KNOWING THE BIOLOGICAL LINKAGE: SPIDER COMPOSITION AND GUILDS IN A HILL RANGE OF NORTHERN URUGUAY

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ABSTRACT

In northeastern Uruguay there are tabular hills, relicts of basaltic depositions occurred during the Mezosoic, wich present strata with different vegetation types. This range of hills constitute a biological corridor which connect riparian forest plains, wetlands, Atlantic Forest, Araucaria Forest, Parana Forest and, in the past, with Cerrado bioma. The aim of this work is the study of the spider fauna in one of the tabular hills, along differents strata, employin two collecting methods: nocturnal search and ground vacuum. There were collected 1337 specimens, 27 families and 71 species/morphospecies. At guild level, Jaccard similarity analysis grouped the rocky strata separate from those of the arboreal-shrub vegetation. Differences in the spider taxonomic composition between the hill strata were found. Based on the results obtained, the importante of this range hills as biological corridor is discussed. These data represent inputs for future studies on this group as well as conservation plans at local or regional level for this hill range.

Key words: Spider, diversity, biological corridor, Uruguay.

RESUMEN

Conociendo el enlace biológico: composición y gremios de arañas en una cadena de cerros del norte de Uruguay. En el noreste de Uruguay se encuentran cerros tabulares, relictos de depósitos basálticos ocurridos en el Mesozoico que presentan estratos con diferentes tipos de vegetación. Esta cadena de cerros constituye un corredor biológico que conecta con planicies de bosques ribereños, humedales, Bosque Atlántico, Bosque Paranaense y en el pasado con el bioma Cerrado. El objetivo del estudio fue relevar la araneofauna en uno de estos cerros tabulares, en diferentes estratos, empleando dos métodos de muestreo: búsqueda nocturna y aspirador de suelo. Se recolectaron 1337 especímenes, 27 familias y 71 especies/morfoespecies. A nivel de gremios el análisis de similaridad de Jaccard mostró agrupaciones de los ambientes rocosos separados de los de vegetación arbórea-arbustiva. Se observaron diferencias a nivel de la composición taxonómica entre los estratos del cerro. En función de los resultados obtenidos, se discute la importancia de esta cadena de cerros como corredor biológico. Estos datos representan insumos para futuros estudios sobre este grupo así como para planes de conservación a nivel local o regional de estos ambientes.

Palabras clave: arañas, diversidad, corredor biológico, Uruguay.

