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Diversity and composition of arbustive spiders in an Atlantic Forest fragment and two adjacent areas

Diversidade e composição de aranhas arbustivas em um fragmento de Mata Atlântica e duas áreas adjacentes

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Abstract

The present study preliminarily investigates the diversity and composition of arbustive spider assemblages occurring in an early stage (arbustive), an intermediate stage (early second-growth), and a mature stage area (Atlantic Forest fragment) in Torres municipality, Rio Grande do Sul. Spiders and other arthropods (potential prey) were caught during the day with beating trays inside ten 3 m2 plots randomly placed inside each area, during two field trips in 2008. An individual-based rarefaction (with confidence intervals) was utilized to access differences in spider richness between areas, spider assemblage composition variation among the three succession areas was accessed by a MANOVA via randomization test, and the correlation between arbustive spider composition and the composition of potential preys was analyzed by a Mantel test. There were no significant differences in arbustive spider abundances between areas. Mature stage area presented higher arbustive spider richness compared to early stage area and intermediate stage area. The three habitats showed different compositions of arbustive spider assemblages, and the composition of arbustive spiders was not correlated with the composition of the potential preys. Higher richness of arbustive spiders in the mature area is probably due to a more diverse plant community. Compositions found in the three habitats indicate that many mature-forest species could not be capable of using matrix habitats. It seems that the mature patch is surrounded mainly by an inhospitable matrix, with little overlap in spider species composition between the habitats showing more similar vegetation composition (mature and intermediate). Our findings outpoint to a habitat-selective spider assemblage in this Atlantic Forest fragment highlighting the importance of protecting Atlantic forest fragments to conserve arbustive spider assemblages. Moreover, intermediate stage areas contiguous to forest fragments could be important to some forest dwelling species and also needs attention.

Key words: fragmentation, matrix-tolerant species, forest succession, forest structure.

Resumo

O presente estudo investigou preliminarmente a diversidade e composição de aranhas arbustivas em uma área de início de sucessão (arbustiva), uma área em estágio intermediário de sucessão (floresta secundária) e um fragmento de Mata Atlântica em Torres, Rio Grande do Sul. Aranhas e outros artrópodes (presas potenciais de aranhas) foram coletados com guarda-chuva entomológico, entre 50 e 200 cm de altura, em 10 parcelas em cada área no ano de 2008. A riqueza de espécies foi acessada através de rarefações baseadas no número de indivíduos, a composição de espécies foi analisada através de uma MANOVA por teste de aleatorização e a correlação entre a composição de espécies de aranhas e as ordens de presas potenciais foi analisada através de um

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teste de Mantel. A abundância de aranhas não variou entre as áreas. A riqueza estimada foi maior no fragmento de Mata Atlântica, enquanto a composição de aranhas foi diferente nas três áreas. Não houve correlação entre a composição das assembléias de aranhas e a composição de presas potenciais. A maior riqueza de aranhas arbustivas no fragmento de Mata Atlântica provavelmente se deve à presença de uma comunidade vegetal mais diversa. As diferenças nas composições indicam que parte das espécies desse fragmento podem não ser capazes de utilizar ambientes da matriz, pois houve pouca sobreposição de espécies entre as áreas com maior similaridade vegetal (madura e intermediária). Os resultados indicam que as espécies desse fragmento de Mata Atlântica são seletivas no uso do hábitat, mostrando a importância da proteção desse e de outros fragmentos para a conservação das assembléias de aranhas arbustivas. Adicionalmente, áreas em estágio intermediário de sucessão, contíguas a esse e outros fragmentos, podem ser importantes para algumas espécies da floresta e também necessitam de atenção para sua conservação.

Palavras-chave: fragmentação, espécies matriz-tolerantes, sucessão florestal, estrutura de floresta.

