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Species richness of spiders in Mt. matutum, South Cotabato, Philippines

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Abstract

Araneae (spiders) is a widespread order found almost anywhere in the world. It is well-adapted to different habitats. his pioneer study was conducted to determine species richness and abundance of spiders in Mt. Matutum, South Cotabato, Philippines. Sampling was conducted for five field days from November 18-22, 2013 for 70 man-hours at five sites with elevations of 1100, 1200, 1300, 1400 and 1500 meters above sea level using sweep netting and vial-tapping. Twenty-three spider species belonging to nine families were collected. Highest species richness was recorded in site 2 at an elevation of 1200 meters above sea level, after which species richness decreased with increasing elevation. *Leucauge decorata* of family Tetragnathidae was the most abundant species. Results indicate that elevation and habitat type affect the species richness and abundance of spiders.

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Introduction

The Philippines is the second largest archipelago in the world (Ong, 2002), and due to its geographical isolation, diverse habitats and high rates of endemism (Garcia *et al.,* 2014) it is recognized as one of the 17 megadiverse countries with 70-80% of the earth's biological diversity (Ong, 2002). The Philippines contains 895 butterfly species (CEPF, 2001), 300 Odonata species (Hämäläinen and Muller, 1997) and around 1,000 species of ants with only 394 species currently known (Alpert and General, 2014). Among the many organisms mentioned that thrive in the Philippines are spiders, which is one of the most diverse group of organisms (Wankhade *et al.,* 2012) that play major role as predators of arthropod pests (Topping and Lövei, 1997) and are best biological control agents that significantly reduce the prey densities in crops (Symondson *et al.,* 2002). They are characterized by the presence of many endemics, at both the genus and species levels (Deltshev, 2008). Today, there are more than 40, 000 known spider species in the world (Braitberg and Segal, 2009) that are 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 (Barrion, 2001) which makes spiders ranked as the seventh most diverse order worldwide (Cardoso, 2012).

Spiders are found in a variety of habitats (Enriquez and Nuñeza, 2014), from the peaks of every high mountain range to the depth of largest caves, from damp marsh to dry desert (Uniyal, 2004) including human reformed areas like agricultural landscapes (Barrion *et al.,* 2012). Their appearance today can be traced back to their ancestors from the early Tertiary Period (Chetia and Kalita, 2012), and their various adaptations including the ability to utilize self-produced silk contributed greatly to their survival. However, many spiders are sensitive to minute changes in the environment (Wankhade *et al.,* 2012) which in turn may affect their distribution and (Bonte *et al.,* 2002) assemblages by variations of plant community structure, ecosystem dynamics (disturbance) and abiotic factors.

In temperate regions, spiders are well studied while tropical areas have relatively less investigation (Chen and Tso, 2004). A study of Freitas *et al.,* (2013) in Brazil showed that areas exposed to human settlements had higher spider diversity indices and evenness values when compared to preserved areas. Maelfait and Hendrickx (1998) in Belgium reported that spiders are also good bio-indicators for evaluating the effects of anthropogenic disturbance on natural ecosystems. In the Philippines, studies on spiders are limited only to rice fields and the surrounding area but it has the highest record in all of Asia's tropical rice fields (Barrion, 2001). Royauté and Buddle (2012) reported that there is evidence that synchronization with habitat changes and disturbances are present in species that are dominant in agricultural fields. Most spiders are as ecologically specialized as the prey groups they rely on (Mcdonald, 2007). This information can tell us how different habitats supporting different prey groups affect spider richness and diversity. The quantity of species and their relative abundance help in describing spider communities (Sørensen *et al.,* 2002).

In Mindanao, the second largest Island in the Philippines (Knack, 2013), studies on terrestrial arthropods include those of Ballentes *et al.,* (2006) who reported 51 species of spiders in Mt. Malindang Range Natural Park; Enriquez and Nuñeza (2014) who reported on species richness and diversity of cave spiders in Mindanao and Abrenica-Adamat *et al.* (2009) who studied the stabilimenta of *Argiope luzona* in a banana plantation in Barangay Dalipuga, Iligan City. However, no data on spiders have been reported in Mt. Matutum.

