INNSPUB

Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 24, No. 1, p. 77-91, 2024
http://www.innspub.net

RESEARCH PAPER OPEN ACCESS

# Biodiversity of diversity of spiders (*Aranaea*) in Tangub City, Philippines with analysis of habitat complexity aided by drone photography

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Article published on January 13, 2024

**Key words:** Spiders, Species diversity, Habitat complexity, Fractal index, Tangub city

**Abstract**

This study aimed to assess the biodiversity of spiders and their habitat complexity in Tangub City, Misamis Occidental, Philippines. The study utilized sweep netting and visual searching in established transect-quadrats on four sites namely; Mangrove forest of Barangays Maloro and Silangga, the City Courtyard and Northwestern Mindanao State College of Science and Technology from October 25-November 20, 2019. Results indicated a high degree of spider (Aranaea) diversity in Tangub City. The highest species diversity was found in site 4 Sulaton Island, Silangga (H=2.8705) and the lowest species diversity (H=2.3230) and richness (13 taxa) was found in the City Courtyard. A total of 388 individual spiders under 8 families, 11 genera and 23 species were trapped and identified. Physical parameters such as air temperature and relative humidity were observed as directly affecting the abundance of spiders in each habitat. Fractal analyses indicated all sites had low differences in terms of the fractal index and therefore fractal analysis could not be utilized as metric for assessing diversity in this study.

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## Introduction

Spiders belong to the Order Araneae, Class Arachnida in the Phylum Arthropoda. Spiders are a highly diverse group containing some of the largest land-dwelling arthropods. Spiders are featured subjects in various ecological studies as bio-indicators of environmental health and biodiversity (Bishop and Ricchert, 1990; Ricchert and Lockley, 1984). There are more than 114 families of spiders, 3,905 genera, and 44,032 species (Alviola *et al.*, 2017). In the Philippines there are 517 identified species belonging to 225 genera and 38 families, and this number is expected to increase as further taxonomic studies are completed (Alviola, *et al.*, 2017).

As apex predators, spiders are keystone species in both agricultural and natural habitats (Chua *et al.*, 2014). They serve as bio-indicators for monitoring environmental quality, and are effective control of arthropod pests in different agricultural habitats (Clausen, 1986; Churchill, 1995). Spider distribution and abundance can be habitat-dependent (Koneri and Nangoy, 2017). Some family groups display habitat preferences while others' preferences may be more closely tied to environmental factors such as temperature and humidity (Maefait and Hendrickx, 1998). Despite their recognized ecological significance, spiders' abundance and species richness have been confronted with various external disturbance such as habitat loss, and degradation posed by an overwhelming utilization of finite resources (Padua and Ontoy, 2014). Studies have shown urbanization negatively affects biodiversity by increasing disturbance and habitat fragmentation of different species of spiders (Aranaea) in the ecosystem (Moorhead and Philpott, 2013). Short-term ecological assessments regarding spider diversity and distribution are important measures for monitoring and determining methods for sustainable conservation of various species (Lapinig *et al.*, 2014).

In Mindanao, Philippines ecological studies of spiders have been investigated by Nuneza *et al.* (2014) on species richness in the caves while Knack (2013) recorded 51 species of spiders in Mt. Malindang Range Natural Park. Abrenica-Adamat *et al.* (2009) investigated the population stability of *Argiope luzona* in selected Mindanao banana plantations while Garciano *et al.* (2014) recorded 23 spider species in Mt. Matutum South Cotabato and Dacanay *et al.* (2014) listed 37 species of spiders at Pulacan Falls, Zamboanga City. Although there have been various studies accounting for spiders in Mindanao, no surveys had been carried out in Tangub City, Misamis Occidental. Species distribution information is needed to sustainably conserve spider species in Tangub City due to the continuous economic development and urbanization (Bolante, *et al.*, 2016).

Fractal analyses of land geography in the Philippines have been employed in past biodiversity studies (Purevtseren *et al.*, 2018). Fractals are repeating geometric patterns that are self-similar as scale increases and had been first used in ecology to measure coastlines (Mandelbrot, 1987). Further fractals have been used in the field of ecology in assessing habitat complexity and species diversity (e.g. prey-predator relationship, modelling coastal size, coral reef structures) (Kovelanko *et al.*, 2011**)**. Fractals are helpful in comparing complexity across ecosystems.

