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Impact of ground cover vegetation types on the diversity and similarity of spider assemblage at two adjacent sites

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Abstract

Spider (Arachnida) is one of the classes of arthropods known to give strong responses to differences in land cover vegetation. This study intended to investigate whether the difference of vegetation types that are located adjacently occupied by the same genera of spiders. Two adjacent areas in Liwa Botanical Garden that covered by two different types vegetation were assigned as the sampling sites. The spiders sampling was carried out over a 100 meter long transect line (5 lines each) by applying active searching and pitfall trapping techniques. There were 21 genera from 9 spider families that were collected from two sampling sites. In the land vegetated with wood, there were 12 genera with 129 specimens. In the herbaceous land, there were 13 spider genera with 120 specimens. The Simpson's index of diversity were 0.7739 and 0.8868, meanwhile the Shannon's index were 1.8575 and 2.2831, respectively obtained at herbaceous and woody land. The difference of diversity between two compared sites by Hutcheson t-test was highly significant ($\alpha < 0.01$). This presumption is also supported by the coefficient of dissimilarity calculated using Sorensen's index formula ($S_s = 75.7575$). Thus it can be concluded that the different types of land cover vegetation have a significant impact on the diversity of the dwelling spiders even though the two fields are located adjacent to each other.

Keywords: Arachnida; Spider diversity; Vegetation type's effect; Spider assemblage; KRL Liwa

Introduction

It is common knowledge that the presence and type of vegetation cover in an area and its management determines the composition and abundance of fauna in that place. Arthropods are one of the groups of animals that are known to be very sensitive to differences in the composition and condition of cover plants in a habitat [1, 2, 3]. One of the classes of arthropods that have been shown to give strong responses to differences in land cover vegetation is spiders (Arachnida). Assemblage composition of spiders much more similar within the same vegetation type in comparison to the different vegetation type [4].

Apart from depending on the type of vegetation, the composition of the spider assemblage is known to depend on the structure of the vegetation [5]. Research on the distribution and diversity of spiders in tropical forests of Sulawesi (Indonesia) revealed that in secondary forest vegetation the diversity of spiders is higher than that of shrubs [6].

However, the studies mentioned above do not include information on whether the vegetations being compared were located adjacently. This research was conducted to determine whether there are differences in the diversity of spiders on two fields with different vegetation cover bordering each other.

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Material and methods

1.1. Study area

This study was conducted in Liwa Botanical Garden, a park established by the West Lampung Regency authority as a place for collection, cultivation, preservation and displays of various types of plants both native and exotic. The garden (common designation: KRL Liwa) is located at the district of Balikhbukit ($5^{\circ}02'18.45''\text{S}$ - $104^{\circ}04'34.77''\text{E}$), West Lampung Regency, Lampung Province, Indonesia. The garden which has an area of 86.68 hectares is located at an altitude of 800-920 meters above sea level. The topography of the Liwa Botanical Garden area is hilly, with a fairly steep slope, some even with a slope of more than 40%. The climatological data owned by the botanical garden manager shows that the annual rainfall is 2,500-3000 mm, wet months 7-9 months, temperature range $17.5 - 7.5^{\circ}\text{C}$, relative humidity 72 - 98%, sunlight intensity 34 - 63%. [7]

This botanical garden is adjacent to the largest national park in Sumatra, the Bukit Barisan Selatan National Park, only separated by a small river called *Way Sindalapai*. Based on the land cover, this botanical garden consists of three types of vegetation, namely trees, shrubs and herbs. Area covered with trees and shrubs is defined as woody ground, while the area covered with herbaceous plants is called herbaceous ground (Figure 1)



BG (back ground) is a part of Bukit Barisan Selatan National Park bordering the garden;
 MG (middle ground) is the woods area covered by trees and shrubs;
 FG (foreground) is the herb area covered by herbaceous plants.
 MG and FG are assigned as the sampling sites of spiders.

Figure 1 Photograph of the study area.

