with elevation but decreased when it comes to site 3 with 1200 masl elevation. The same observation was also found by Quasin and Uniyal (2011) and Garciano *et al.* (2014) that spider richness is negatively correlated with elevation ranging from 1100 masl to 4000 masl.

Of the total number of species, 24 species (13.9%) in 12 families, namely: Oxyopidae (2 spp.), Pholcidae (2 spp.), Salticidae (4 spp.), Tetragnathidae (2 spp.), Theridiidae (6 spp.), Thomisidae (2 spp.) and one each in Araneidae, Clubionidae, Corinnidae, Linyphiidae, Oonopidae and Sparassidae are possibly new species. *Araniella sp., Singa perpolita, Nasoona sp.*, *Dyschiriognatha tangi*, *Tylorida cylindrata* and *Lycopus sp.* are new records in Mindanao.

Table 2. Species richness and abundance of spiders in three sampling sites of Brgy.Baganihan, Marilog District, Davao City.

SPECIES	SITE 1	SITE 2	SITE 3	Total	RA (%)
Araneidae					
Acusilas sp.	0	2i	0	2	0.416
Anepsion sp.	1♀	1i, 2♀	3♀	7	1.455
Anepsion sp. 2	0	2♀	0	2	0.416
Anepsion sp. 2b	0	3♀	0	3	0.624
Araneidae immature	0	1i	0	1	0.208
Araneus sp.	1♂	2i	1i	4	0.832
Araneus sp. 2	0	1♀	0	1	0.208
Araniella sp. nr	0	1♀	0	1	0.208
Cyclosa bifida	2♀	1♂, 10♀	0	13	2.703
Cyclosa hexatuberculata	0	1♀	0	1	0.208
Cyclosa insulana	0	1i, 2♀	1♀	4	0.832
Cyclosa sp.	0	0	1i	1	0.208
Cyclosa sp. 2	0	1i	0	1	0.208
Cyclosa sp. 2b	0	1♂	0	1	0.208
Cyclosa sp. 3A	0	3i	0	3	0.624
Cyclosa sp.*	1♀	1♀	0	2	0.416
Cyclosa spirifera	0	1♀	0	1	0.208
Cyrtophora cicatrosa	0	1i	0	1	0.208
Cyrtophora exanthematica	0	1♀	0	1	0.208
Cyrtophora sp.	1i	0	2i	3	0.624
Cyrtophora sp. 2A	0	1♀	0	1	0.208
Eriovixia laglaizei	0	2i	1♂	3	0.624
Eriovixia sp.	1i	1i	1i	3	0.624
Eriovixia sp. 2	0	1♀	0	1	0.208
Gasteracantha diardi	0	3♀	0	3	0.624
Gasteracantha doriae	1i	4i	1♀	6	1.247
Gasteracantha sp.	1i, 2♂	4i	0	7	1.455
Gea sp.	0	1i	0	1	0.208
Macracantha arcuata	0	1i, 1♀	2♀	4	0.832

Milonia sp.	0	2i, 2♀	0	4	0.832
Neoscona molemensis	1i	1i	1♀	3	0.624
Neoscona sp.	2i	1i	1i	4	0.832
Poltys sp.	0	0	1i	1	0.208
Singa perpolita nr	0	1♀	0	1	0.208
Clubionidae					
Clubiona sp.	0	3i	1i	4	0.832
Nusatidia luzonica	1i	1i	0	2	0.416
Nusatidia sp.	8i	9i	2i	19	3.95
Nusatidia sp. A2	1♀	0	0	1	0.208
Nusatidia sp.*	1♀	0	0	1	0.208
Corinnidae					
Oedignatha scrobiculata	2♀, 2♂	0	0	4	0.832
Oedignatha sp. 2	0	1♀, 1♂	0	2	0.416
Oedignatha sp.*	1♀, 1♂	0	0	2	0.416
Ctenidae					
Ctenus sarawakensis	2i, 1♀, 1♂	1♂	1♀	6	1.247
Ctenidae immature	1i	0	0	1	0.208
Ctenus sp.	6i, 1♀	3i	5i, 1♀	16	3.326
Gnaphosidae					
Gnaphosidae immature	0	1i	0	1	0.208
Hitobia sp.	0	0	1i	1	0.208
Poecilochroa sp.	0	0	1i	1	0.208
Hahniidae					
Alistra sp.	0	1♀	0	1	0.208
Alistra sp. 2	0	0	1i	1	0.208
Linyphiidae					
Linyphiidae 1b immature	0	1♂	0	1	0.208
Gonatium sp.	0	2♀	0	2	0.416
Linyphia sp.	0	1i, 1♀	1♀	3	0.624
Linyphia sp.*	1♀	0	0	1	0.208
Linyphiidae 1a immatures	1i	0	1i	2	0.416
Meioneta sp.	0	1♂	0	1	0.208
Nasoona sp. nr	1♀	0	0	1	0.208
Neriene macella	0	2♀	0	2	0.416
Neriene sp.	0	1i, 2♀, 1♂	1i, 1♀	6	1.247
Neriene sp. 2	1♂	1♀	0	2	0.416
Neriene sp. 2a	0	1♀	0	1	0.208
Neriene sp. 3	0	1♀	0	1	0.208
Neriene sp. 3c	0	3♀	0	3	0.624
Plectembolus sp.	1i	2i, 2♀	0	5	1.04
Lycosidae					