This survey documented spider diversity in Tangub City, Misamis Occidental. Additionally, this study sought to assess the usage of fractal index analyses on the complexity of habitats in terms of physical composition and likelihood of determining spider-preferring habitats. The study focused on determining species' diversity in two distinct types of habitats; mangroves and residential, where the disparate habitat types were theorized to differ in fractal complexity.

## Materials and methods

Spiders were trapped through opportunistic sampling where the researcher relied on a transect-quadrat method in order to triangulate the habitats where spiders were suspected to live then selectively choosing the spiders to be trapped to gather a representative sample. Computational software was used for the fractal dimension analyses of the habitats while The Shannon index through Paleontological Statistics Software (PAST) was employed to compute species diversity. The resulting values were utilized to determine the significant difference between habitats and fractal complexity of rugged and smooth environments. The study utilized the Box-Counting method as described by Longly and Batty (1989) for analyzing complex patterns by breaking data set, object, and images into smaller compartments. Box-Counting was used to find the rate of change in complexity with scale, as well as measure of heterogeneity of various biological components of the habitats.

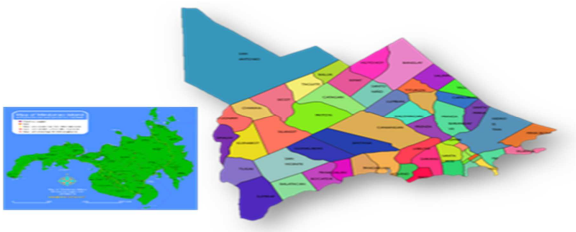

**Fig. 1.** Map of the study site

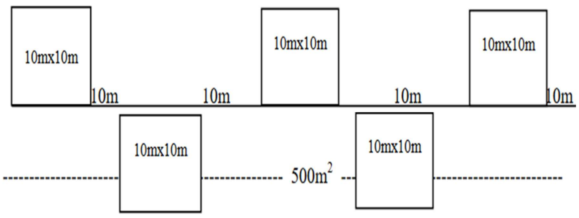


**Fig. 2.** Diagram of the Transect-Quadrat Method

*Site selection and locations*

The study was conducted in Tangub City, Province of Misamis Occidental (Fig. 1). The City is composed of fifty-five barangays (Philippine Administrative Divisions) spread over a land area of 16,572 hectares. The topography is approximately 40% plain along the coast of Panguil Bay and 60% rolling hills, gradually rising to the slopes of Mt. Malindang (Lapinig *et al.*, 2014). Mangrove forests (in Maloro and Sulaton Island, Silangga) are considered viable spider biomes because of the complex structure of Mangrove tree branching and leaf covers (Primavera, 2007). Mangrove forests utilized for this study were located at: (a) Barangay (a) Maloro- 8003'19.0"N 123045'30.9"E, and (b) Sulaton Island, Silannga- 8003'53.4"N 123046'20.3"E. These barangays served as representations for high fractal complexity of habitats as well as biodiversity because of their structure, mangrove composition, and topography (Lapinig *et al.*, 2018).

The presumptive smooth areas of the City, City Courtyard and NMSCST ground, are highly urbanized where many natural sites were developed, potentially affecting spider biodiversity within the site area. These areas are urbanized due to major shifts in educational developments, urban centered areas in the City, and for the purpose of boosting economy. Two distinct sites were selected based on the number of physical structures at the sites. These areas are: City Courtyard located in upper Maloro- 8003'38.0"N 123045'02.5"E., and academic institutions such as Northwestern Mindanao State College of Science and Technology (Brgy. Labuyo)- 8003'33.9"N 123043'16.1"E. The physical structures of these terrestrial habitats are presumed smooth/simple in nature because of standardized building development processes.

*Sampling and identification*

Transect-Quadrat method (TQM) was employed to quantify the likely relative abundance of spiders within the sampling points. The identified areas such as the mangrove forest and residential areas in Tangub City were stationed with 50-meter transect line distance with 3 replicates. The total distance (500m) was divided into five (5) similar plots with 10mx10m perimeter. Each plot was measured with 10-meter length from one another to allow for random quantification of the expected spiders' species in the area. The diagram of this method is shown in Fig. 2.