Mt. Matutum is a protected landscape declared under Presidential Proclamation Number 552, s. 1995 and is also a tentative UNESCO world heritage site. It is a highly elevated land formation. Variations to climatic conditions brought about by the increasing elevation may imply that the environment could be different in the highlands compared to the lowlands. This study aimed to determine species richness and species distribution of spiders at varying elevations in Mt. Matutum Protected Landscape, South Cotabato.

Materials and methods

Study Area

The sampling site is Mt. Matutum (Fig. 1) located in Barangay Maligo, Municipality of Tupi, South Cotabato, approximately 30 km heading northwest from General Santos City. A 2 km transect was set up where five sites according to elevation (1100, 1200, 1300, 1400, 1500 meters above sea level) were selected.

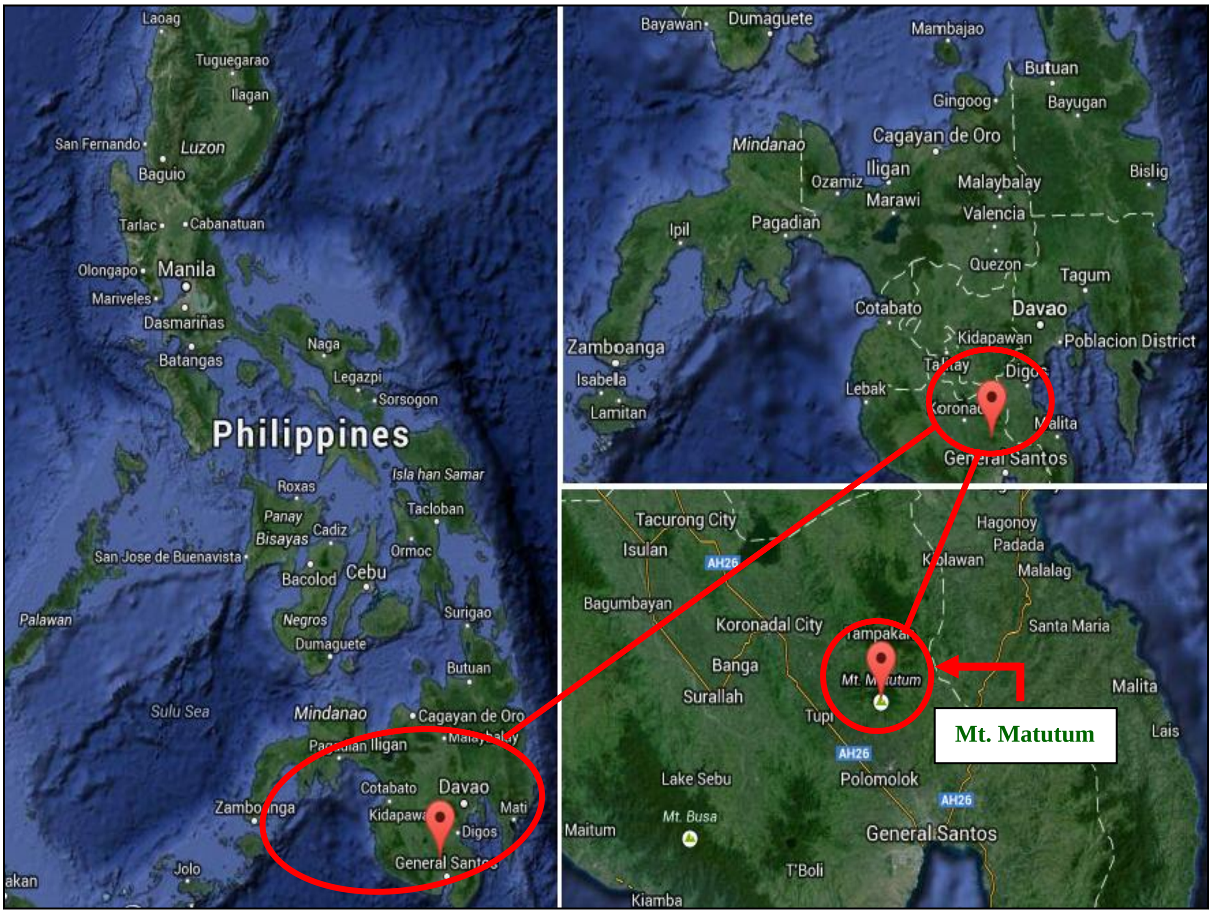

Fig. 1. Map of the Philippines and the study area (Googlemaps.com, 2014).

