Salticidae species richness in Rajah Sikatuna Protected Landscape (RSPL), Bohol, Philippines

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Abstract. The aim of this study was to determine the species richness of jumping spiders in Rajah Sikatuna Protected Landscape (RSPL), Bohol, Philippines. Field sampling was conducted on June 8-15, 2015 for 64 man-hours using beat-netting and vial-tapping methods from all the field layers. One hundred eighteen individuals belonging to 45 species and 21 genera were recorded. Highest species richness (H' = 2.441) was recorded in barangay Nueva vida este. *Cytaea* sp. was the most abundant species. *Emathis makilingensis* was identified as a new record to Bohol. The result of this study showed high species diversity and greater evenness of salticids in RSPL. However, the overall estimated species richness in the study area is 148 species or more which means that there are still several species of jumping spiders in RSPL, Bohol Island to be discovered in future studies.
Key Words: beat-netting, *Cytaea*, *Emathis makilingensis*, evenness, vial-tapping.

Introduction. Jumping spiders (Salticidae) are the most speciose family of spiders, with more than 500 described genera and about 5,000 described species (Richman et al 2005). They are one of the expert silent predators in the tea and paddy ecosystems that feed on small insects like moths, butterflies, beetles, aphids, hoppers etc., which help maintain ecological equilibrium by suppressing insect pest (Chetia & Kalita 2012). These spiders resemble ants in body form and move like ants (Cutler & Edwards 2002). They are commonly known because of their springing movements especially when they are alarmed and hunt on vegetation. Most of them do not spin webs or use silk to capture prey (Cutler & Edwards 2002), but they build silk nests in which they moult, oviposit, sometimes mate, and use during other periods of inactivity (Jackson 1986). Edwards (2000) reported that this type of species is commonly found in open woodland and the smaller salticids are often found in the herbaceous zone. The subfamily Euophryinae is one of the most speciose groups of jumping spiders worldwide (Edwards 2002). Peng et al (1993) had described 130 species in 46 genera of jumping spiders. Most of the salticids live in the tropics, hence, they can be found everywhere the sun shines and hide during night and rainfall. They occur in a range of microhabitats from beneath leaf litter up into the forest canopy (Richman et al 2005).

The main objective of this study is to evaluate the species richness and diversity of salticids present in Rajah Sikatuna Protected Landscape (RSPL) using species richness estimation and diversity measures. This research would provide baseline information on little-known spiders in Bohol, specifically the jumping spiders.

Material and Method. The study was carried out at five selected sites of the RSPL (9°42′19″N and 124°7′27″E) which is located in the Island province of Bohol in the village of Nan-od, Datag, Marawis, Nueva vida este, and Magsaysay Park. The sampled area (Figure 1) with a total area of 25 km^2 is characterized by rolling hills with remnants of natural forest on steep limestone terrain surrounded by plantation forest, denuded hills and grasslands. The selected sites are the following: barangay Nan-od, Sierra Bullones (site 1), barangay Datag, Garcia Hernandez (site 2), barangay Marawis, Valencia (site 3), barangay Nueva vida este, Carmen (site 4), and Magsaysay Park, Bilar (site 5).

Site 1, Barangay Nan-od is located in the municipality of Sierra Bullones where farming is the most important livelihood of the people in which rice and corn are the chief crops. This site has an elevation of 589 masl. A farm of tomatoes and eggplant was commonly found in the area.

Site 2, Barangay Datag with an elevation of 538 masl is situated in Garcia Hernandez where a large tomato farm and tall trees of molave (*Vitex parviflora*) and mahogany (*Swietenia macrophylla*) were found.

Site 3, Barangay Marawis is located in the municipality of Valencia. This sampling site has an elevation of 444 masl which is partly being used for agricultural purposes. Eggplant, corn, and tomatoes are cultivated near the site. Balete (*Ficus balete*) was also found in this area.