INTRODUCTION

In a biogeographic context Uruguay is situated in the Pampean Province (Morrone, 2001). Grela (2004) based in a study of the dendroflora stated that this country represents a confluence of two types of biotas belonging to the Chaco and Parana Forest Provinces in the Occidental area of the country and the Parana influence in the Oriental region. Recently, Simó *et al.* (2014) proposed that Uruguay appears as a biogeographic crossroad for the order Opiliones with representatives of Pampean and Paranaense biota. Crossroads are crucial for biological conservation because they colaborate with maintaining the gene flow and evolutionary process between the biogeographic zones (Spector, 2002). In these regions biological corridors are crucial because they preserve connectivity between habitats patches, mitigate fragmentation process and represent valuable issues for wildlife conservation (Rosenberg *et al.*, 1997; Bennet, 2003; Mac Donald *et al.*, 2003). Islands and riparian forests, along the corridor constituted by the Uruguay River, present habitats with subtropical conditions that allow some species their expansion to more temperate zones. The presence of some spider species in Uruguay as a consequence of this biological corridor was reported for *Deinopis amica* Schiapelli & Gerschman, 1957 (Deinopidae) (Laborda *et al.*, 2011) or *Iviraiva pachyura* (Mello-Leitão, 1935) (Hersiliidae) (Laborda & Simó, 2015), both representing the southernmost records for these species. Brussa & Grela (2007) indicated the importance of some biological corridors as the truncated hills range that link northern Uruguay and southern Brazil. In the Gondwana, this region was occupied by a desertic system which was covered for a great lava flow in the Mesozoic (Perea *et al.*, 2008). Today the tuncated hills are remnants of these basaltic depositions and sandstone sediments originated between the Jurasic and Cretacic (Evia & Gudynas, 2000; Muzio, 2004; Brussa & Grela, 2007; de Borba *et al.*, 2013; de Souza *et al.*, 2015). The hills are connected with forests and wetlands of fluvial plains (Evia & Gudynas, 2000) and at a regional scale with Parana Forest, Araucaria Forest and Atlantic Forest in southern Brazil, Paraguay and northeastern Argentina (Brussa & Grela, 2007). It was indicated that dendroflora contains representatives of the Brazilian Cerrado biome (Grela, 2004) which be a sign of past landscape connections. Furthermore these hills show several strata along a gradient between the top and the botton which is represented by different vegetation types. For truncated hill it was reported the presence of two endemic plant species, as the palm *Butia paraguayensis* (Barb.-Rodr.) L.H. Bailey (Arecaceae) who inhabit in the hilltop and *Agarista eucalyptoides* (Cham. & Schltdl.) D. Don (Ericaceae) a tree species which mainly grow in crevices along the stone walls. Recently a new genus and species of the nemesiid spider *Bayana labordai* (Pérez-Miles *et al.*, 2014) was described and reported only for two sites: the truncated hills in northern Uruguay and the Aracucaria Forest in southern Brazil. Therefore, the truncated hills range constitutes a relictual area of a biological corridor which maintains endemic species so require the implementation of conservation plans and the biota study. Spiders constitute a megadiverse order, with more than 45000 species described (World Spider Catalogue, 2015) that gives useful information for application on environmental management strategies (Coddington *et al.*, 1996; Cardoso *et al.*, 2004). Furthermore, spider fauna of northern Uruguay are poorly known (Simó, 2005). So improve the knowledge on the spider diversity in the truncated hills is a substancial first step for understanding the biota of these relictual habitats. Therefore, the aim of this study is provide data about the araneological fauna of this singular hill range.

MATERIAL AND METHODS

Study site.

The field work was performed in Miriñaque hill, which belongs to the range of truncated hills of northern Uruguay and southern Brazil. It is located in northeastern Uruguay, in Rivera Department (31º 30' S; 55º 39' W) (Fig. 1A). The hill reaches 282 meters a. s. l. where it can be distinguished five strata following the different types of vegetation along the hillside (Fig. 1B). 1) Tophill (TH). It is characterized by rocky outcrops surrounded by grasslands with the presence of the palms *Butia lallemantii* Deble & Marchiori and *Butia paraguayensis* (Barb. Rodr) L. H. Bailey (Brussa & Grela, 2007). 2) Wall rock (WR). It surrounds the hilltop and presents crevices where lower insolation and higher humidity allow grow of a singular type of arboreal and shrub association. Some typical representatives are: *Agarista eucalyptoides* (Cham. & Schltdl.) D. Don (Ericaceae), *Agarista chlorantha* (Cham.) G. Don (Ericaceae), *Hexalchlamys humilis* O. Berg and *Myrciaria delicatula* (D. C.) O. Berg (Myrtaceae). 3) Rocky grassland (RG). This stratum, with more exposition to the wind action, is occuped by some plant species such as *Andropogon lateralis* Nees (Poaceae), *Paspalum polyphyllum* Nees ex Trin. (Poaceae), *Paspalum nicorae* Parodi (Poaceae), *Aristida jubata* (Arechav.) (Poaceae), *Schizachyrium imberbe* (Hack.) A. Camus (Poaceae), *Arachis burkartii* Handro (Fabaceae), *Chrysolaena flexuosa* (Sims) H. Rob. (Asteraceae), *Schlechtendalia luzulifolia* Less. (Asteraceae), and *Mandevillea coccinea* (Hook. et Arn.) Woodson (Apocynaceae). 4) Hilly forest (HF). This stratum develops on the slopes of the hill and is characterized by arboreal and shrub xerophytic species tolerant to the wind action and water deficit, also associated with rocky soils. Some common representatives are: *Scutia buxifolia* Reiss (Rhamnaceae), *Lithraea molleoides* (Vell.) Engl. (Anacardiaceae) and *Schinus molle* L. (Anacardiaceae). 5) Shrubland (S). Situated in the botton of the hill is represented by grass and shrub species some of them are: *Blepharocalyx salicifolius* (Humb.; Bonpl. & Kunth) O. Berg (Myrtaceae), *Psidium salutare* (Kunth) O. Berg. (Myrtaceae), *Eryngium regnellii* Malme (Apiaceae), *Hypogynium virgatum* (Desv. ex Ham.) Dandy (Poaceae), *Baccharis megapotamica* Spreng. (Asteraceae) and *Mimosa cruenta* Benth. (Fabaceae).