Spider sampling in the coastal environment (mangrove forests) was done during low tide to allow for easy access and deeper exploration in the mangrove forest as described by Davies and Tsomides (2002). Spiders collected were preserved in 10% formalin on site and transported to the laboratory.

Spiders (defined as taxa >1 mm in size and visible to the naked eye) were identified and enumerated using a checklist of Araneae species as described by Nuneza *et al.* (2016) and the World Spider Database (Platnick, 2008). Trapping of spiders was completed through sweep-netting where approximately (10mm) passes of the net were made for approximately 20-30 minutes and visual inspection where a walk through the habitat to search visually for spiders, their webs or retreats (cured leaves, silken cases) was completed for 2 hours. All specimens collected in the field were preserved in an absolute 100% ethyl alcohol solution. After each sampling, initial sorting of all the collected specimens took place based on their taxonomic characteristics.

All collected spider specimens were taxonomically identified down to species level (when possible) to ensure that diversity of the target taxa was captured (Platnick, 2013). Final identification of species was made with the assistance of taxonomists at Mindanao State University-Iligan Institute of Technology, (Dr. Olga Nuneza), the World Spider Database (Platnick, 2008), and the University of the Philippines-Los Banos (Dr. Aimee Lynn B. Dupo) and compared the sample species of spiders with the voucher specimen collections of the National Museum of the Philippines, and published articles of the International Union for Conservation of Nature (IUCN).

*Habitat assessment*

Qualitative descriptions and assessments of spider habitats were made during collection. Habitat variables such as relative humidity and air temperature were measured during the sampling hours for a period of 22 days which incurred ten-man hour in the nighttime and ten- man hours in the day with the use of psychrometer and thermometer (RS Pro Psychrometer, Philippines). Air temperature was measured with thermometer (RS Pro Thermometer, Philippines), the day and night temperature of air in every sampling point and every micro-habitat of macroinvertebrates was measured (average with Standard Deviation) while relative humidity was measured by relative humidity meter of air volume. Average values were determined from scaling points, from 20 up to present measure.

*Photography for fractal index*

A 20-megapixel drone camera (DJI Mavic 1 Zoom, RS Components Philippines) was mounted at 80 ft elevation and captured the entire area of the habitat at 500m2. All shots were taken uniformly throughout the four sampling sites in order to ensure that all images will be equally analyzed in the software. All shots were taken uniformly throughout the four sampling sites to ensure no biases on the results of the results of the fractal analysis.

*Statistical analysis*

The Shannon index (eq. 1) was used to determine the diversity and complexity of spiders' species. In the Shannon index, p is the proportion (n/N) of individuals (n) of one particular species found divided by the total number of individuals found (N), ln is the natural log, Σ is the sum of the calculations, and s is the number of species.

The similarity index (eq. 3) determines the interspecific association between the species of plant communities. Sorensen similarity index was used to determine and compare the similarities of plant species in transects A and B, A and C, A and D, and B and C, B and D, and C and D because the plots and transects are of equal sizes. Sorensen's species similarity index (SI) between the transects and the two sites was calculated according to Nath *et al.* (1986) where C is the number of species in sites a and b; a and b are the number of species in sites a and b.

Geographic fractal data collected were analyzed through Frackout! (v. 3.0, Benoit, Fractal Analyses System) software which was used to compute the fractal dimensions of habitat. This was done by taking photograph images on the habitat structure together with its species compositions. A camera (Cannon-600D, Japan) mounted by drone with a minimum of 20 mega-pixel resolution and above was used to capture the habitat area and was converted into black and white quality.