Sampling Methods

Sampling was conducted for five field days for a total of 70 man- hours from Nov. 18-22, 2013. Collection in every site extended 10m on each side heading perpendicular from the transect to provide an extensive area for sampling. Spider microhabitats like fallen logs and crevices were thoroughly checked for ground-dwelling spiders while leaves of trees and visible webs were searched for arboreal spiders. Conventional collection techniques were used like sweep nettingand vial-tapping. 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 80% ethanol. The third author identified the specimens at the University of the Philippines Los Baños Museum of Natural History.

Sampling Sites

Site 1 has an elevation of 1100 masl. It is partly being used for agricultural purposes. Some areas in the site were burned as evidenced by charred soil and plants. Sugar cane (*Saccharum* sp.) and ferns were common in this area.

Site 2 is at 1200 masl. Eggplants and tomatoes were cultivated near this site with some areas containing wild plants like wild strawberries (*Fragaria* sp.), grasses and shrubs.

Sampling sites 3 and 4 at elevation of 1300-1400 meters above sea level (masl) are in a montane-mossy forest where canopy cover decreases penetration of sunlight to the forest floor. Among the flora found in these sites are figs (*Ficus* sp.), cinnamon (*Cinnamomum mercadoi*), rattan (*Calamus* sp.), along with ferns and vines. Forest floor is covered by leaf litters and fallen logs, which are common microhabitats of ground-dwelling spiders.

Site 5 is located at an elevation of 1500 masl. This area was the least disturbed among the five sites with numerous moss-covered rocks. Balete (*Ficus balete*) and cinnamon (*Cinnamomum mercadoi*) were found in this area. The area is generally moist due to the high elevation.

Data Analysis

Biodiversity indices were computed. Paleontological Statistics Software Package (Hammer *et al.,* 2001) was used to correlate the sampling sites with the spider species collected and to determine if elevation affects species diversity.

Results and discussion

Species richness

Fifty individuals belonging to 23 species under 19 genera and nine families were collected (Table 1). Six species are probably new to science. A lower number of spider species in the caves of Siargao Island was recorded by Cabili and Nuñeza (2014) and in the caves of Mindanao (Enriquez and Nuñeza, 2014). However, a higher number of species and species that are new to science was recorded by Barrion *et al.*, (2012) in the agricultural landscape of China. According to Barrion (2001), spiders are common in agroecosystems due to the abundance of prey and this may be the reason for the abundance of spiders in Site 2. Mcdonald (2007) reported that spiders are as ecologically specialized with their prey group and are essential control agents for agroecosystems (Sudhikumar *et al.,* 2005a). The highest species richness was recorded at site 2, which is being utilized for agriculture. The second highest species richness was obtained from sites 1 and 3. Site 1 is being converted for agricultural purposes through slash-and-burn which may have caused disturbance to potential prey therefore decreasing spider richness. Horváth *et al.*, (2009) observed that overgrazed habitat was characterized by low number of spider species. Barrion (2001) stated that spider diversity is affected by low prey density in overgrazed and burned habitats. Site 3, a montane-mossy forest where canopy cover decreases the penetration of sunlight to the forest floor has low spider richness. Yanoviak *et al.* (2003) reported that the abundance of spiders is generally lower in the forest canopy than the understory. Among all the species collected in this study, *Leucauge decorata* (Walckenaer, 1841) was the most abundant (28%). Most of the individuals were collected in sites 1 and 2 around the crop fields on low bushes where their orb webs were easily found. Yadav *et al.,* (2012) reported that *Leucauge decorata* is a diurnal species found on paddy plants and on bushes near crop fields. Site 2 had more species than site 1 although their vegetation type is similar. Sites 4 and 5 which are located in the mossy forest at higher elevations had lower species richness. This result coincides with the findings of Quasin and Uniyal (2011) that species diversity of spider decreases with increasing elevation due to their sensitivity to small changes in the environment, especially changes in the vegetation, climate and topography. The patterns of linear decline are probably related to the more severe climatic conditions, leading to species declines and absence of less tolerant species. Bowden and Buddle

(2010) reported that 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. According to Gill *et al.,* (2013) there is a typical knowledge among ecologists that species richness decreases as elevation increases and this explains why spider richness has decreased starting at the elevation of 1300 masl.