Collecting methods.

Two field surveys were performed between september-october 2012. On each one, two collecting methods were used along the different strata of the hill: four samples of nocturnal search with headlamp for an hour and ten samples of one minute extraction with a modified ground vacumm (G-Vac). In the wall rock stratum, spiders were collected using only G-Vac method. Specimens were identified at family, species/morfospecies levels and vouchers were deposited in the arachnological collection of Facultad de Ciencias, Universidad de la República, Uruguay. Immatures and adults were used for guilds classification following Cardoso *et al.* (2011) and analyzed with a Jaccard similarity analysis comparing the strata and collecting methods. The data analysis was performed using Past Paleontological Statistics Software 2.16 (Hammer *et al.*, 2001).

RESULTS

Spider composition. A total of 1337 spiders were collected belonging to 27 families and 71 species/morphospecies (Tables 1 and 2). Immatures represented 79% of the spiders collected. The families Caponiidae, Corinnidae, Filistatidae, Miturgidae, Scytodidae and Tetragnathidae were constituted only by juveniles. The highest abundance was registered in shrubland (30 %) and the lower in the rocky wall (5%). Nocturnal search registered the most abundance (790 specimens; 11 families; 26 spp.; 7 guilds) but G-Vac registered more taxonomic richness and guilds (547 exemplars; 25 families; 49 spp.; 8 guilds). The hill forest was the most speciosus stratum (29 spp. - 41%) and shrubland registered the lower species richness (15 spp. – 21%). Two families, Filistatidae and Nemesiidae were exclusive of one stratum (HT) (Table 2). At family level the most diverse families were Theridiidae (12), Salticidae (11), Linyphiidae (9) and Lycosidae (7). Between the strata it was recognized exclusive species: HT 10 spp., RW 9 spp., RG 7 spp., HF 17 spp., S 5 spp. (Table 1).

Guilds. Considering all the spiders collected, 8 spider guilds were recognized in all the strata of the hill. Ground runners were the most abundant guild, mainly represented by Lycosidae. In the other hand, the sensing web spiders were the less represented in the study (Table 2).

The similarity analysis indicated that with nocturnal hand collection the stratum rocky grassland is the most different in comparaison with the others. With vacuum extraction, the Jaccard Index conformed two groups: one associates the rocky habitats (RW and RG) and the other grouping strata of shrubs and arboreal vegetation (HT, HF, S) (Fig. 2).

DISCUSSION

This study provides the first data of spider diversity in the range of truncated hills of northern Uruguay. *Aysha chicama* Brescovit, 1992 (Anyphaenidae) was registered in the hilly forest and represents the first record for this country. Spiders of families scarcely recorded for this country as Mysmenidae, Trachelidae and Oonopidae represent interesting data to increase the knowledge of Uruguayan spider fauna. Differences in the spider abundance and assemblages suggest high spider replacement between the hill strata. The eight categories of spider guilds proposed by Cardoso *et al.* (2011) were found in this study (Table 2). Shrubland was the stratum with higher spider abundance, mainly represented by web builders, ambush hunters, ground hunters and other hunters. Web-building represent several guilds which capture preys on the webs constructed on the vegetation and are beneficiated by plant structure and diversity (Cardoso *et al.*, 2011; Rodrigues *et al.*, 2015). Ambush hunters (Thomisidae) are sit and wait predators present in flowers or leaves with more activity during the day (Benjamin *et al.*, 2008). Ground hunters included nocturnal dwelling spiders where Lycosidae was the main representative in this study.