Fractal dimension (D) in each area was used as basis for categorizing the selected habitats as smooth, slightly rugged, and rugged habitats. The basis of comparison of the sites' fractal dimension (D) was set at 15.9844 cell size. This cell size was found to be more manageable by having enough number of cells which are not too large and not too small while performing the analysis. The software then (eq. 1) computed the possible fractal dimension of the area given the quality of the photographs. The resulting values of the fractal dimensions of the habitat (per quadrat) was used to categorize the type of habitat such as D = 0-0.9 = smooth habitat, D = 1.0-1.3 = slightly rugged habitat, and D = 1.4- beyond = rugged habitat (Mandelbrot, 2012). Frak-Out Software (3.0) was used to calculate the fractal dimension of the habitat following an equation:

$$\lambda = \lim_{\varepsilon \to 0} \frac{\log N(\varepsilon)}{\log \frac{1}{\varepsilon}}$$

*Hazards statement*

All Northwestern Mindanao State College of Science and Technology and Mindanao State University safety policies and precautions were observed. Labeled instructions were followed for the use of all chemical agents including the donning of recommended PPE. Before sampling the researcher obtained a permit from the Department of Environment and Natural Resources (DENR) of the Philippine national government.

## Results

*Species diversity*

A total of 388 individual spiders belonging to 23 species, 11 genera under 8 families (Table 1) were collected. A total of 38 individuals were brought to the Museum of Natural History in the University of the Philippines-Los Banos, Laguna for species validation and taxonomic classification by the UPLB Arachnid expert, Dr. Aimee Lynn B. Dupo. Of the 38 specimens, 31% were identified up to family, 8% were identified up to genus, and the rest were identified up to species level. A total of 31 individual of spiders at site 3 at the City Courtyard (Table 4) were recorded with a fractal index of D= 1.93098 which implies that the area was slightly disturbed. The highest number of spiders individuals (188) was recorded in site 4 in Sulaton Island, Silangga (Table 5) with a fractal index of D= 1.93951 which showed variable assumptions that the site was more complex.

Table 1 displays the total number of individual spiders recorded in each site with their corresponding relative abundance. The mangrove areas (Maloro = 120 & Sulaton Island, Silangga = 188) have the highest number of individual spiders compared to the other two sites (NMSCST = 49 &City Courtyard = 31). The lowest number of individuals and species of spiders found was recorded in Tangub City Courtyard with only 31 individuals. Sampling at site 4 in Sulaton Island, Silangga resulted in the highest number of individual spiders (186) with almost all species/families are present except for *Orphnaecus kwebaburdeos* of the family Theraphosidae.

In Maloro (site 1), NMSCST (site 2), and in the city Courtyard (site 3), *Oxyopes javanus* registered the highest number of individuals and was the most abundant species with 58 individuals. At site 4, *Leucage decorata* dominated in the area. *Orphnaecus kwebaburdeos* registered the lowest (only 1 individual) number of individuals for the duration of the study of Tangub City. *O. kwebaburdeos* are very sensitive to their environment.

Table 2 showed the corresponding diversity indices of the spiders in the different sampling sites of Tangub City. Sites 1 (Maloro) and 4 (Silangga) have the same number of composition of species taxa (23), site 2 has 17 taxa, and site three has the lowest number of taxa (13). Shannon diversity analysis showed that site 4 has the highest diversity index (H=2.8705) followed by site 1 (H=2.8605), site 2 ranked third (H=2.4935) while site 3 has the lowest diversity (H=2.3230). In general, all sites registered medially per diversity of spider species.