Introduction

Atlantic forest fragmentation resulted in only about 12% of the original area of forests left, with a critical spatial configuration where more than 80% of the fragments are < 50 ha and almost 50% of the forest is < 100 m from the edge, which subject it to significant pressure by the surrounding human-dominated landscape (Ribeiro *et al*., 2009). Therefore, the forest fragmentation originated various forest fragments distributed in a matrix of different land uses. Although the majority of fragments are small, they are important in reducing isolation in all regions of Atlantic forest (Ribeiro *et al*., 2009). Whenever the areas surrounding fragments do not undergo repeated disturbances, it is possible that the vegetation could start a pattern of directional and continuous changing as time passes, which causes alterations in species structure and community processes, the ecological succession (Connell and Slatyer, 1977).

The growth of vegetation surrounding forest fragments provides resources to animal colonization and survival. In that sense, recent changes in landscape structure can affect species persistence, and surrounding areas in different stages of succession could enhance matrix permeability, a key connectivity component in a fragmented landscape that plays a major role in determining the movement between forest fragments (Fonseca *et al*., 2009; Metzger *et al*., 2009; Turner, 1996). Invertebrate assemblages that follow in response to vegetation dynamics present generalist species in early successional stages, while specialist herbivores and other taxa that need complex plant structures appear in latter stages of succession (Gibson *et al*., 1992). Spider diversity correlates to vegetation structure and, as generalist feeders, spiders are likely to be more sensitive to changes in the physical structure of microhabitats (Wise, 1993). In different successional stages we could expect to find different spider assemblage structure and compositions because alterations in the number and diversity of plant structures are known to influence spider species distribution and occurrence (Baldissera *et al*., 2008a; Baldissera *et al*., 2004; Halaj *et al*., 2000; Greenstone, 1984; Barnes and Barnes, 1955).

The study of sequential alterations in species composition that follow a tropical forest succession involves a time scale not accessible to short studies. However, snapshot studies of animal community structure in areas with different successional stages could be important to access similarities between recent disturbed areas and older forests. It becomes more important in forest conservation context since we will be able to recognize patterns of community structure associated to the matrix surrounding fragments, which is especially important in a scenario where short movements through the matrix can promote fragment connections (Ribeiro *et al*., 2009).

Therefore, the present study preliminarly investigates the diversity and composition of arbustive spider assemblages occurring in three areas of different successional stages of Atlantic Forest: early stage (arbustive), intermediate stage (early second-growth), and late stage (forest fragment) in Torres municipality, northeastern Rio Grande do Sul. We hoped to find higher richness and abundance in late stage area, as well as different species composition in the three areas. Disturbance in matrix patches, either natural or human-induced, could prevent the formation of steady conditions by reducing the variety of substrates and habitat available for spider taxa colonization and establishment (Engelmark *et al*., 2001). Additionally, we also tested the correlation between arbustive spider composition and the composition of potential preys. Although habitat structure could exert a major effect on understory spider assemblages (Halaj *et al*., 2000), potential prey composition could be an important factor influencing spider assemblage composition (Baldissera *et al*., 2008b).

Methods

Study site

The three contiguous areas are located in Torres municipality, RS (Figure 1) (UTM Coordinates 22 J 65756248 N – 620219 E, in the centre of this area). The mature stage area (forest fragment) is a 4.73 ha Atlantic forest fragment characterized by a forest composed by multiple strata with high and old trees (*e.g. Cedrela fissilis*, *Ocotea* spp*.*, *Euterpe edulis*) (Figure 2). Arbustive stratum possesses juvenile trees (including palm-trees), bushes, and vines. The intermediate stage area is *ca.* 1.3 ha presenting many bushes (*Baccharis* and *Dodonea*) more than 3 m height, juvenile trees of the genera *Myrsine* and *Cupania,* and exotic trees (*Pinus* and *Eucalyptus*) (Figure 2). The early stage area is *ca.* 3 ha almost all covered with *Baccharis* bushes no more than 2 m height (Figure 2). The region is inserted in the Coastal Plain of Rio Grande do Sul and the areas lie over a sandy hill (54 m.a.s.l.) *ca*. 4.9 km far from the sea. Climate is subtropical mesothermic and humid, mean annual lowest and highest temperature is 15.7ºC and 22.4ºC respectively, and total annual precipitation is 1,387 mm.