1.2. Sampling

Spiders sampling was conducted on those two fields depicted in Figure 1, namely woody and herbaceous grounds. The animals sampling was carried out over a 100 meter long transect line. The number of transects made in the two sampling areas, the woody and herbaceous lands, is 5 lines each. The spider sampling was carried out using active searching and pitfall trapping techniques.

Active searching is intended to catch spiders that are nesting in the nest or that are actively moving or jumping. Active searching technique is the direct catching of spiders using a sweeping net along the transect (100 meters) within a range of 5 meters to the left and right of the transect line. The spiders that are caught are put in an anesthetic bottle which already contains tissue paper that has been dripped with acetone. After that, the spider is put in a bottle containing 40% alcohol fixative.

The pit-fall trapping technique is applied in an attempt to catch spiders that are actively moving on the surface of the ground. The traps were set in the transect line. The number of traps planted per transect was 10. The ten traps were placed alternately at a distance of 10 meters, five on the left and five on the right of the line. The traps consisted of open plastic cups (6 cm in diameter and 9 cm deep). The trap cups were buried into the ground until the lip of the cup is level with the ground. The cup was filled with a mixture of water and detergent and spiked with table salt as a preservative. Trapping results are collected after 24 hours of the trap being set.

The process of identification is based on the morphology and the determination of spiders carried out to the Genera level using various reference books such as: Barrion and Litsinge (1995) and Deeleman-Reinhold (2001) [8,9].

1.3. Data analysis

The data analysis applied in the study adopted from Adelusi et al.(2018),i.e. by analyzing the diversity of spiders using Simpson's index of diversity (1-D), Shannon-Wiener diversity index (H'), and Sorensen's similarity index (Ss)[10].

The Simpson's index of diversity (1-D) was calculated using following formula:

$$1 - D = 1 - \left(\frac{\sum_{i=1} ni(ni - 1)}{N(N - 1)} \right)$$

Where: D = Simpson's index; ni = number of individuals of the i -th species; N = total number of entities.

Next, the Shannon-Wiener diversity index (H') was quantified using formula bellows:

$$H' = - \sum pi \ln pi$$

Where: H' = Shannon-Wiener index; $pi = (ni/N)$ proportion of the i -th species; ni = number of i -th species; N = total number of individuals; ln = natural logarithm

To let Shannon diversity index of the two spider sampling areas can be compared statistically, the Hutcheson t-test was applied using formula recommended by Magurran (1988) [11].

$$t = \frac{H1' - H2'}{\sqrt{\text{Var } H1' + \text{Var } H2'}}$$

Where: t = t test value; H_i' = Shannon diversity index at the i -th area; var H' = variance in diversity

For this purpose, variance in diversity (Var H') is calculated using following formula:

$$\text{Var } H' = \frac{\sum pi (\ln pi)^2 - (\sum pi \ln pi)^2}{N} - \frac{S - 1}{2N^2}$$

Where: S = total number of species; $pi = (ni/N)$ proportion of the i -th species; N = total number of individuals.

To determine the appropriate range of the t distribution, the degrees of freedom can be calculated using the formula:

$$df = \frac{(\text{Var } H1' + \text{Var } H2')^2}{[(\text{Var } H1')^2/N1] + [(\text{Var } H2')^2/N2]}$$

Where: df = requisite degree of freedom (df) in t test; Var H_i' = variance in diversity of i -th site; N_i = total number of individuals at i -th site.

The formula of Sorensen's Similarity Index (Ss) is:

$$Ss = \frac{2a}{(2a + b + c)} \times 100$$

Where: a = number of species found at the two sites; b = number of species found only at the first site; c = number of species found only at the second site.

Results and discussion

The number of spider specimens according to their clan and family that we managed to collect from two locations, namely herbaceous and woody vegetation areas, is presented in Table 1. Next, the quantification results of the diversity of spiders at the two locations that were compared using diversity indices of Simpson and Shannon-Wiener are

presented in Table 2. Meanwhile, the results of statistical tests using the Hutcheson t-test on the variance in diversity at the two spiders sampling sites are presented in Table 3.