Site 4, Barangay Nueva vida este is located in the municipality of Carmen. This site has an elevation of 432 masl. Some areas in the site were burned as evidenced by charred soil and plants. Tall coconuts, mahogany (*Swietenia* sp.) trees, gmelina (*Gmelina arborea*) and shrubs were found in this area. Some portion of the site has a small farm of pineapple and taro plant.

Site 5, Magsaysay Park is located in the municipality of Bilar where the "Simply Butterflies Conservation Center" is found. The area is situated next to a ranger station and the Logarita spring. Its forest cover is dominated by native dipterocarp trees such as molave. Monkeys are commonly found in this area.

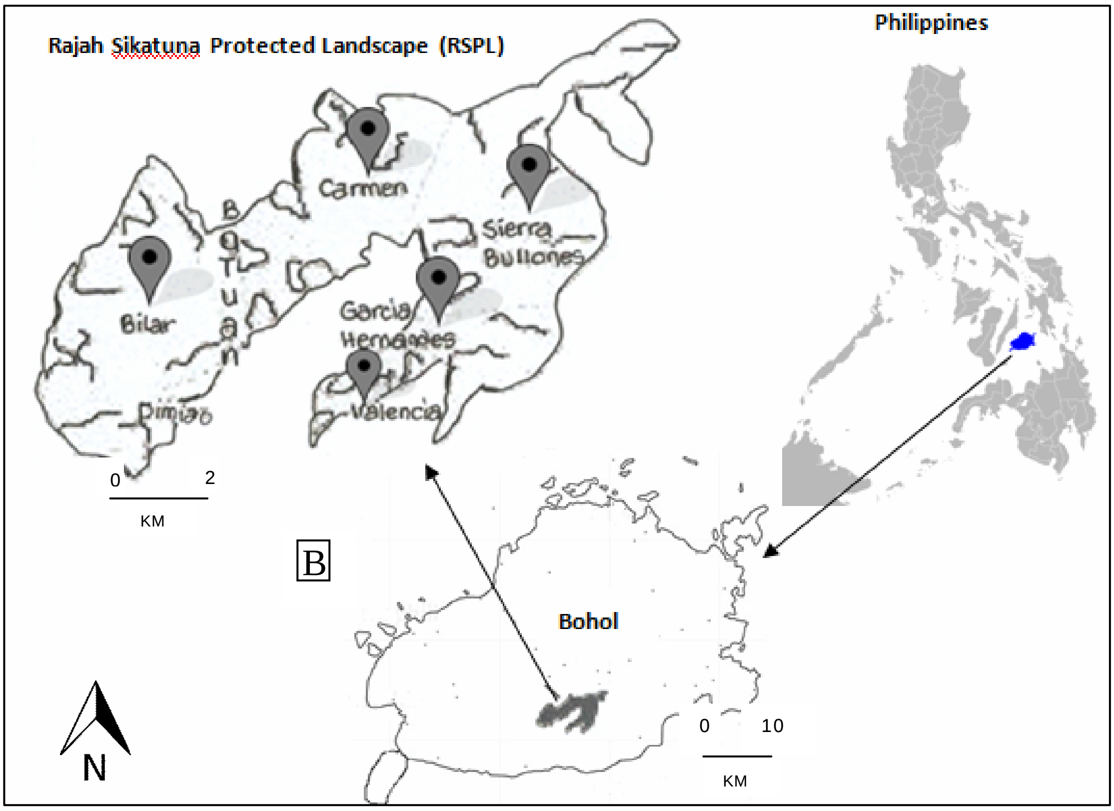

Figure 1. Map showing the location of Bohol Island where RSPL is located. Map A source: wikipedia.org, 2015; Map B and C source: Barcelona et al 2006.

A gratuitous permit (GP) was obtained from the Department of Environment and Natural Resources-CEBU region for collection of samples.