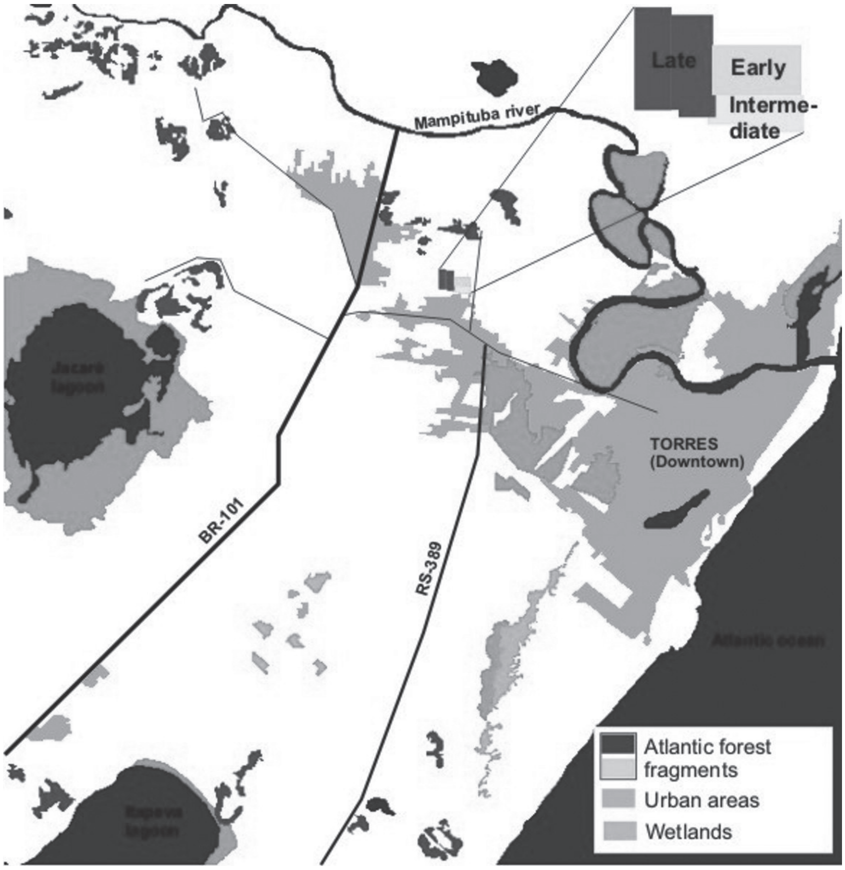

Figure 1. Map showing Atlantic forest fragments in Torres municipality, RS, detaching the three successional stage areas studied (upper right). Map generated from a shape ArcView file based on a land use map (Dobrovolski, 2006). Scale: 1:67,000.

Data collection

Spiders and other arthropods were caught during the day with beating trays inside ten 3 m^2 sampling units (plots) randomly placed inside each area, during two field trips in mid January and one field trip in early March 2008. All plant parts between 50-200 cm inside each plot were beaten and fallen vegetation was placed inside plastic sacs. Afterwards spiders and other arthropods were sorted out from the vegetation by hand in the laboratory and stored in 80% alcohol. Spider specimens were identified by M.Sc. Everton N. L. Rodrigues to species level whenever possible; otherwise a morphspecies criterion was used. Voucher specimens are deposited in the Natural Sciences Museum of Zoo-Botanical Foundation of Rio Grande do Sul (MCN, FZB-RS). Other arthropods were identified to order level, except for caterpillars and early stage individuals.