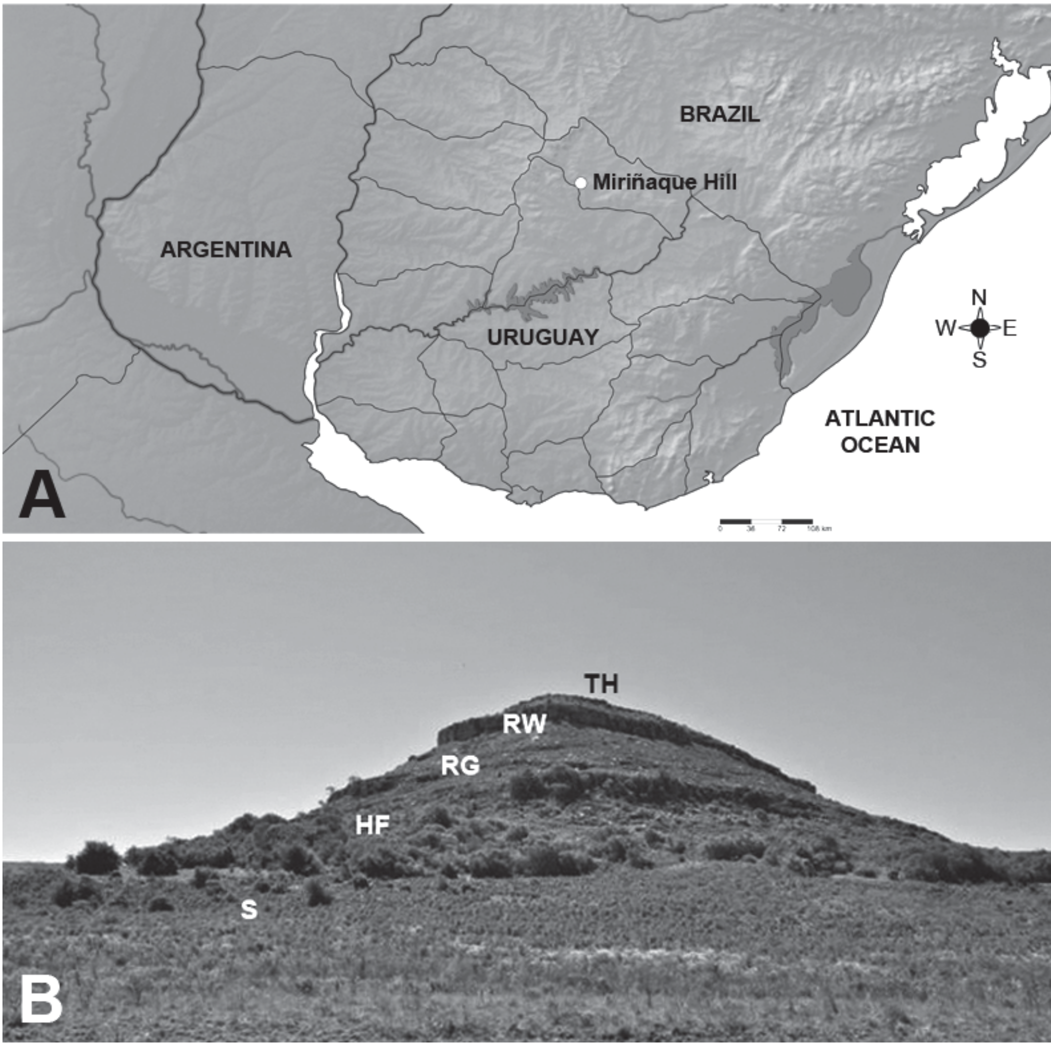

Fig.1 A. Geographic location of the study site. **B.** Differents strata of the Miriñaque hill. TH: tophill, WR: rocky wall, RG: rocky grassland, HF: hilly forest, S: shrubland.

Table 1. Spider families and species composition in differents strata in the Miriñaque hill. TH: tophill; RW: rocky wall; RG: rocky grassland; HF: hilly forest; S: shrubland.