Sampling was conducted on June 8-15, 2015 for 64 man-hours. Sampling was done every morning from 9:00 hours to 12:00 hours and in the afternoon from 13:00 hours to 17:00 hours. Three 1 km transect points were made in each barangay. Collection in every point was extended 1 km on each side perpendicular of the transect point to obtain extensive sampling. Vial tapping and beat netting were the collection techniques used. Beat netting was done by shaking branches of the tree and beat net was held below (Whitmore et al 2002). Vial tapping was done to collect samples on spider microhabitats like fallen logs, leaf litters, crevices, and leaves of trees. All collected samples were preserved in 75% alcohol solution in glass vials labeled with the date of collection in the field, site, and habitat (Romero & Vasconcellos-Neto 2005). Collected salticid samples were identified by the second author at the University of the Philippines Los Baños Museum of Natural History. Voucher specimens were deposited at the MSU-IIT Natural Science Museum and the UP Los Banos Museum of Natural History.

Biodiversity indices were calculated using Microsoft Excel 2010. Nonparametric richness estimators were used to estimate the species richness of the sampling area using EstimateS version 9.1.0 software. Similarity and diversity indices were calculated using PAST (PAleontological Statistics) software version 3. Similarity index was used to measure the degree of similarity between the five sampling sites based on shared species. Diversity indices i.e. Taxa (S), Pielou's evenness (E), and Shannon index (H) were calculated to obtain species diversity in a community.

Results and Discussion. A total of 118 individuals belonging to 45 species and 21 genera were recorded during the study (Table 1). Nineteen species are probably new to science. Among the 45 species recorded, *Thania bhamoensis*, *Thania* sp. 1, *Thania* sp. 2, *Epeus* sp., *Euryattus* sp. 1, *Euryattus* sp. 2 and the genus *Cytaea* are endemic to South East Asia. In addition, genus *Chalcotropis* is endemic in the Oriental region of the Philippines (Barrion & Litsinger 1995). Eight species found in this study belong to genus *Cytaea*. Site 1 (Nan-od) had the highest number of individuals collected whereas site 4 (Nueva vida este) had the least number of samples collected. However, jumping spider community in this study showed a more even distribution of individuals among species based on the rare species found.

Table 1

Species checklist of jumping spiders in RSPL

No.	*Species*	*Site 1*	*Site 2*	*Site 3*	*Site 4*	*Site 5*	*Total*	*RA (%)*
	1. *Bavia*							
1	*Bavia f. aericeps*	0	1♀	0	0	0	1	0.85
	2. *Bocus*							
2	*Bocus* sp.	1 imm♂	0	0	0	0	1	0.85
	3. *Carrhotus*							
3	*Carrhotus* sp.	0	0	0	1 imm	0	1	0.85
4	*Carrhotus sannio*	0	0	0	1♂, 1 subA♂	0	2	1.71
	4. *Chalcotropis*							
5	*Chalcotropis f. luceroi**	0	0	0	2♂	1♂	3	2.56
	5. *Cytaea*							
6	*Cytaea* sp.	2♂, 7 imm	1♂, 3 imm	7 imm	1 imm	3 imm	24	20.51
7	*Cytaea* sp. 2*	0	0	0	0	1♂, 1 imm♀	2	1.71
8	*Cytaea* sp. 2Aa	2♂	0	6♂	0	0	8	6.84
9	*Cytaea* sp. 3A*	0	1♂	0	0	0	1	0.85
10	*Cytaea* sp. 4B*	0	1♀	0	0	0	1	0.85
11	*Cytaea* sp. 5A	2♀	0	1♂, 2 imm	0	0	5	4.27
12	*Cytaea* sp. 5Aa*	0	0	1♂	0	0	1	0.85
13	*Cytaea* sp. 6	0	1♀	0	0	0	1	0.85
	6. *Donoessus*							
14	*Donoessus f. striatus**	0	0	2♀	0	0	2	1.71
	7. *Emathis*							
15	*Emathis* sp. 2Ab*	1♀	0	0	0	0	1	0.85
16	*Emathis makilingensis*	0	1♀	0	0	0	1	0.85