Pardosa sp.	1i	0	0	1	0.208
Mimetidae					
Mimetus sp.	1i	0	0	1	0.208
Nephilidae					
Herennia sp.	0	1♀	0	1	0.208
Nephila pilipes	0	2i	1i	3	0.624
Nephila sp.	0	1i	0	1	0.208
Ochyroceratidae					
Althepus sp.	0	1i	0	1	0.208
Ochyroceratidae immature	0	1i	0	1	0.208
Oonopidae					
Ischnothyreus sp.*	0	2♀	0	2	0.416
Oxyopidae					
Hamataliwa sp.	0	0	1i, 1♀	2	0.416
Hamataliwa sp. 2	0	0	1♀	1	0.208
Hamataliwa sp. 2*	0	0	1♂	1	0.208
Oxyopes lineatipes	1 ♀	0	1i, 1♀	3	0.624
Oxyopes sp.	0	0	6i	6	1.247
Oxyopes sp.*	0	0	1i	1	0.208
Pholcidae					
Micropholcus sp.	1i	0	0	1	0.208
Micropholcus sp.*	1♀, 1♂	0	0	2	0.416
Pholcidae immatures	0	0	6i	6	1.247
Pholcus sp.	0	3i	1♀	4	0.832
Pholcus sp. A*	1♂	1♀	0	2	0.416
Pisauridae					
Eurychoera sp.	0	1i	0	1	0.208
Psechridae					
Psechrus sp.	0	2i	0	2	0.416
Salticidae					
Agorius sp.	0	0	1i	1	0.208
Agorius sp. 2	1i	0	0	1	0.208
Agorius sp. B1	1i	0	0	1	0.208
Cytaea sp.	2i, 1♂	1i, 1♀	1i	6	1.247
Cytaea sp. 2	0	0	1♀	1	0.208
Euryattus sp.	1i	1i	0	2	0.416
Ligonipes sp.	0	1i♂, 1♂	0	2	0.416
Neon sp.	0	1i	1♀	2	0.416
Orthrus sp.	0	1i	0	1	0.208
Orthrus sp.*	0	0	1♂	1	0.208
Palpelius beccarii	1♀	0	0	1	0.208
Palpelius sp.	11i	3i	0	14	2.911

Pancorius sp.	1i	0	0	1	0.208
Phintella sp.	0	1i	0	1	0.208
Phintella sp.*	1♀	0	0	1	0.208
Pseudicius sp.*	1♂	0	0	1	0.208
Salticidae 1a immature	4i	5i	0	9	1.871
Salticidae 1b immature	0	1i	0	1	0.208
Salticidae 1c immature	0	1i	0	1	0.208
Telamonia sp.	3i	1i	1i	5	1.04
Thiania sp.	1i	1♂	1i, 1♂	4	0.832
Thiania sp.*	0	0	1♂	1	0.208
Zenodorus sp.	0	0	1♀	1	0.208
Sparassidae					
Heteropoda sp.	5i	7i	3i	15	3.119
Heteropoda sp. 1	0	0	2i	2	0.416
Heteropoda sp. 2	0	0	1i	1	0.208
Heteropoda sp.*	0	0	1♀	1	0.208
Tetragnathidae					
Dyschiriognatha sp.	0	0	1i	1	0.208
Dyschiriognatha sp. nr	1♂	0	0	1	0.208
Dyschiriognatha sp.*	3i	1i	1♀, 3♂	8	1.663
Leucauge argentina	1i	4i, 7♀	0	12	2.495
Leucauge decorata	2i, 1i♂, 4♀	1i, 1♀	4♀, 2i	15	3.119
Leucauge sp.	1i	5i	4i	10	2.079
Leucauge sp. B	0	0	1i	1	0.208
Prolochus sp.*	0	0	1♂	1	0.208
Tylorida cylindrata nr	0	0	1♀	1	0.208
Tylorida striata	2♀	1i	0	3	0.624
Theraphosidae					
Milonia sp.	0	1i	0	1	0.208
Phlogiellus sp.	2i	1i	2i	5	1.04
Phlogiellus sp. 2	0	1i	0	1	0.208
Phlogiellus sp. B	1i	0	0	1	0.208
Theridiidae					
Argyrodes sp.*	1♂	0	0	1	0.208
Argyrodes sp.	0	1i, 1♀	1i, 1♀	4	0.832
Chrysso sp.	1i, 1♀	0	1i	3	0.624
Chrysso sp. B1	0	0	1♀	1	0.208
Chrysso sp.*	1♀	0	0	1	0.208
Chrysso timaculata	1♀	1♀	0	2	0.416
Coleosoma sp.	1i	0	0	1	0.208
Enoplognatha sp.	0	0	1♂	1	0.208
Episinus sp. B	0	1♀	0	1	0.208