Data analysis

An individual-based rarefaction (with confidence intervals) was utilized to access differences in spider richness between areas utilizing EcoSim 7.0 software (Gotelli and Entsminger, 2001). Rarefaction generates the expected number of species in a small collection of *n* individuals drawn at random from the large pool of N individuals (Gotelli and Colwell, 2001). The method used to decide whether the three assemblages differ in richness is to ascertain whether the observed richness of the smaller assemblage lies within the 95% confidence limits of the rarefaction curve of the larger assemblage (Magurran, 2004).

A spider species × plots matrix was organized with species described by its $\log(x + 1)$ abundance. Based on this matrix and utilizing the software MULTIV (Pillar, 2004) a dissimilarity matrix between plots by chord distance (Podani, 2000) was calculated. Afterwards spider assemblage composition variation among the three succession areas was accessed by a multivariate analysis of variance (MANOVA) via randomization test (1,000 iterations). Using the same distance matrix, a Principal Coordinate Analysis was done to visualize the distribution pattern of plots according to species abundances. In order to check for autocorrelation

Figure 2. Photographs of the three successional stage areas in Torres municipality, RS. Left photo shows late stage (background) and early stage area. Right photo shows intermediate stage (right hand) and early stage area.

in the multivariate data we utilized Multivariate Mantel Correlograms (Legendre and Legendre, 1998). The principle is to quantify ecological relationships among sampling units inside *each habitat* by means of a matrix **Y** of similarities (chord distance in our case), and compare **Y** to a model matrix, which is different for each distance class (Legendre and Legendre, 1998). In our case, distance class "0" corresponds to completely similarity (null distance) between the first and the other sampling units, i.e., perfect autocorrelation. The other cells of the matrix were filled with "1". That is the matrix $\mathbf{X_1}$. A first Mantel statistic (r_M) is calculated between **Y** and $\mathbf{X_1}$. The process is repeated for each one of the sampling units inside the particular habitat ($\mathbf{X_n}$). In every step, significance of Mantel correlation was evaluated by 1,000 permutations taking into account the upper tail of reference distribution (positive correlation) (Legendre and Legendre, 1998). Therefore, we were able to check whether the multivariate data is spatially autocorrelated.

In order to check the correlation between arbustive spider composition and the composition of potential preys (order level) a Mantel test was utilized. Null hypothesis of Mantel test states that the distances among objects (plots) in response matrix **Y** (arbustive spider composition) are not correlated with the corresponding distances in explanatory matrix **X** (composition of potential preys) (Legendre and Legendre, 1998). The two matrices were *log (x+1)* transformed and a chord distance (Podani, 2000) resemblance measure was calculated in order to run the Mantel test.

Results

Spider diversity

A total of 401 spiders were collected in the three successional areas. Spider species sorting is possible only from adult sexual mature specimens, therefore from the above total 151 individuals could be divided in 30 species (14 families) used in the analyses. Juvenile spiders were not included in the analyses. Theridiidae was the most abundant family (49 spiders; 32.45%), followed by Linyphiidae (34; 22.52%), and Salticidae (32; 21.19%) (Table 1). *Thymoites* sp. (Theridiidae) was the most abundant species (28; 18.54%) and also presented higher abundance in the intermediate area (27 individuals). Fissidentati sp.1 (Salticidae) and *Scytodes* sp. (Scytodidae) were the second most abundant species. The former occurred solely in the early stage area, while the later occurred in the intermediate area and in the mature area (Table 1). The intermediate area showed the higher abundance (N = 61; mean 6.1), followed by mature (N = 52; 5.2) and early stage area (N = 38; 3.8). Nevertheless there were no significant differences in arbustive spider abundances between areas as shown by a randomization based ANOVA (SS = 26.867; P = 0.581).

A total of 835 other arthropods were identified to 18 orders (Table 2). Seven orders had less than 1% of relative abundance and were removed from the matrix utilized to run Mantel test. Collembola was the most abundant order (21.32%), followed by Coleoptera (16.65%) and Acarina (11.62%).