	8. *Epeus*							
17	*Epeus* sp.*	0	0	1imm, 1♀	0	0	2	2.56
18	*Epeus* sp. 2	0	0	0	0	1 imm	1	
	9. *Ergane*							
19	*Ergane* sp.	0	0	1♂	0	1♀	2	1.71
	10. *Euryattus*							
20	*Euryattus* sp.*	0	0	2♂	0	1 imm	3	2.56
	11. *Orthrus*							
21	*Orthrus* sp.	10 imm	1 subA♂	0	0	0	11	9.40
22	*Orthrus* sp. 2A*	0	2♀, 1♂, 1 imm♀	3 imm♀	0	0	7	5.98
23	*Orthrus* sp. $2B_1$*	0	0	0	0	1♂	1	0.85
24	*Orthrus* sp. $3A_3$*	0	1♂	1♂	0	0	2	1.71
25	*Orthrus* sp. 3Bb*	3♂	0	0	0	0	3	2.56
	12. *Palpelius*							
26	*Palpelius* sp.	0	0	0	0	2 imm	2	1.71
27	*Palpelius* sp. $2A_1$	1♀	0	0	0	0	1	0.85
28	*Palpelius* sp. $2A_2$*	0	0	0	0	1 imm, 2♀	3	2.56
29	*Palpelius* sp. $3B_1$*	0	0	0	0	1♂	1	0.85
30	*Palpelius* sp. $4B_1$*	1♂	0	0	0	0	1	0.85
	13. *Phintella*							
31	*Phintella* sp.	0	0	0	1 imm	0	1	0.85
32	*Phintella piatensis*	0	0	0	1♀	0	1	0.85
	14. *Pristobaeus*							
33	*Pristobaeus* sp.	0	2 imm, 1 imm♂	0	0	0	3	2.56
34	*Pristobaeus* sp. 2	0	1 imm♂, 1 imm♀	0	0	0	2	1.71
35	*Pristobaeus* sp. $3A_1$*	0	1♂	0	0	0	1	0.85
	15. *Rhene*							
36	*Rhene* sp.	0	0	0	1 imm	0	1	1.71
37	*Rhene flavigera*	0	0	0	1 imm♀	1♀	2	1.71
	16. *Salticidae*							
38	*Salticidae* sp. 1	1 imm	0	0	0	0	1	0.85
39	*Salticidae* sp. 2	0	0	0	1 imm	0	1	0.85
	17. *Simaetha*							
40	*Simaetha* sp.	0	0	0	1♀	0	1	0.85
	18. *Thania*							
41	*Thania bhamoensis*	0	1♂	0	0	0	1	0.85
	19. *Thianitara*							
42	*Thianitara* sp.	0	0	0	0	1subA♂	1	0.85
43	*Thianitara spectrum*	1imm♀, 2 imm	0	2♂	0	0	5	4.27
	20. *Viciria*							
44	*Viciria* sp.*	0	0	0	1♀	0	1	0.85
	21. *Zenodorus*							
45	*Zenodorus* sp.*	0	0	0	1♀	0	1	0.85
	Total number of species	11	13	11	12	12	45	
	Total number of individuals	34	22	30	14	18	118	

Legend: Letters or combination of letters and numbers refer to species name; subscript (number form) refers to no. of individuals; ♀ - Female; ♂ - Male; imm – immature; RA (%) – Relative Abundance; * - possibly new species; subA - subadult.