**Table 1.** Number of individual spiders recorded in each site with its corresponding relative abundance

| Species | Site 1 Maloro | Site 2 NMSCST | Site 3 Courtyard | Site 4 Silangga | Total | RA (%) |
|---|---|---|---|---|---|---|
| *1. Araneidae* | | | | | | |
| *Cyclosa insulana* | 2 | 1 | 1 | 4 | 8 | 16 |
| *Argiope luzona* | 2 | 2 | 1 | 4 | 9 | 18 |
| *Nephila* | 1 | 3 | 0 | 6 | 10 | 20 |
| *Gasteracantha cancriformis* | 4 | 2 | 3 | 6 | 15 | 30 |
| *Neoscona nautica* | 2 | 1 | 2 | 5 | 10 | 20 |
| *Parawixia dehaani* | 3 | 3 | 0 | 5 | 11 | 22 |
| *Eriovixia* | 4 | 0 | 3 | 6 | 13 | 26 |
| *Neoscona vigilans* | 6 | 3 | 2 | 6 | 17 | 34 |
| *Acacesia* sp. | 7 | 2 | 2 | 6 | 17 | 34 |
| *Argiope appensa* | 4 | 2 | 2 | 5 | 13 | 26 |
| *Cyclosa* sp. | 5 | 3 | 0 | 5 | 13 | 26 |
| *Poltys illepidus* | 6 | 0 | 0 | 3 | 9 | 18 |
| *2. Oxyopidae* | | | | | | |
| *Oxyyopes javanus* | 20 | 11 | 5 | 22 | 58 | 116 |
| *3. Pholcidae* | 6 | 2 | 4 | 8 | 20 | 40 |
| *4. Salticidae* | | | | | | |
| *Salticidae* sp. 1 | 5 | 3 | 3 | 7 | 18 | 36 |
| *5. Sparassidae* | | | | | | |
| *Sparassidae* sp. 1 | 4 | 2 | 0 | 5 | 9 | 18 |
| *Heteropoda* | 5 | 2 | 0 | 5 | 12 | 24 |
| *6. Tetragnathidae* | | | | | | |
| *Leucage sp.* | 5 | 0 | 0 | 11 | 16 | 32 |
| *Tetragnatha* sp. 1 | 2 | 0 | 0 | 8 | 10 | 20 |
| *Tetragnatha* sp. 2 | 3 | 0 | 0 | 4 | 7 | 14 |
| *Tetragnatha* sp. 3 | 9 | 0 | 0 | 7 | 16 | 32 |
| *Leucage decorata* | 7 | 1 | 1 | 28 | 37 | 74 |
| *Leucage argentina* | 4 | 2 | 2 | 11 | 19 | 38 |
| *7. Theraphosidae* | | | | | | |
| *Orphnaecus kwebaburdeos* | 0 | 1 | 0 | 0 | 1 | 2 |
| *8. Thomsidae* | | | | | | |
| *Thomsidae* sp. 1 | 4 | 3 | 0 | 11 | 18 | 18 |
| Number of Individuals | 120 | 49 | 31 | 188 | 388 | |

**Table 2.** Diversity Indices in each sampling site

| Indices | Site 1 Maloro | Site 2 NMSCST | Site 3 City Courtyard | Site 4 Sulaton Island, Silangga |
|---|---|---|---|---|
| Taxa | 23 | 17 | 13 | 23 |
| Shannon | 2.8605 | 2.4935 | 2.323 | 2.8705 |
| Evenness | 0.8211 | 0.7977 | 0.8941 | 0.826 |
| Dominance | 0.06375 | 0.08941 | 0.09469 | 0.06349 |

**Table 3.** Mean Average of the physical parameters

| Physical parameters | Site 1 Maloro | Site 2 NMSCST | Site 3 City Courtyard | Site 4 Sulaton Island, Silangga |
|---|---|---|---|---|
| Air temp. | 26.05°C | 25.27°C | 26.00°C | 26.05°C |
| Relative Hum. | 76.00% | 82.16% | 84.80% | 76.82% |

**Table 4.** Similarity indices of the sampling sites

| | Maloro and NMSCST | Maloro and City Courtyard | Maloro and Sulaton Island, Silangga | NMSCST and City Courtyard | NMSCST and Sulaton Island, Silangga | City Courtyard and Sulaton Island, Silangga |
|---|---|---|---|---|---|---|
| Similarity indices | 90% | 67% | 100% | 80% | 85% | 72% |

**Table 5**. Relationship between air temp. And species diversity

| Two-sample | N | Mean | St. Dev | SE Mean |
|---|---|---|---|---|
| Air temp | 4 | 25.842 | 0.382 | 0.19 |
| Species diversity | 4 | 2.637 | 0.273 | 0.14 |

Difference = mu Air temperature - mu Species Diversity

Estimate for difference: 23.206

95% CI for difference: (22.631, 23.781)

T-Test of difference = 0 (vs not =): T-Value = 98.77 P-Value = 0.000 DF = 6

Both use Pooled St. Dev = 0.332

**Table 6**. Relationship between relative hum. And species diversity

| Two-sample | N | Mean | St. Dev | SE Mean |
|---|---|---|---|---|
| Relative Humidity | 4 | 79.94 | 4.24 | 2.1 |
| Diversity Indices | 4 | 2.637 | 0.273 | 0.14 |