Table 1 Spider specimens from two compared sampling sites

Familia	Genera	Number of individuals	
		HG	WG
Agelenidae	Tegenaria sp.	0	4
Araneidae	Cyclosa sp.1	23	14
	Cyclosa sp.2	10	16
	Nephila sp.	8	2
	Gasteracantha sp.1	0	15
	Gasteracantha sp.2	0	9
	Argiope sp.	0	2
	Neoscona sp.	3	0
Corinnidae	Corinnomma sp.	3	0
Ctenizidae	Ctenizasp.	0	2
Lycosidae	Rabidosa sp.	54	26
	Trochosa sp.1	6	0
	Trochosa sp.2	1	0
Phalangidae	Phalangium sp.	1	0
Salticidae	Simaetha sp.	0	10
Tetragnathidae	Leucauge sp.	0	11
Theridiidae	Theridion sp.	0	7
	Steatoda sp.	0	2
	Argyrodes sp.1	13	0
	Asagena sp.	5	0
	Argyrodes sp.2	2	0

HG=Herbaceous ground; WG=Woody ground

Table 2 Diversity indices of both sampling sites

Parameters	Vegetation types	
	Herbaceous	Woody
Number of Genera	12	13
Number of individuals	129	120
Simpson's index of diversity (1-D)	0.7739	0.8868
Shannon-Wiener index (H')	1.8575	2.2831
Variance in diversity (Var H')	0.00771	0.00305

Table 3 Results of Hutcheson t-test against the variance in diversity of both sites

Parameters	Score/value
Hutcheson t-test	4.1030
Degree of freedom (df)	215
t-distribution limit ($t_{215, 0.01}$)	2.601

The last, the results of the similarity quantification using the Sorensen's similarity index, we get the $S_s=24.2424$. Since similarity is the opposite of dissimilarity, so the similarity coefficient can be modified to a coefficient of dissimilarity by taking its inverse: $1-S_s = 100 - 24.24 = 75.7575$.

Discussion

Based on the actual data and the results of quantitative analysis of the spider samples obtained from two adjacent sampling sites in this study, it is clear that the type of ground cover vegetation determines the composition of the occupant spiders. Where the diversity indices (Simpson and Shannon-Wiener) of spiders at the area covered by vegetation comprised of trees and shrubs are higher than that of covered by herbaceous vegetation. Based on the Hutcheson t-test results, the difference of diversity of spider genera between woody ground and herbaceous land is highly significant ($\alpha < 0.01$).

This confirms the results of research that has been carried out in many regions of the world which reveal that differences in vegetation types, structure and conditions greatly affect species composition of the spider assemblage. The impact of the type, structure and condition of vegetation on the diversity and abundance of spiders can be seen, among others, in the research reported by Greenstone (1984) in Costa Rica, Russell-Smith and Stork (1995) in Borneo, Samu et al. (2014) in Hungary, or Junggebauer et al. (2021) in Sumatra [12, 13, 14, 15].

The high diversity of spiders on land with higher and dense vegetation is thought to be related to their role as predators requiring a variety of prey species [16]. As has been revealed by Meloni et al. (2020), the decreasing vegetation cover and/or changes in vegetation pattern towards small and over-dispersed vegetation patches can lead to decrease in ground arthropods diversity [17]. The complex vegetation of forests and shrubs is known to provide shelter and hibernation, oviposition, and foraging sites for major kinds of arthropods including spiders [18].

Conclusion

The composition of the spider genera is proven to be largely determined by the type of land cover vegetation. The land covered by vegetation consisting of trees and shrubs is inhabited by a more diverse genus of spiders than land covered by herbs, even though the two fields share a border.

Compliance with ethical standards

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Disclosure of conflict of interest

Authors declared there is no conflict of interest.

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