Families	Species	TH	RW	RG	HF	S
Amphinectidae	*Metaltella simoni* (Keyserling, 1878)		X			
Anyphaenidae	*Arachosia praesignis* (Keyserling, 1891)	X				
	Aysha chicama Brescovit, 1992				X	
	Aysha prospera Keyserling, 1891		X		X	
	Sanogasta maculatipes (Keyserling, 1878)				X	
	Tasata sp.	X				
Araneidae	*Alpaida veniliae* (Keyserling, 1865)				X	
	Eustala photographica Mello-Leitão, 1944				X	
	Larinia bivitatta Keyserling, 1885					X
	Parawixia audax (Blackwall, 1863)				X	X
Ctenidae	*Parabatinga brevipes* (Keyserling, 1891)	X		X	X	X
Gnaphosidae	*Gnaphosidae sp.*			X		
Hahniidae	*Hahniidae sp.*				X	X
Linyphiidae	*Dubiaranea sp1*				X	X
	Dubiaranea sp2				X	
	Dubiaranea sp3				X	
	Linyphiidae sp1		X			
	Linyphiidae sp2		X		X	
	Linyphiidae sp3		X			
	Linyphiidae sp4	X				
	Sphecozone sp1		X	X		
	Sphecozone sp2	X			X	
Lycosidae	*Lobizon humilis* (Mello-Leitão, 1944)		X		X	
	Lycosa u-album Mello-Leitão, 1938			X	X	X
	Lycosa carbonelli Costa & Capocasale, 1984			X		
	Lycosa erythrognatha Lucas, 1836	X		X	X	X
	Lycosa poliostoma (C. L. Koch, 1847)	X		X		X
	Navira naguan Piacentini & Grismado, 2009				X	
	Pavocosa gallopavo (Mello-Leitão, 1941)			X	X	
Mysmenidae	*Mysmenidae sp.*		X			
Nemesiidae	*Stenoterommata crassistyla* Goloboff, 1995	X				
Oonopidae	*Gamasomorpha sp.*		X	X		
	Orchestina sp.		X			

Table 1. *(Cont.)*

Families	Species	TH	RW	RG	HF	S
Oxyopidae	*Oxyopes salticus* Hentz, 1845					X
Palpimanidae	*Othiotops birabeni* Mello-Leitão, 1945				X	
Philodromidae	*Philodromidae sp.*			X		
Pholcidae	*Mesabolivar charrua* Machado *et al.*, 2013		X			
Salticidae	*Aillutticus nitens* Galiano, 1987	X				
	Akela ruricola Galiano, 1999	X		X		
	Aphirape flexa Galiano, 1981		X			
	Dendryphantes mordax (C. L. Koch, 1846)	X				
	Salticidae sp1	X				
	Salticidae sp2	X				
	Salticidae sp3					X
	Salticidae sp4	X				
	Salticidae sp5					X
	Salticidae sp6	X				
	Salticidae sp7			X		
Sparassidae	*Polybetes germaini* Simon, 1897				X	
Theraphosidae	*Grammostola anthracina* (C. L. Koch, 1842)			X		
Theridiidae	*Anelosimus vierae* Agnarsson, 2012				X	
	Euryopis sp.			X		X
	Theridiidae sp1			X		
	Theridiidae sp2				X	
	Theridiidae sp3		X			
	Theridiidae sp4		X			
	Theridiidae sp5				X	
	Theridiidae sp6				X	
	Theridiidae sp7				X	
	Theridiidae sp8				X	
	Theridiidae sp9			X		
	Tymoites sp.	X	X	X	X	X
Thomisidae	*Runcinioides sp1*					X
	Runcinioides sp2				X	
	Tmarus sp1				X	
	Tmarus sp2		X		X	X
	Tmarus sp3	X		X		
Trachelidae	*Trachelidae sp.*	X	X	X		

Table 2. Spider guilds composition and abundance in different strata in the Miriñaque hill. TH: tophill; RW: rocky wall; RG: rocky grassland; HF: hilly forest; S: shrubland.