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

Species	Site 1 1100 masl	Site 2 1200 masl	Site 3 1300 masl	Site 4 1400 masl	Site 5 1500 masl	Total	RA (%)
1.) Araneidae							
Arachnura sp. nr. *Angora*	0	0	3♀	0	0	3	6
Cyclosa hexatuberculata Tikader, 1982	0	2♀	0	0	0	2	4
Cyclosa insulana (Costa, 1834)	0	1♀	0	0	0	1	2
Cyrtophora unicolor (Doleschall, 1857)	0	0	1♀	0	0	1	2
Neoscona bengalensis Tikader & Bal, 1981	0	1♀	0	0	0	1	2
Neoscona molemensis Tikader & Bal, 1981	3♀	0	0	0	0	3	6
Neoscona sp.	0	2i	0	0	0	2	4
Neoscona vigilans Blackwall, 1865	0	1♀	0	0	0	1	2
Parawixia dehaani Doleschall 1859	0	0	0	0	1 ♀	1	2
2.) Ctenidae							
Ctenus sp.	0	0	1♂	0	0	1	2
3.) Lycosidae							
Pardosa sp.	0	1	0	0	0	1	2
4.) Psechridae							
Fecenia sp.	1i	0	0	0	0	1	2
Psechrus singaporensis (Thorell, 1894)	0	0	1♀	0	1♀	2	4
5.) Salticidae							
Harmochirus brachiatus (Thorell, 1877)	1♀	0	0	0	0	1	2
6.) Sparassidae							
**Heteropoda* sp.1	1i	0	0	7 (3♂, 1♀, 3i)	0	8	16
**Pandercetes* sp.	0	0	1♂	0	0	1	2
**Pandercetes* sp.2	0	0	1♂	0	0	1	2
7.) Tetragnathidae							
Leucauge decorata (Walckenaer, 1841)	6♀	7 (6♀, 1i)	1♀	0	0	14	28
**Okileucauge* sp.	1♀	0	0	0	0	1	2
**Tylorida* sp.	0	1♀	0	0	0	1	2
8.) Theraphosidae							
Phlogiellus sp.	0	0	0	1i	0	1	2
9.) Theridiidae							
**Chrysso* sp.	1♀	0	0	0	0	1	2
Steatoda sp.	0	1♀	0	0	0	1	2
Total number of individuals	14	17	9	8	2	50	
Total number of species	7	9	7	2	2	23	
Total number of Families	6	4	5	2	2	9	

♀ - Female, ♂ - Male, i – immature. RA (%) – Relative Abundance. * - possibly new species.

Family Araneidae was mostly seen in Sites 1, 2 and 3. Their webs were easily seen on low-lying shrubs and tree branches. The same observation was also obtained by Quasin and Uniyal (2011) in Uttarakhand, India. Armendano and Gonzalez (2011) reported that family Araneidae is abundant in the herbaceous layer of both the margins and crops Three species under family Sparassidae were recorded in this study. According to Edwards (2009), Sparassidae spiders are extremely valued in tropical countries as they prey on cockroaches. Two species belonging to genera *Psechrus* and *Fecenia* under family Psechridae were collected in sampling sites 1 and 3. The genera *Fecenia* Simon 1887 are spread from China, Southeast Asia to Papua New Guinea (Wang and Yin, 2001).

The genera *Chrysso* and *Steatoda* of family Theridiidae were collected in sampling sites 1 and 2 and were also found by Levi and Randolph (1975) in the state of New Mexico, USA. There was only one species of Salticidae recorded in this study, although Peng *et al.,* (2001) stated that it is the most diverse taxon in order Araneae.