Table 2 shows that most of the spiders found in this study were males (35%) while there were only 29 females (24%). The 41% (48 immature spiders) were not identifiable whether male or female. Immature spiders (total = 59) comprised the bulk of the collection. This is in contrast with the study of Dippenaar-Schoeman et al (2001) where females exceed males of salticid spiders in macadamia orchards in the Mpumalanga Lowveld of South Africa. High abundance of females in spider studies is often attributed to several factors such as fatal encounter of males with predators during mate-searching (Gaskett et al 2004), cannibal behavior of females after mating (Dean & Sterling 1985), and deadly combat between male rivals (Dodson & Beck 1993). Longevity of females compared to males is also an important factor. The adult female of the salticid genus *Portia* can live up to three times longer than its male contemporary (Guseinov et al 2004). Hence, the unusual prevalence of males in this study requires considering some aspect of the life history of salticids. The collection of samples in this study was done in June, a month when females are expected to oviposit. Matsumoto & Chikuni (1987) studied the life history of the jumping spider *Sitticus fasciger* and concluded that reproductive females oviposit from June to July in their nests. Female spends several days in her nest after laying eggs. Since female salticids' nests are usually built on well-hidden places such as cavities on the underside of stones, crevices, and bark of various trees (Guseinov et al 2004; Edwards 1980), it appears that this resulted to the undersampling of females in this study. Another possible consideration is that among protandric (mature earlier) male spiders like salticids, there is usually a high abundance of mature males early in the breeding season (Jackson 1978), a time when this study was conducted. The high number of immature individuals is a common incidence in many spider surveys (Horner 1975; Cardoso et al 2008; Cardoso et al 2009; Maya-Morales et al 2012). This could be explained by the high mortality rate of the juveniles (Fasola & Mogavero 1995) and their long developmental stage before they reach maturity (Buddle 2000).

Table 2

Total number of jumping spiders according to their sexes and life-history stage

	Site 1	*Site 2*	*Site 3*	*Site 4*	*Site 5*	*Total*		*Percent (%)*
Adult Male	8	6	14	3	4	35		30
Adult Female	4	6	3	4	4	21		18
Immature*	20	5	10	5	8	48		41
Immature male	1	2	0	0	0	3	=59	2
Immature female	1	2	3	1	1	8		7
Subadult male	0	1	0	1	1	3		2
Subadult female	0	0	0	0	0			
Total no. of individuals	34	22	30	14	18	118		100
Total no. of males	95	9	14	4	5	41		3524
Total no. of females		8	6	5	5	29		

* can't be distinguished whether male or female.

The observed species richness together with the species richness estimates of the different nonparametric estimators is depicted in Figure 2. Species accumulation curve was constructed in order to show if an asymptomatic number of species has been achieved. In this study, the species accumulation curve of the jumping spider community in the sampling areas was continuously rising which clearly shows that not all species were obtained during the sampling. The estimated number of species of salticids was 79 to 153 species. Chao 1 obtained the lowest estimate while Michaelis-Menten (MM) estimator acquired the highest estimate. Among the nonparametric estimators, only Michaelis-Menten estimator has shown much tendency to asymptote with a final count of 153 species. However, the Incidence-based Coverage Estimator (ICE) reaches a peak of 320 species as shown in the graph. However, the curve declines until it reaches its saturation point of 148 species. Thus, the true species richness of the salticid community in this study might be 148 species or more based on the estimated species richness of Chao 1 and MM estimators. This clearly shows that the 45 species of salticids recorded was just 30% of the total species richness in the sampling area.