Guilds/Families	TH	RW	RG	HF	S	Total	%
Ambush hunters							
Thomisidae	5	7	9	14	48	83	6,208
Total guild	5	7	9	14	48	83	6,208
Ground hunters							
Corinnidae	1	-	1	-	4	6	0,449
Gnaphosidae	-	1	1	1	2	5	0,374
Lycosidae	104	2	282	82	109	579	43,306
Oonopidae	-	4	1	-	-	5	0,374
Trachelidae	1	1	1	-	-	3	0,224
Total guild	106	8	286	83	115	598	44,727
Orb web							
Araneidae	6	3	3	94	95	201	15,034
Tetragnathidae	-	-	-	1	1	2	0,15
Total guild	6	3	3	95	96	203	15,183
Other hunters							
Anyphaenidae	14	9	12	21	22	78	5,834
Ctenidae	9	-	14	14	11	48	3,59
Miturgidae	-	-	-	-	3	3	0,224
Oxyopidae	-	-	2	-	5	7	0,524
Philodromidae	24	8	30	2	66	130	9,723
Salticidae	35	7	16	5	18	81	6,058
Scytodidae	-	2	-	-	1	3	0,224
Sparassidae	-	-	-	1	-	1	0,075
Total guild	82	26	74	43	126	351	26,253
Sensing web							
Filistatidade	1	-	-	-	-	1	0,075
Nemesiidae	1	-	-	-	-	1	0,075
Theraphosidae	1	-	1	-	-	2	0,15
Total guild	3	-	1	-	-	4	0,299
Sheet web							
Amphinectidae	-	1	1	-	3	5	0,374
Hahniidae	-	-	-	1	1	2	0,15
Linyphiidae	7	6	2	12	2	29	2,169
Total guild	7	7	3	13	6	36	2,693

Table 2. *(Cont).*

Guilds/Families	TH	RW	RG	HF	S	Total	%
Space web							
Mysmenidae	-	3	-	-	-	3	0,224
Pholcidae	1	2	-	-	-	3	0,224
Theridiidae	5	14	12	11	7	49	3,665
Total guild	6	19	12	11	7	55	4,114
Specialists							
Caponiidae	3	-	-	-	1	4	0,299
Palpimanidae	-	-	1	1	1	3	0,224
Total guild	3	-	1	1	2	7	0,524
Total	218	70	389	260	400	1337	100
Families	16	15	17	14	19	27	
Exclusive Families	2	1	0	1	0		

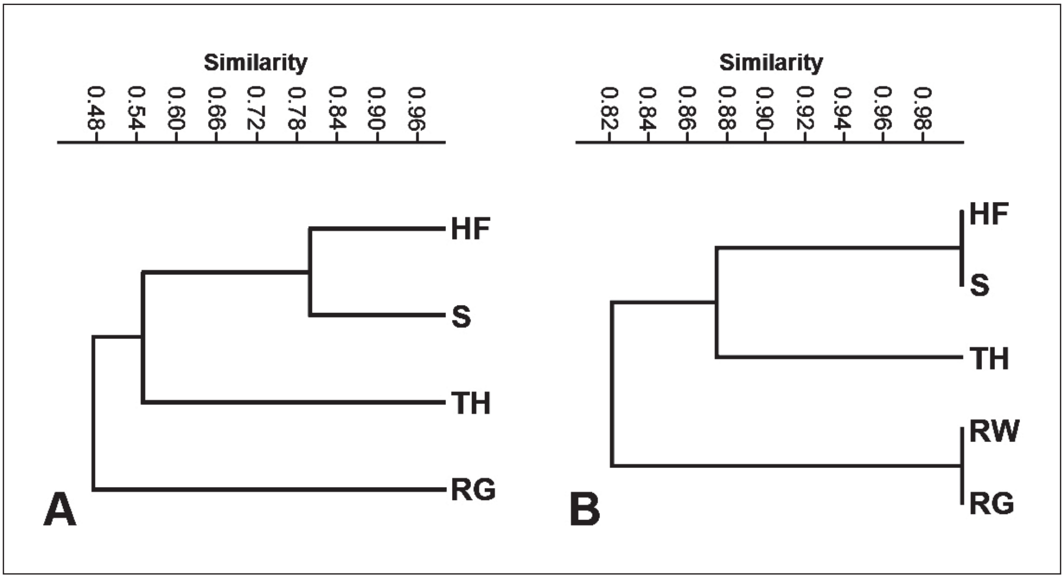

Fig. 2. Jaccard similarity dendrogram comparing the strata of the Miriñaque hill with the two collecting methods used. A. Nocturnal searching. (Cophenetic correlation: 0,9506). B. Ground vacuum (Cophenetic correlation: 0,8707).