Difference= mu Realtive Humidity- mu Diversity Indices

Estimate for difference: 77.31

95% CI for difference: (72.11, 82.50)

T-Test of difference = 0 (vs not =): T-Value = 36.43 P-Value = 0.000 DF = 6

Both use Pooled StDev = 3.00

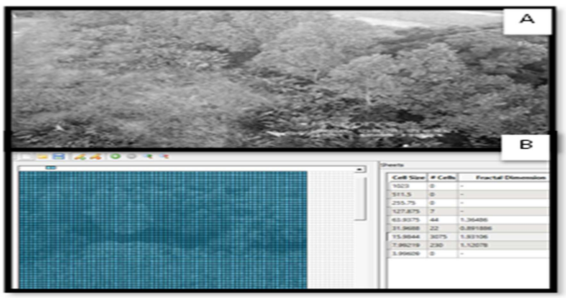


**Fig. 3.** Captured Image of Site 1(A) and Fractal Dimension of Site 1 (B)

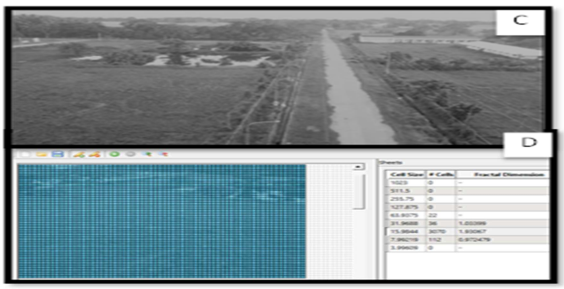


**Fig. 4.** Captured Image of Site 2(C) and Fractal Dimension of Site 2 (D)

*Physical parameters*

Table 3 above showed the average measures of the physical parameters of the selected habitats sampled in assessing the complexity of spiders in the area. In this study, air temperature and relative humidity were considered as variables in identifying the complex structures of the habitats in Tangub City. In terms of air temperature sites 1(in Maloro), and 4 (Sulaton Island, Silangga) have the same measurement (26.05°C) while site 2 (NMSCST) has an average air temperature of 25.27°C site 3 (City Courtyard) has an average air temperature of 26.000°C respectively.

*Similarity indices of different habitats*

Table 4 showed the index of similarities of the habitats considered in the study. The highest index of similarity was found between Maloro and Sulaton Island, Silangga with 100% index which indicates these two habitats have a similar species composition. Highest similarity index was evidently found on these two sites due to their similarity of the habitat structure, the type of ecosystem, and the availability of food. Conversely, the lowest similarity index was found between Maloro (site 1) and City Courtyard (site 3) with an index value of 67% which implies these two habitats have lowest commonalities of species composition. Maloro and NMSCST has an index value of 90%, NMSCST and City Courtyard has a similarity index of 80%, NMSCST and Sulaton Island, Silangga got an index value of 85% and City Courtyard and Sulaton Island, Silangga has an index value of 72% respectively.

*Effects of physical parameters to the abundance of spiders in Tangub city*

Table 5 depicted the relationship between air temperature and species diversity. Based on the analysis, the relationship revealed a p-value of 0.00 which indicated a high significant relationship at t-value=98.77 with 95% confidence level. This indicates that as air temperature increases, the abundance of spider species in the selected habitats also increases.

Table 6 summarized the relationship between the relative humidity and the diversity of spider species in the four sampling sites in Tangub city.

This comparison resulted to a p-value of 0.000 at t-value= 36.43 which can be interpreted very significant with 95% confidence level. This result indicates that the increased relative humidity in the area resulted in an increased abundance of spider species at the different sites considered in this study.