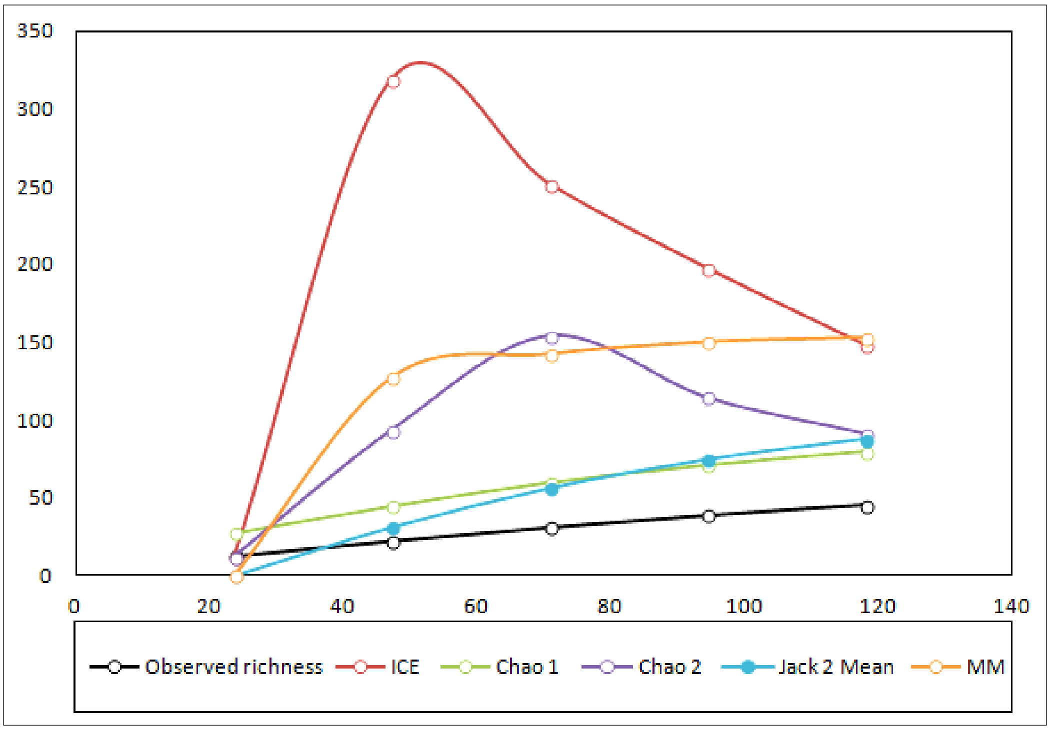

Figure 2. Species accumulation curves for observed species richness and richness estimators for the total data of jumping spiders in Rajah Sikatuna Protected Landscape. Jack 2: Jackknife 2; MM: Michaelis Menten.

Shannon diversity indices (*H'*) and evenness for the five sampling sites in Rajah Sikatuna is depicted in Table 3. The typical values of Shannon diversity index generally ranged from 1 to 2 which means that the diversity is moderate, low diversity if the index value is below 1 and high diversity if the index value is greater than 2. The value of *H'* increases as species richness and evenness increase (Colwell 2009). For species evenness, a value closer to zero means a species dominates the area, and if evenness value is closer to one, it means that the abundance of the compared species is of the same counts (Beals et al 2000).

The total Shannon diversity index recorded in this study was 3.2680 which means that the overall diversity of jumping spiders in RSPL is relatively high. All sampling sites obtained moderate to high diversities which ranged from 1.992 to 2.441. Among the five sampling sites, site 1 located in Nan-od is the least diverse site while site 4 in Nueva vida este obtained the highest diversity index. For the species evenness of jumping spiders, the community of jumping spiders also in site 4 showed a more even distribution. Site 4 (Nueva vida este) has complex vegetation as compared to the other sites. According to Dobel et al (1990) spider abundance is directly related to habitat complexity and vegetation. Many spiders live directly in specific environments depending on the kind of vegetation present (Foelix 1982; Malumbres-Olarte et al 2013). In addition, Cord (2011) observed that vegetation communities which provide heterogeneous structure at many scales can support a more diverse arthropod community. On the other hand, site 1 in Nan-od appears to be the least diverse site among the sampling sites. This means that the area was dominated by a particular species. In this case, this site was dominated by the species *Donoessus f. striatus*. Rice as considered the chief main crop in the area indicates a simple structure of vegetation. As a result, site 1 with a large scale homogenization of habitat structure affects spiders and might explain the less-favored species diversity in the area.