They are common in more open vegetation structure (Pao-Shen Huang *et al.*, 2014) as the small patches of grass between the shrubs. Other hunters (Philodromidae) do not construct webs but capture preys ambushing on the foliages and the tree barks (Korenko *et al.*, 2010; Cardoso *et al.*, 2011). It was assumed that spider diversity increases with the vegetation complexity (Diehl *et al.*, 2013). Our results are agreed with this assumption because the high species richness was registered in the hill forest which presents higher diversity of arboreal and shrub vegetation. *Polybetes germanii* Simon, 1897 (Sparassidae) was only registered in this stratum, probably because this species, as others of this family (Gershman & Schiapelli, 1965), prefers to leave in the barks of the trees. This species with scarce records in Uruguay, is registered by Paraguay, northeastern Argentina (Formosa to Córdoba) and Mato Grosso in Brazil (Gershman & Sciapelli, 1965), indicating this species is distributed along the subtropical forests and wetlands of this part of South America. The rocky grassland was mainly represented by ground hunters (Lycosidae), epigeic spiders that usually prefer open habitats, outside from cover vegetation (Frick *et al.*, 2007). This was the only stratum where was collected the theraphosid *Grammostola anthracina* (C. L. Koch, 1842), this species is typical of hilly areas and lives under stones (Montes de Oca, 2014). The rocky wall was the stratum with lower spider abundance. Because the difficult conditions for apply the collecting methods, only wall crevices were surveyed using G-Vac. But the singularity of this stratum reported for the vegetation (Brussa & Grela, 2007) was in concordance with the spider species found. There, it was recorded 9 exclusive taxa, mainly of web builders, and the only record of Mysmenidae (Tables 1 and 2). Wall crevices are singular habitats protected against the wind action and isolation (Brussa & Grela, 2007) and constitute suitable conditions for the establishment of webs in the shrub and arboreal vegetation. The hilltop was the stratum with higher species richness, with all the guilds represented and the most exclusive taxonomic composition (two families and 10 species). *Stenoterommata crassistyla* Goloboff, 1995 was recorded only in the hilltop. This species lives under stones in grasslands or forest plantations (Toscano-Gadea, 2011). Sensing web was poor represented in this study probably by the collecting methods used. Spiders of this guild as mygalomorphs, live under stones or subsurface in burrows (Huang *et al.*, 2014). Hand diurnal collection and pit fall traps were reported as good methods for capture them (Ferretti *et al.*, 2010). Specialists were represented by few specimens of Palpimanidae and Caponiidae. This guild inhabit decayed wood, litter and rocks on ground, hunting freely woodlouse or ants (Huang *et al.*, 2014). These families have been captured mainly with pit fall traps or Winkler apparatus (Höfer & Brescovit, 2001). Elliot *et al.* (2006) indicated that suction sampling was a highly efficient method in the collection of Araneae and other arthropods in winter wheat. Doxon *et al.* (2011) indicated the benefits of this method capturing small invertebrates. Moreover nocturnal hand collection is adequate for collection of greater and visible spiders in trunks, silk webs (Vedel *et al.*, 2013) or soil, mainly actives in the night. In this study, G-Vac was the most efficient method considering it captured more species and guilds, particularly small spiders as representatives of Mysmenidae, Oonopidae or Hahniidae. With nocturnal searching were collected more spiders of higher size mainly Theraphosidae, Lycosidae and web builders. These allow us to consider that both methods provided complementary information about the spider fauna.

At guild level, similarity index indicates that rocky habitats are more different than the others strata. Pinzón *et al.* (2012) found high species turnover between different strata in boreal white spruce stands levels which provide basic knowledge for forest management decisions. Our results reveal that species composition in each stratum was highly distinctive and the spider assemblages are highly associated with the types of ecological strata in the truncated hill studied. This suggests that local and regional plans of conservation of this range hill should consider the maintenance of these strata. Future studies should be focused on the comparison of the spider fauna in others truncated hills of northern Uruguay. They will be useful tools for the knowledge and conservation of the biota in this biological corridor.

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