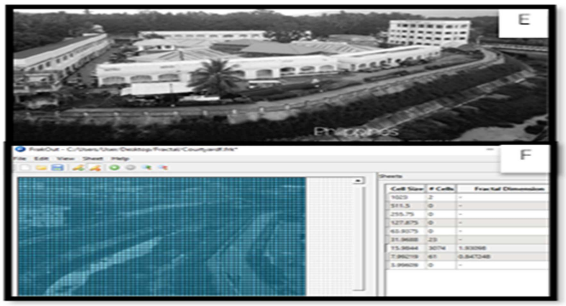


**Fig. 5.** Captured Image of Site 3(E) and Fractal Dimension of Site 3 (F)

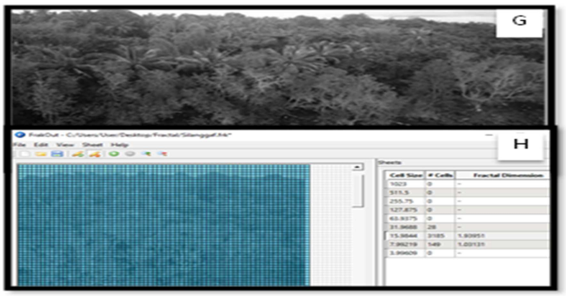


**Fig. 6.** Captured Image of Site 4 (G) and Fractal Dimension of Site 4 (H)

*Fractal analysis*

Fig. 3 (Maloro), Fig. 4 (Northwestern Mindanao State College of Science and Technology), Fig. 5(City Courtyard), and Fig. 6 (Sulaton Island, Silangga) displays the fractal denomination in each spiders' sampling site in Tangub city, Misamis Occidental, Philippines. Results revealed that the sampling habitat at Brgy. Maloro (Site 1) was assigned a fractal (D) value equivalent to D=1.93106, in Northwestern Mindanao Sate College of Science and Technology (Site 2), the area got a fractal value D= 1.93067, the City Courtyard has a fractal value D= 1.93098, and Sulaton Island in Brgy. Silangga obtained a fractal value D= 1.93951 respectively. Results of the fractal analysis of the different sites were determined as rugged given that the computed fractal indices were greater than 1 (D>1) rather than being Euclidean (Mandelbrot, 1987). Subsequently, the four sampling sites showed very low variances in terms of fractal index where City Courtyard (site 3) got the lowest fractal value (D=1.93098) among the four sampling sites while Sulaton Island in Brgy. Silangga (site 4) got the highest fractal value (D= 1.93951).

**Discussion**

This study indicates a high degree of spider (Aranaea) diversity across various habitat types in Tangub City. The highest species diversity was found in Sulaton Island, Silangga (site 4) and the highest species richness was found both in Sulaton Island, Silangga (site 4) and Brgy. Maloro (site 1). This implied that the habitat structures in the city are generally less disturbed which allows more spaces for spiders' prey and spider microhabitats, stimulating complex trophic interactions.

The lowest species diversity, as well as the lowest species richness was found in the City Courtyard (site 3) where the area was dominated with shrubs. This likely affected the spiders' distribution as shrubs do not usually attract the abundance of insects spiders depend on for food consumption. The high degree of urban construction at the City Courtyard site may have negatively impacted spider habitat availability, in addition to prey habitat availability (Lawrence and Wise, 1999). There is a strong relationship between the physical structure of the environment, its vegetation cover, and the species composition of spiders in an area (Olarte *et al.*, 2012). Conversely, site 4 (Sulaton Island, Silangga) recorded the highest number of individual spiders likely due to the area being primarily characterized by mangrove forest, shrubs, and agricultural crops. Structurally, complex forests provide more diverse conditions in comparison to homogenous forests because of greater variety of microhabitats and trees (Khanaposhtani, *et al.*, 2012) consistent with the mangrove forests of Tangub City.

The role of habitat structure in determining the complexity of organisms greatly affect diversity (Padua, *et al.*, 2017). In the case of Tangub City

Courtyard, the river basin (where sampling took place) has experienced a high degree of development resulting in the river banks being paved over with concrete as part of the ongoing development. These anthropogenic interventions have altered the ecological balance in the area and may have caused other spider species migrate to more suitable habitats. These factors were directly correlated to the low number of observed spider individuals in the City Courtyard area. Barrion (2001) stated that spider diversity is affected by low prey density in overgrazed and burned habitats typified by urban centers.