Episinus sp.*	0	0	1♀	1	0.208
Parasteatoda sp.	0	2♀	0	2	0.416
Parasteatoda sp. *	0	1♀	0	1	0.208
Parasteatoda sp. 1	0	1♀	0	1	0.208
Parasteatoda sp. 2	0	1♀	0	1	0.208
Steatoda sp.	0	0	2♀	2	0.416
Theridion karamayensis	0	1♀	0	1	0.208
Theridion pustuliferus	1♀	0	0	1	0.208
Theridion sp.	1i	1♀	1i, 1♂	4	0.832
Theridion sp. 2	0	0	1i	1	0.208
Theridion sp. 2*	1♂	0	0	1	0.208
Theridion sp. 3	1i	0	5♀	6	1.247
Theridula sp.*	0	0	1♀	1	0.208
Theridiosomatidae					
Theridiosomatidae immature	0	1♀	0	1	0.208
Thomisidae					
Camaricus sp.	1i♀	0	0	1	0.208
Diaea sp.	3i, 1♂	0	2i, 1♂	7	1.455
Ebrechtella sp.	11i, 1♀	3i	0	15	3.119
Ebrechtella tricuspidata	1i, 1♀	0	0	2	0.416
Loxobates sp.	1i	0	0	1	0.208
Lycopus sp. nr	0	0	1♂	1	0.208
Misumenops sp.	1i	1i	0	2	0.416
Oxytate sp.	0	0	1i♀	1	0.208
Oxytate virens	0	0	1♀	1	0.208
Sanmenia sp.	1i	0	0	1	0.208
Spilosynema sp.	1i	14i, 2♀	3i	20	4.158
Spilosynema sp. 2	0	1i	0	1	0.208
Spilosynema sp. A*	1♂	0	0	1	0.208
Synema sp.	0	1i	1i, 1♀	3	0.624
Synema sp. *A**	0	0	1♂	1	0.208
Takachihoa sp.	1♀	0	0	1	0.208
Thomisidae 1a immatures	0	2i	0	2	0.416
Thomisidae 1b immatures	0	2i	0	2	0.416
Thomisidae 1c immatures	0	4i	0	4	0.832
Uloboridae					
Philoponella sp.	0	1♂	0	1	0.208
Uloborus sp.	0	1i, 1♀	0	2	0.416
Zodariidae					
Mallinella sp.	*0*	0	1♂	1	0.208
Total number of individuals	142	218	121	481	

Legend: ♀- Female, ♂- Male, i- immature, RA (%)- Relative Abundance, *- Possibly new species, nr- new record.

Twenty-five spider families (Fig. 1) were recorded in the study. Some families were distributed widely throughout the sampling site while others were restricted to one or two sites. Families that were only found at a single site include: Lycosidae, Mimetidae, Ochyroceratidae, Oonopidae, Pisauridae, Psechridae, Theridiosomatidae, Uloboridae and Zodariidae. Although these families were found at only one site, the species are not rare. They may be cryptic or have a patchy distribution and thus may not have been adequately sampled.

Table 3. Biodiversity indices of the three sampling sites.

Indices	Site 1 1000 masl	Site 2 1100 masl	Site 3 1200 masl
Species richness	72	104	71
Shannon Index	3.881	4.272	4.024
Evenness	0.6825	0.7028	0.7992

In terms of percentage and cluster composition of the 25 families collected, the most abundant were the Araneidae (19.75%), Thomisidae (13.93%), Salticidae (12.27%), and Tetragnathidae (11.02%) which constitute 56.97% forming cluster 1 (Fig. 2). Cluster 2 has seven families, namely: Theridiidae, Linyphiidae, Clubionidae, Ctenidae, Sparassidae, Oxyopidae and Pholcidae that comprised 34.72% of the spiders collected. The remaining 14 families represent the remaining 8.32%. Occurrence of high number of Araneidae could be due to the mixed vegetation type of the forest which provides enough space to different sizes of webs and protection from predators. Also, the presence of such web would make it more visible and obvious during collection, hence the large number of species was identified. Ward (2007) reported that Araneidae prefers locations either near water, in shaded vegetation, logs, trunks or buttresses of trees.