Collected samples of orb-weaving spiders (Araneidae and Tetragnathidae) were mostly females. Sherman (1994) reported that significant variations in the web construction of spiders exist primarily at, or above the species level. Hand picking has proven effective for capturing foliage runners (Salticidae), ground runners (Ctenidae, Lycosidae, and Sparassidae) and burrow dwellers (Theraphosidae) in this study. Guild type varies on the different habits of the spiders. Taxonomic relationships reflect related species since they utilize similar resources while taxa of distant relationships may not necessarily belong to the same guild (Uetz *et al.,* 1999). Enriquez and Nuñeza (2014) studied the cave spiders of Bukidnon and Davao Oriental and found certain species like *Heteropoda* sp.1, *Heteropoda* sp.2 and *Ctenus* sp., which are the same genera as the ones collected in Mt. Matutum.

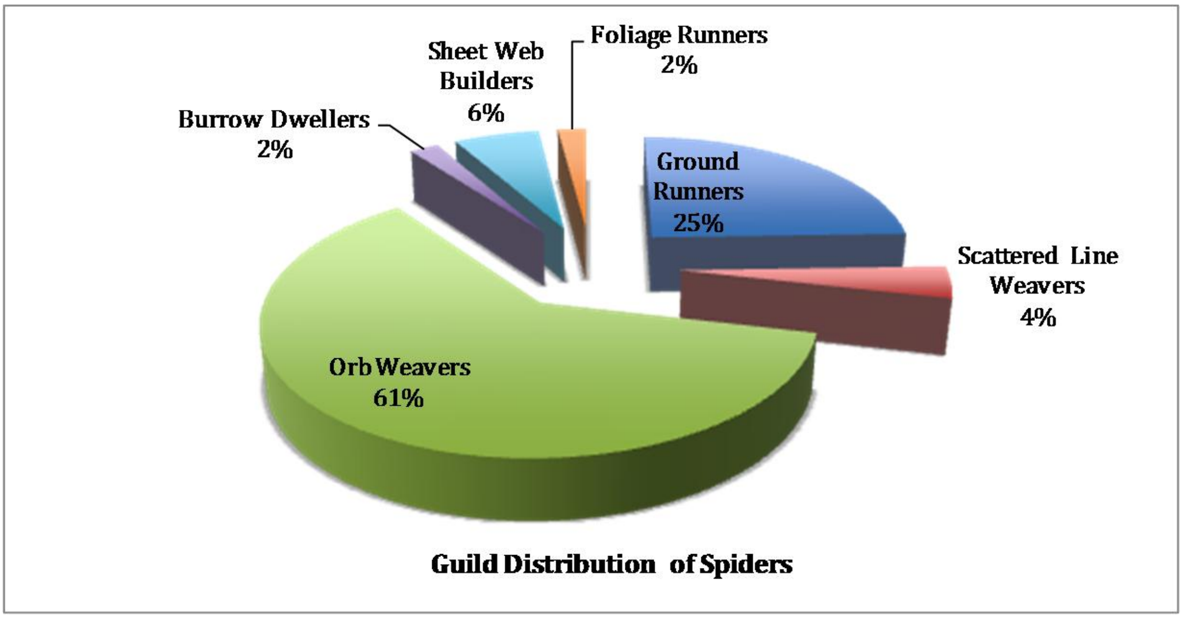

Fig. 2. The distribution of Araneae in Mt. Matutum according to guilds.

Spider richness per guild

The most dominant guild is the orb weavers 61%) composed of families Araneidae and Tetragnathidae which were mostly collected in the agroecosystems, in sites 1 and 2 (Fig. 2). The same result was obtained by Barrion *et al.* (2012) in their study in the rice agricultural landscape of Hainan Island, China. Orb webs were frequently encountered at the shrubs and grasses. Ground runners (Ctenidae, Lycosidae and Sparassidae) and burrow dwellers (Theraphosidae) that were collected on fallen logs and leaf litters were found common in the mossy forests of sites 3, 4 and

5. One foliage runner (Salticidae) was caught on a wild strawberry plant (*Fragaria* sp.) near the upper end of site 1. Sheet-web builders (Psechridae) were collected at sites 1, 3 and 5 indicating their presence in both agroecosystems and primary forest. Seyfulina (2005) reported that abiotic (soil acidity, soil moisture, organic matter content) and biotic (wheat ear height, weed abundance, plant biomass) factors have different impacts on the distribution of different spider groups and these factors can also change the habitat structure. The differences in web support structures brought about by the differences in microhabitats also affect spider density (Balfour and Lypstra, 1998).