Table 3
Biodiversity indices of jumping spiders for the five sampling sites of Rajah Sikatuna Protected Landscape

Indices	*Site 1*	*Site 2*	*Site 3*	*Site 4*	*Site 5*	*Total*
Number of species	11	13	11	12	12	45
Shannon diversity index (H')	1.992	2.374	2.184	2.441	2.37	3.2680
Evenness	0.664	0.8263	0.8076	0.9671	0.8916	0.5833

Figure 3 shows the dendrogram of the five sampling sites in RSPL which was based on shared species. It has been shown in the graph that the similarity between the sampling sites did not reach up to 50% similarity. This means that each site was independent with each other such that each site has its own unique species found. Datag and Nan-od sampling sites were closely related with each other with 41% similarity. They shared the same species of jumping spiders which were; *Cytaea* sp., *Cytaea* sp. 2Aa, *Cytaea* sp. 6A, *Orthrus* sp. and *Thianitara spectrum.*

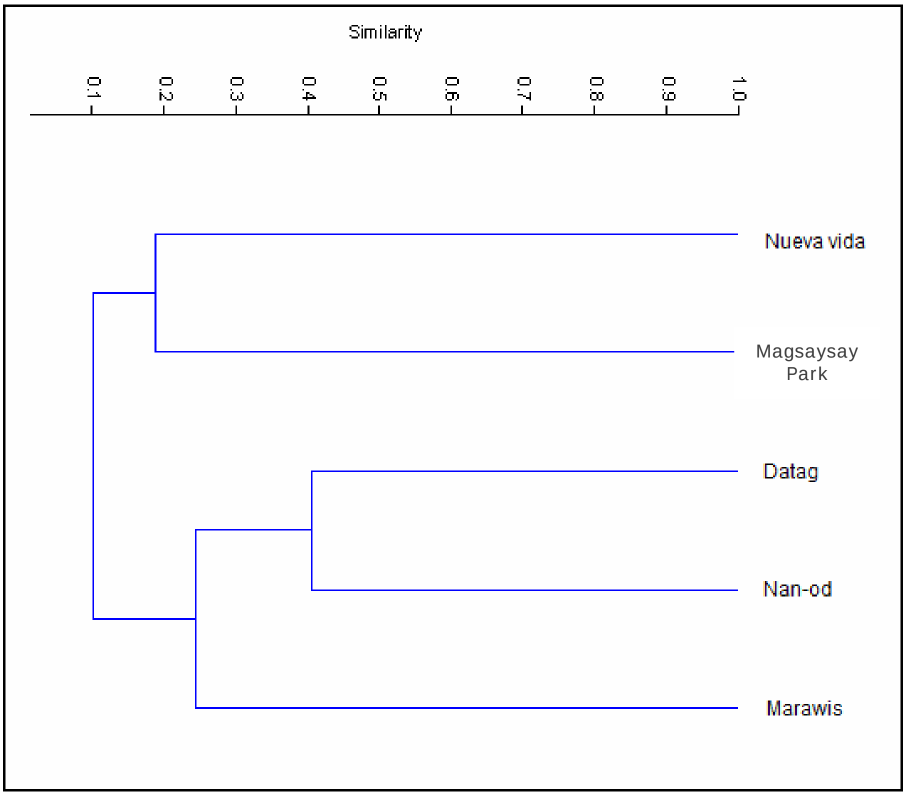

Figure 3. Cluster analysis of the five sampling sites in RSPL based on similarity of species.

Conclusions. Forty-five species of jumping spiders were obtained in this study in which 19 species are probably new species. The overall estimated species richness in Rajah Sikatuna Protected Landscape is 148 species or more. High species diversity and more or less even distribution have been also observed in this study. This would mean that further studies should be taken in the future to probably discover more species of jumping spiders in RSPL, Bohol.

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