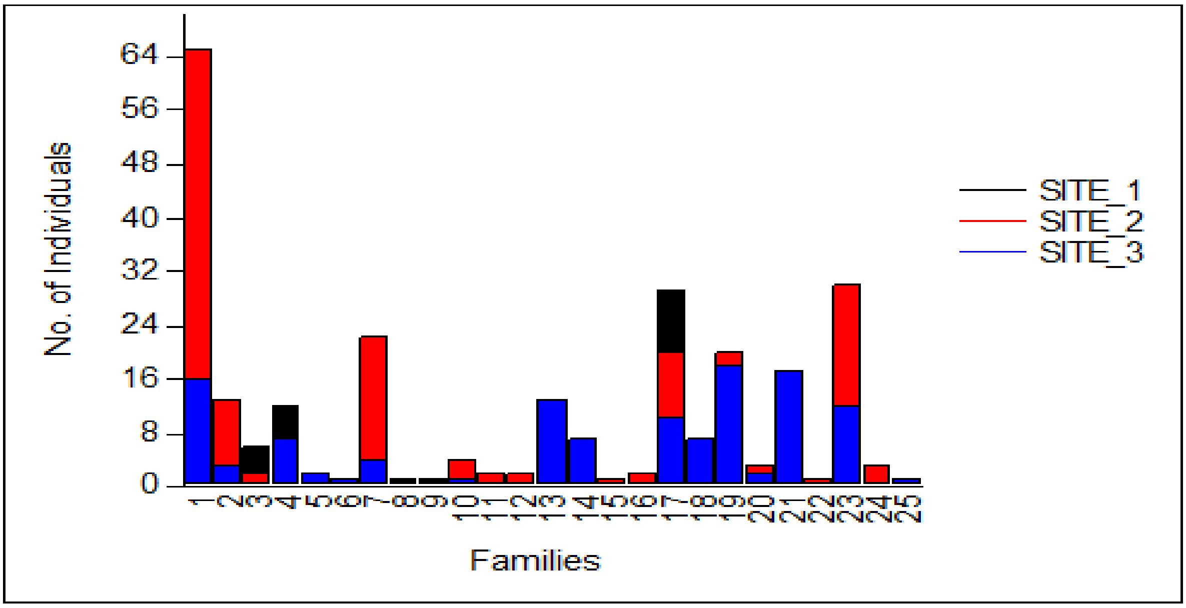

Fig. 1. Total collection of spiders per family of the three sites of Brgy.Baganihan, Marilog District, Davao City. 1= Araneidae, 2= Clubionidae, 3= Corinnidae, 4= Ctenidae, 5= Gnaphosidae, 6= Hahniidae, 7= Linyphiidae, 8= Lycosidae, 9= Mimetidae, 10= Nephilidae, 11= Ochyroceratidae, 12= Oonopidae, 13= Oxyopidae, 14= Pholcidae, 15= Pisauridae, 16= Psechridae, 17= Salticidae, 18= Sparassidae, 19= Tetragnathidae, 20= Theraphosidae, 21= Theridiidae, 22= Theridiosomatidae, 23= Thomisidae, 24= Uloboridae, 25= Zodariidae.

Biodiversity indices

Site 2 had the most abundant spiders with 218 individuals comprising 104 species. Site 1 had 142 individuals in 72 species. Site 3 had the least abundance of 121 individuals with 71 species. Differences among the three sites are probably connected to differing physiognomy and its changes. According to Döbel *et al.* (1990) and Gunnarsson (1990), spider abundance is directly related to habitat complexity and vegetation since many spiders live directly in specific environments related to the kind of vegetation present (Foelix, 1982; Malumbre-Olarte *et al.*, 2013).