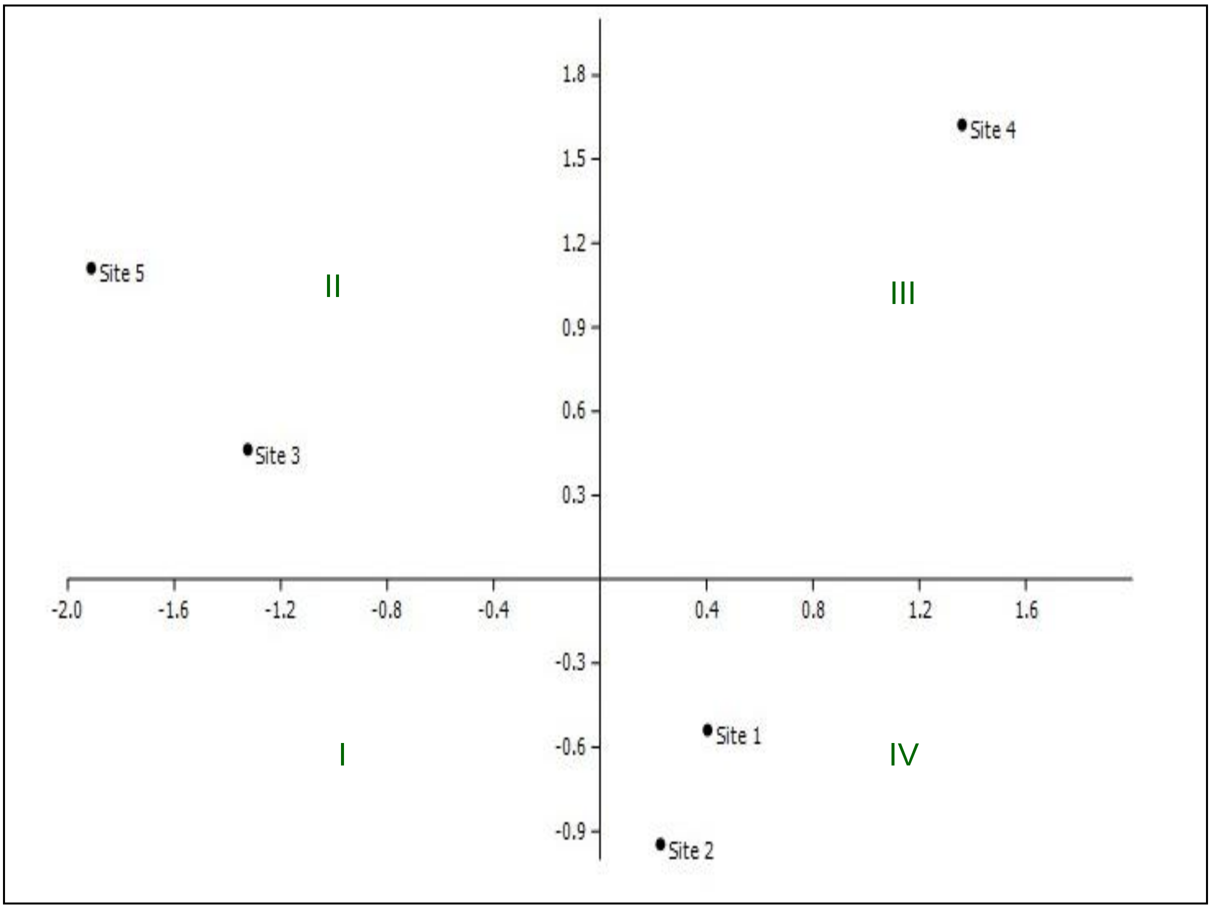

Fig. 3. Canonical Correspondence Analysis (CCA) of Araneae species of the five sites using PAST.