Family, *Araneidae* was the most abundant family of spiders containing two genera with ten species identified. These groups of spiders are considered as very common to all types of habitats due to their ability to easily adjust to their microenvironments and their web structures. Moreover, *Oxyyopes javanus* in the family Oxyopidae was the most abundant species of the area in Tangub City because these species were opportunistic with regard to habitat selection and are highly adaptive to their ecosystem. Past observations of this species indicates a slight change of the temperature will have a relative impact to their distribution and structure in any given environment (Garciano *et al.*, 2016). *L. decorata* was highly observed and were recorded establishing their webs on the shrubs or leaf surfaces of mangroves near the water. *L. decorata* are builders of delicate orb-webs with open hubs. The webs are suspended horizontally or in an inclined plane (Koh, 2000). The area where this species was most abundant is primarily characterized with complex mangrove forests and large degree of shrub-cover which could directly be associated with the large number of individual spiders and indicated by the optimum amount of humidity and temperature. The geographical location of site 4 (Silangga) was also considered as a contributing factor in the abundance of spiders because it is an isolated island that is distantly located from the households.

Similarity index showed high between Maloro (site 1) and Sulaton Island, Silangga (site 4) at 100% index value, while the lowest similarity index was registered between Maloro (site 3) and NMSCST (site 2) with 67% index value which implied that habitats which have the same structures, will also have the same composition of species present or the index of similarity is very high and on the other hand, fractals which have opposite or different structures will have low similarity of the number of species occupying in an area.

In a study conducted by Dupo *et al.* (2014), they found out that spiders in Mt. Matutum, South Cotabato are diversely distributed which corresponds to elevation. Knowing the complex structure of a Mountain, where trees and shrubs are everywhere, spiders can easily acquire habitat and prey to different insects in the area (Dupo *et al.*, 2014). Another study on diversity of spiders was conducted by Dupo (2014) at Pulacan Falls Zamboanga del Sur has concluded that the area is a species-rich environment. However, species richness and diversity were low in the disturbed areas. The results of this study are consistent with the study conducted by Koneri and Nangoy (2016) in the different habitats at the forest of Mt. Tumpa Park, Indonesia where distribution of the spiders was seen diverse and are dependent to the complexity of vegetation habitats. Additionally, past studies of forest floor vegetative liter decomposition found the abundance of nonweb-making hunting spiders was negatively correlated with the rate of vegetative decomposition (Lawrence and Wise, 2000). In this study, spiders were found to be diversely distributed in the primary forest just like in the mangrove habitats in Tangub City (Koneri and Nangoy, 2017).

Physical parameters such as air temperature and relative humidity were observed as directly affecting the abundance of spiders in each habitat with a very significant relationship value (Nime *et al.,* 2013). In terms of the fractal complexity of the areas, all types of habitats considered in this study were categorized as rugged habitats based on the fractal indices computed. However, fractal complexity as a measure of species diversity could not directly be assumed as a suitable metric for assessing spiders' diversity because none of the areas sampled were smooth/simple habitat (which was previously assumed in the residential areas) which limit comparisons.

## Conclusion

The difference of this study's two habitats' ecological structure greatly constitutes to their lower similarity index. This means that most spiders in the City Courtyard are unlikely to adapt in the mangrove forest of Maloro due to temperature difference, as well as relative humidity. This study indicated that changes in temperature systematically altered the relationship between biodiversity and ecosystem functioning. The fractal analyses in this study indicated that fractal complexity as measure of species diversity could not directly be assumed as metric for assessing spiders' diversity because none of the areas sampled belonged to the category of smooth/simple habitat which limited comparisons. While the fractal imaging analysis was not able to successfully determine statistical differences in the two habitat types surveyed in this study, future directions of this work include utilizing higher resolution cameras to increase computer software's ability to evaluate differing habitat types which may display similar fractal characteristics. Additional future directions of this work include surveying urban sites in Tangub city for spiders of medical importance. The findings on the impact of spider abundance on the rate of vegetative decomposition should be replicated in a tropical forest environment such the sites in Tangub City.

## Acknowledgements

Thank you to Dr. Olga Nuneza and the Mindanao State University-Iligan Institute of Technology, the World Spider Database, Dr. Aimee Lynn B. Dupo and the University of the Philippines-Los Banos, the National Museum of the Philippines, the International Union for Conservation of Nature (IUCN) and the Department of Environment and Natural Resources (DENR) all of whom contributed to this study.

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