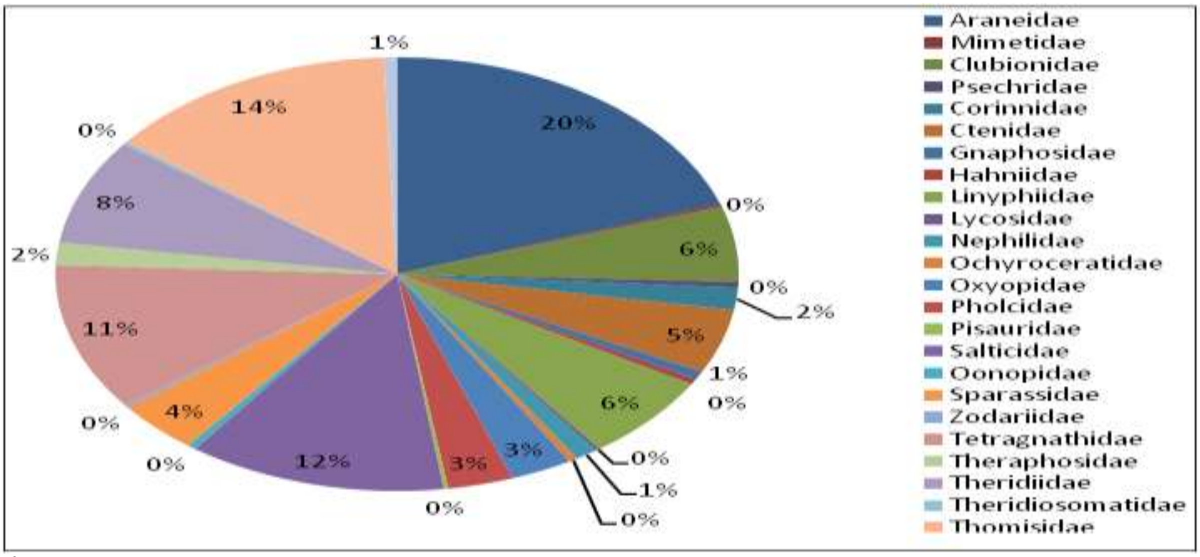

Fig. 2. Percentage composition of the key spider families in three sites of Brgy. Baganihan, Marilog District, Davao City.

Site 2 was found to have the highest species richness which may be caused by its distance from the cultivated area and anthropogenic disturbances. This site also had thicker leaf litter depth in which the presence of some species may be facilitated by leaf litter size that increases the essential surface area for some foraging species (Uetz, 1991). Site 1 being converted for agricultural purposes and the presence of anthropogenic clearing observed in Site 3 may have caused disturbance to potential prey therefore decreasing spider richness and abundance in both sites. Whitmore *et al.* (2002) reported that increasing disturbance level leads to decreasing spider richness. Site 3 which is located at higher elevation had lower species richness. This result coincides with the findings of Garciano *et al.* (2014) and Quasin and Uniyal (2011) that species diversity decreases with elevation due to the sensitivity of spiders to small changes in the environment, especially changes in the vegetation, climate, and topography. Local change in climate as a result of increasing elevation and changes in spatial gradients causes changes in the habitat that may affect species diversity (Bowden and Buddle, 2010).

Table 3 shows the biodiversity indices in the three sampling sites of Brgy. Baganihan, Marilog District, Davao City using Margalef species, Pielou evenness and Shannon index to describe the community structure of the spiders. Species diversity was high in all sampling sites, however, Site 1 with the most disturbed vegetation type had the lowest species diversity compared to the other sites (Table 3). Dacanay *et al.* (2014) and Topping and Love (1997) also observed lower spider density and species richness in highly disturbed areas. Henderson (2007) reported that spider community is highly affected by disturbance and vegetation structure and as the areas are subjected to high levels of disturbance, they are characterized by lower spider abundance and species density. In Pielou's evenness index, all three sampling sites were found to be more or less evenly distributed although Site 1 got the lowest value compared with the two sites, which means that a species dominates the area. In this case, it was dominated by the species *Ebrechtella sp.* belonging to family Thomisidae. In addition, although site 2 had the highest species richness and species diversity, site 3 still has the highest evenness. This result is caused by the high number of *Spilosynema* sp. belonging to family Thomisidae that is found in Site 2.

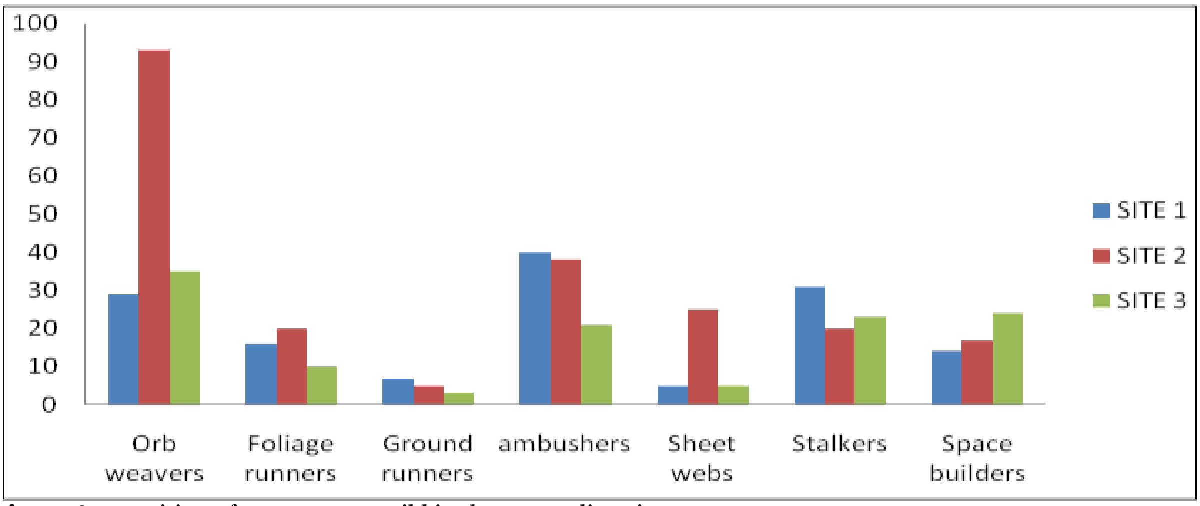

Fig. 3. Composition of Araneae per guild in three sampling sites.