Similarity of spider species collected per sampling site

Fig. 3 shows the canonical correspondence analysis, using Paleontological Statistics Software Package (PAST). In general, the quadrants showed the different sites clustered into habitat types. The most similar species collected in sites 1 and 2 is *Leucauge decorata*. This result further correlates the similarity of the two habitats as agricultural sites and their grouping together in quadrant 4. According to Sudhikumar *et al.,* (2005b), vegetation affects distribution to the family level because same families cluster within the same vegetation type. Pinkus *et al.,* (2006) stated that vegetation as well as several abiotic and biotic factors such as web structure, temperature, humidity, shading, and presence of prey influence the presence of spider species and their diversity in an area. Species found in the mossy forest is less likely to be collected in the agricultural areas. Sites 3 and 5 were grouped together into quadrant 2. The two individuals of *Psechrus singaporensis* were only found in these sites. Even though Site 4 is in the mossy forest, where seven individuals of *Heteropoda* sp. were collected, another individual was collected in the lower elevation of site 1. Cabili and Nuñeza (2014) recorded the same genus, *Heteropoda* sp. in the seven cave sites of Siargao Island, Philippines having a lower elevation of 29-60 masl compared to the recorded elevation of this study indicating that the genus *Heteropoda* could be found in different elevations.

Biodiversity indices

Table 2 shows the biodiversity indices of the five sampling sites. Diversity is higher in the lower elevations with site 2 having the highest diversity. A more or less even distribution was noted in sites 1, 2, 3, and 5. The distribution in sampling site 4 is uneven indicating the dominance of *Heteropoda* sp. 1. In Mt. Matutum, reformed habitats brought about by agricultural activities are usual as it is the common means of living for the local people. Hajian-Forooshani *et al.,* (2013) stated that elevation is also the most important factor driving species richness. Yanoviak *et al.,* (2003) reported that richness and abundance of spiders is due to the lower elevation or greater habitat complexity of the area. Results in this study however, showed that the highest spider species richness is at 1200 masl. This could also be because the area has a lot of shrubs which are ideal habitats for spiders. It is also easier to spot spiders in the cleared area than in the forest.

Table 2. Biodiversity indices of the five sampling sites.

Indices	Site 1 1100 masl	Site 2 1200 masl	Site 3 1300 masl	Site 4 1400 masl	Site 5 1500 masl
Species	7	9	7	2	2
Shannon	1.6357	1.8689	1.8310	0.3768	0.6931
Evenness	0.6198	0.6596	0.8333	0.1811	1

Effects of elevation to species richness of spiders

Fig. 4 shows the linear bivariate model of the five sites using Paleontological Statistics Software Package (PAST). It was found that diversity correlated with elevation. It showed that species diversity decreased as elevation increased. But with an r value of -0.7673 and p value of 0.1299, it showed that the decrease in diversity with elevation is insignificant in this study. Probably this is due to the fact that the number of individuals reported was low. Grill *et al.,* (2005) stated that species richness of spider is significantly, negatively correlated with elevation. The same finding was obtained by Quasin and Uniyal (2011) in their study in the Nanda Biosphere Reserve in India that species diversity has a negative correlation with elevation.

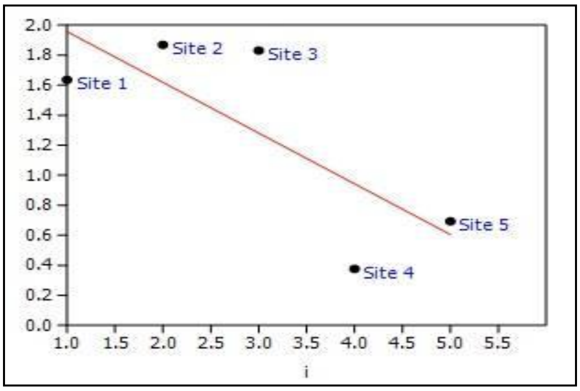

Fig. 4. The trend of decreasing species diversity (red line) with respect to the elevation of the 5 sites (Site 1 = 1100masl, Site 2 = 1200masl, Site 3 = 1300masl, Site 4 = 1400masl and Site 5 = 1500masl).

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