After individual-based rarefaction, mature stage area presented higher arbustive spider richness (14 expected species) compared to early stage area (9 expected species), and higher richness (17 expected species) than intermediate stage area (10 expected species) (Figure 3). Early stage and intermediate stage areas showed the same number of expected species (Figure 3).

Inspection of table 1 showed that seven species occurred solely in the early

Table 1. Species list of arbustive spiders colleted in three successional areas in Torres, RS. Early = early stage area; Intermediate = intermediate stage area; Mature = mature stage area. % = relative abundances.

Species	Family	Early	Intermediate	Mature	TOTAL	%
Anelosimus ethicus	Theridiidae	9			9	5.96
Cryptachea hirta	Theridiidae	5			5	3.31
Fissidentati sp.1	Salticidae	14			14	9.27
Oxyopes salticus	Oxyopidae	1			1	0.66
Tmarus sp.2	Thomisidae	1			1	0.66
Dipoena alta	Theridiidae	1			1	0.66
Keijia mneon	Theridiidae	1			1	0.66
Anodoration claviferum	Linyphiidae		12		12	7.95
Neospintharus trigonum	Theridiidae		1		1	0.66
Tmarus sp.3	Thomisidae		1		1	0.66
Mopiopia labyrinthea	Salticidae		2		2	1.32
Coryphasia sp.	Salticidae			1	1	0.66
Coryphasia aff. fasciventris	Salticidae			1	1	0.66
Onocolus sp.	Thomisidae			4	4	2.65
Sphecozone sp.	Linyphiidae			9	9	5.96
Lygarina sp.	Linyphiidae			13	13	8.61
Theridion opolon	Theridiidae			1	1	0.66
Mesabolivar luteus	Pholcidae			1	1	0.66
Mimetinae sp.1	Mimetidae			1	1	0.66
Mimetinae sp.2	Mimetidae			2	2	1.32
Spintharus gracilis	Theridiidae			2	2	1.32
Phoroncidia reimoseri	Theridiidae			1	1	0.66
Mopiopia sp.	Salticidae			1	1	0.66
Fissidentati sp.2	Salticidae	2	1		3	1.99
Cheiracanthium inclusum	Miturgidae	4	2		6	3.97
Scytodes sp.	Scytodidae		10	4	14	9.27
Cotinusa sp.	Salticidae		3	5	8	5.3
Vinnius subfasciatus	Salticidae		1	1	2	1.32
Thymoites sp.	Theridiidae		27	1	28	18.54
Tmarus sp.1	Thomisidae		1	4	5	3.31
TOTAL		38	61	52	151	

stage area (23%), four occurred only in the intermediate stage area (13%), and 12 only in the mature stage area (40%). Taking into account the numbers of species in each pair of habitats, early stage area did not share species with mature stage area, but shared two species with intermediate stage area (11%). Intermediate stage area and mature stage area shared five species (24%). In spite of the similarity between some habitats, results of MANOVA showed different compositions for the three habitats (SS = 5.645; P = 0.001, Table 3). The multivariate data inside each habitat did not present positive correlation ($P > 0.05$ for all tests between matrices $\mathbf{Y}$ and $\mathbf{X}_n$ in each habitat), i.e., data were not autocorrelated.