Spider richness per guild

Guild type varies on the different habits of the spiders. Uetz *et al.* (1999) stated that taxonomic relationships reflect related species since they utilize similar resources while taxa of distant relationships may not necessarily belong to the same guild.The result in this study showed that the most dominant guild is the orb weavers (33%) composed of Araneidae, Nephilidae, Tetragnathidae, Theridiosomatidae and Uloboridae (Fig. 3). The same result was obtained by Garciano *et al.* (2014) in Mt. Matutum and Barrion *et al.* (2012) in their study in the rice agricultural landscape of Hainan Island, China. Orb weavers were frequently encountered at the grasses and scrubs. Abundance of orb-weavers is influenced by the physical structure of the vegetation and the availability of the web sites (Wise, 1993). The bushes and sparse ground-layer vegetation that are required for web construction in Brgy. Baganihan, Marilog District, Davao City may be able to support a large population of orb-weaving spiders thus explaining their abundance. Orb-weavers are observed to be the most abundant in site 2. According to Rodrigues *et al.* (2009) they may be better adapted to areas with lower disturbances, possibly due to web format and construction site. They are indications that vegetation structure influences spider diversity (Whitmore *et al.*, 2002).

Distribution of spider species per sampling site

Canonical Correspondence Analysis (CCA) was performed to visualize the distribution of spider species according to their families in the three sampling sites. Fig. 4 shows the relationship of temperature, relative humidity, and elevation on the abundance of species in different sampling sites. Quadrant 1 shows that the species abundance of *E. laglaizei* under Family Araneidae and Linyphidae 1b under Family Linyphiidae is directly related to elevation.

Quadrant 3 shows that the abundance of *Oedignatha* sp. 2, *Gonatium* sp., *Ischnothyreus* sp., *Psechrus* sp., *Ligonipes* sp. and *Parasteatoda* sp. is related to temperature. Result showed that all these species were only found in Site 2 with an average temperature of 24.14 ºC Favorable or stable temperature increases the activity of spiders and it can be an important microclimate scale for website selection and certain vegetation attributes for spiders (Glime, 2013).

Quadrant 2 shows that the presence of spider species such as *Acusilas* sp. and *Diaea* sp. under Family Araneidae and Thomisidae 1a and Thomisidae 1b under Family Thomisidae is related to relative humidity. These spiders were found mostly at Sites 2 and 3 with relative humidity values ranging from 97.18%-97.15%. The abundance of spider species may also be related to the ability of spiders to survive in high humidity and stable low temperature.

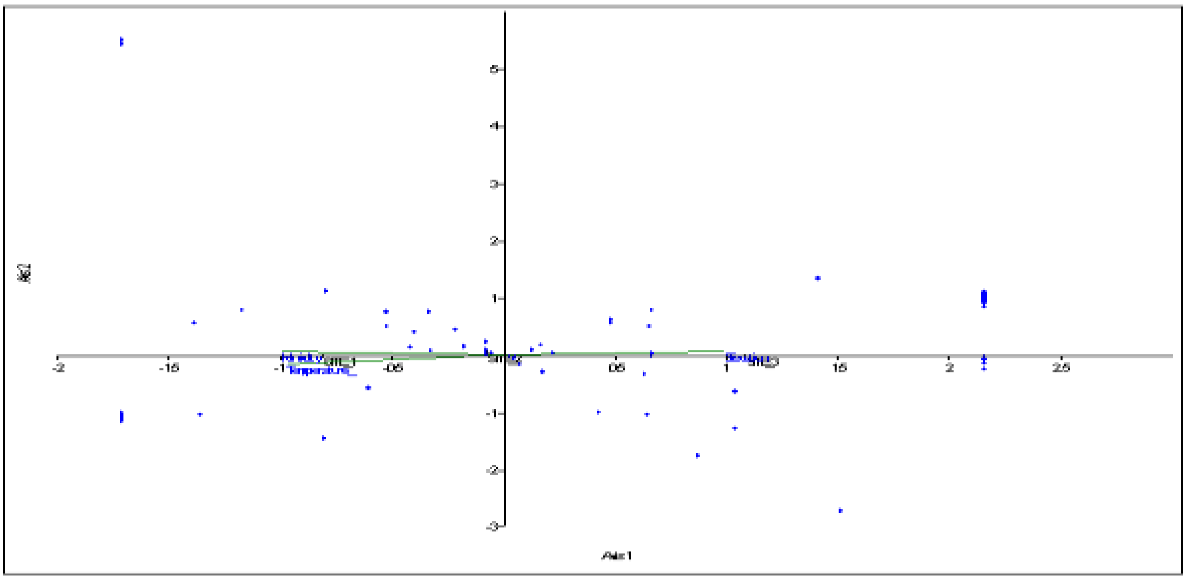

Fig. 4. An ordination diagram showing the relationship of temperature, elevation and relative humidity to the abundance of spider species per sampling site.

The rest of the species were not directly associated with the environmental factors (altitude, air temperature and relative humidity). Some spider species live on the ground and are not directly affected by the shift of vegetation structure (Quasin and Uniyal, 2011) while others are reliant on the type of their habitat associated with their foraging manner thus vegetation affects their population. Additionally, there are many factors that determine the species composition at a site and not simply the habitat type. According to Pinkus *et al.* (2006), vegetation as well as several abiotic and biotic factors such as web structure, humidity, shading, and presence of prey influence the presence of spider species and their diversity in the area.

Conclusion

Brgy. Baganihan, Marilog District, Davao City has a relatively high species richness of spiders. Across the sampling sites, spiders were richly distributed in secondary forest where vegetation was dense compared to the primary forest and agroecosystem where anthropogenic disturbances were observed. Vegetation and habitat disturbance influence the diversity and abundance of the spider species. Temperature and humidity were also seen to influence the distribution of spider families.

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References

Abrenica-Adamat LR, Torres MAJ, Barrion AA, Barrion-Dupo AL, Demayo CG. 2009. Salient features of the orb-web of the garden spider, *Argiope luzona* (Walckenaer, 1841) (Araneae:

Araneidae). Egyptian Academic Journal of Biological Sciences **1(1),** 73- 83.

Ballentes MG, Mohagan AB, Gapud VP, Espallardo MCP, Zarcilla MO. 2006. Arthropod Faunal Diversity and Relevant Interrelationships of Critical Resources in Mt. Malindang, Misamis Occidental. Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA), 1-166 p.

Barrion AT. 2001. Spiders: natural biological control agents against insect pests in Philippine rice fields. Transactions of the National Academy of Science and Technology **23,** 121-130.

Barrion AT, Villareal SS, Catindig J, Cai D, Yuan QH, Heong KL. 2012. The spider fauna in the rice agricultural landscape of Hainan Island, China: Composition, abundance and feeding structure. Asia Life Sciences **21(2),** 625-651.

Bowden JJ, Buddle CM. 2010. Determinants of ground-dwelling spider assemblages at a regional scale in the Yukon Territory, Canada. Ecoscience **17(3),** 287-297.

Cabili MD, Nuñeza OM. 2014. Species diversity of cave-dwelling spiders on Siargao Island, Philippines. International Journal of Plant, Animal and Environmental Sciences **4(2),** 392-399.

Cardoso P. 2012. Diversity and Community assembly patterns of epigean vs. troglobiont spiders in the Iberian Peninsula. International Journal of Speleology **4(1),** 83-94.

Chua JC, Uba MO, Carvajal TM. 2014. A Rapid assessment of spider diversity in Kabigan Falls, Pagudpud, Ilocos Norte, Philippines. Philippine Journal of Systematic Biology **8,** 16-26.

Dacanay CC, Barrion-Dupo AA, Nuñeza OM. 2014. Rapid assessment of spider fauna of Pulacan falls, Zamboanga Del Sur, Philippines. Journal of Biodiversity and Environmental Sciences **5(1),** 455-464.

Dobel HG, Denno RE, Coddington JA. 1990. Spider (Araneae) community structure in an intertidal salt marsh: effects of vegetation structure and tidal flooding. Environmental Entomology **19,** 1356- 1370.

Enriquez CMD, Nuñeza OM. 2014. Cave spiders in Mindanao, Philippines. Extreme Life, Biospeology and Astrobiology Bioflux **6(1),** 46-55.

Foelix RF. 1982. Biology of spiders. Cambridge, Massachusetts. Harvard University Press, Cambridge.

Garciano DP, Nuñeza OM, Barrion-Dupo A. 2014. Species richness of spiders in Mt. Matutum, South Cotabato, Philippines. Journal of Biodiversity and Environmental Sciences **4(6),** 214-224.

Glime JM. 2013. Arthropods: Arachnida – Spider biology. In: Glime JM, (Ed). Bryophyte ecology. Bryological Interaction **2,** 7-2-1.

Gunnarsson B. 1990.Vegetation structure and the abundance and size distribution of spruce-living spiders. Journal of Animal Ecology **59,** 743-752.

Hammer O, Harper DAT, Ryan PD. 2001. PAST: Paleontological Statistic software package for education and data analysis. Palaeontologia Electronica **4(1),** 1-9.

Henderson TY. 2007. Diversity, Distribution, and Abundance of Ground Dwelling Spiders At Lick Creek Park, College Station, Texas. A Thesis. Master of Science in Entomology. Texas A&M University, 1-86.

Hodge MA. 1987. Macrohabitat selection by the orb weaving spider, Micrathenagracilis. Psyche **94,** 347–361.

Kremen C, Colwell RK, Erwin TL, Murphy DD, Noss RF, Sanjayan MA. 1993 Terrestrial arthropod assemblages: their use in conservation planning. Conservation Biology **7,** 796–808.

Malumbres-Olarte J, Vink CJ, Ross JG, Cruickshank RH, Paterson AM. 2013. The Role of Habitat Complexity on Spider Communities in Native Alpine Grasslands of New Zealand. Insect Conservation and Diversity **6,** 124–134.

Mascord R. 1980. Spiders of Australia: A Field Guide. Reed Books, Sydney, 128 p.

Nyffeler M. 2000. Ecological impact of spider predation in critical assessment of Bristowe's and Turnbull's estimates. Bulletin of the British Arachnological **103,** 321-339.

Nyffeler M, Benz G. 1987. Spiders in natural pest control: a review. Journal of Applied Entomology **103,** 321-339.

Pinkus MA, Ibarra-Nuñez G, Parra-Tabla V. 2006. Spider diversity in coffee plantations with different management in Southeast Mexico. Journal of Arachnology **34(1),** 104–112.

Platnick NI. 2013. The world spider catalog, version 13.5.American Museum of Natural History. Retrieved from http://research.amnh.org/iz/spiders/catalog.

Quasin S, Uniyal VP. 2011. Spider diversity along altitudinal gradient and associated changes in microclimate attributes in nandadevi biosphere reserve, Uttarakhand, India. ENVIS bulletin: Arthropods and their conservation in India (insects & spiders) **14(1),** 219 – 232.

Rodrigues E, Mendonça M Jr, Ricardo O. 2009. Spider diversity in a rice agroecosystem and adjacent areas in southern Brazil. Revista Colombiana de Entomología **35(1),** 89-97.

Rubio GD, Corronca JA, Damborsky MP. 2008. Do spider diversity and assemblages change in different contiguous habitats? A case study in the protected habitats of the Humid Chaco Ecoregion, Northeast Argentina. Environmental Entomology **37,** 419–430.

Thomas CD, Cameron A, Green RE, Bakkenes M, Beaumont LJ, Collingham YC, Erasmus BFN, De Siqueira MF, Grainger A, Hannah L, Hughes L, Huntley B, van Jaarveld AS, Midgley GF, Miles L, Ortega-Huerta MA, Townsend Peterson A, Philips OL, Williams SE. 2004. Extinction risk from climate change. Nature **427,** 145-148.

Topping RJ, Love GL. 1997 Spider density and diversity in relation to disturbance in agro-ecosystems in New Zealand. New Zealand Journal of Ecology **21(2),** 121-128.

Turnbull AL. 1973. Ecology of the true spiders (Araneomorphae). Annual Review of Entomology **18,** 305–348.

Uetz, GW. 1991. Habitat structure and spider foraging. In Bell, S. S., McCoy, E. D., and Mushinsky, H. R. (eds.), Habitat Structure, the Physical Arrangement of Objects in Space, Chapman and Hall, London, 325–348.

Uetz GW, Halaj J, Cady AB. 1999. Guild structure of spiders in major crops. The Journal of Arachnology **27,** 270–280.

Van Swaay C, Warren M, Lois G. 2006. Biotope use and trends of European butterflies. Journal of Insect Conservation **10,** 189–209.

Ward L. 2007. Habitat Specificity of Selected Spiders of Dominica. Texas A&M University, Study Abroad Dominica Program, 1-16 p.

Warui CM, Villet VH, Young TP, Joque R.

2005. Influence of grazing by large mammals on the spider community of a Kenyan Savanna biome. Journal of Arachnology **33,** 269–279.

Whitmore C, Slotow R, Crouch TE, Dippenaar Schoeman. 2002. Diversity of spiders (Araneae) in a savanna reserve, Northern Province, South Africa. Journal of Arachnology **30(2),** 344-356.

Wise DH. 1993. Spiders in Ecological Webs. Cambridge University Press. Cambridge, 328.