The ordination scatterplot shows the differences in composition (Figure 4). The first ordination axis explained 17.7% of variation, while second axis explained 15.2%. The intermediate stage area and the early stage area were associated with the first axis of ordination. Plots of the intermediate area concentrated on the left side of the ordination axis 1 (Figure 4) and they were characterized by the presence of *Thymoites* sp. (Theridiidae), *Scytodes* sp. (Scytodidae), *Anodoration claviferum* Millidge, 1991 (Linyphiidae), *Neospintharus trigonum* (Hentz, 1850) (Theridiidae), and *Mopiopia labyrinthea* (Mello-Leitão, 1947) (Salticidae). On the right side of first axis early area plots

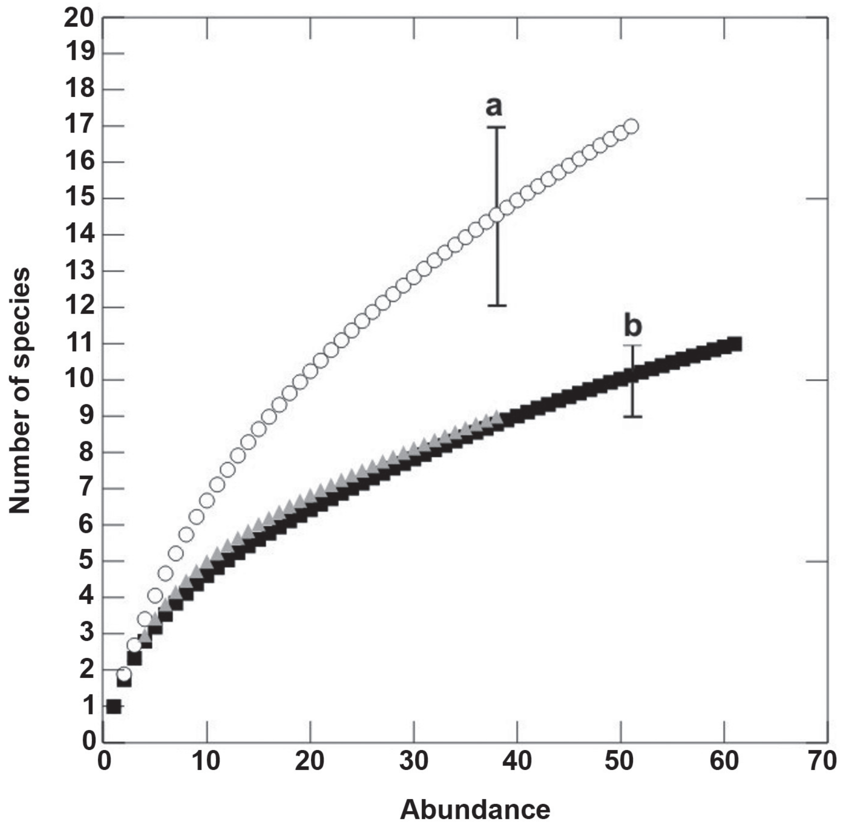

Figure 3. Rarefaction curves of three areas of different successional stages in Torres municipality, RS. Circles = mature stage area; squares = intermediate stage area; triangles = early stage area. (a) low (12) and high (17) 95% confidence limits for interpolation of mature stage area to early stage area expected richness; (b) low (9) and high (11) 95% confidence limits for interpolation of intermediate stage area to mature stage area expected richness.

were characterized by the presence of Fissidentati sp.1 and sp.2 (Salticidae), *Achaearanea hirta* (Taczanowski, 1873) (Theridiidae), and *Cheiracanthium inclusum* (Hentz, 1847) (Miturgidae). The species describing the composition of the mature stage dispersed along the negative side of second axis: *Lygarina* sp. (Linyphiidae), *Onoculus* sp. (Thomisidae), *Sphecozone* sp. (Linyphiidae), and *Cotinusa* sp. (Salticidae).

The composition of arbustive spiders was not correlated with the composition of potential preys (Mantel test matrix correlation = 0.14; P = 0.22).

Discussion

Our results corroborated initial hypotheses. Mature stage area showed higher richness than areas undergoing early stages of succession. The composition of mature stage area was different from the other two areas in spite of some degree of similarity. These findings suggest that this fragment of Atlantic Forest supports a particular spider assemblage and that even a secondary forest in the surrounding matrix do not shelter many mature-forest spider species. However, we must be prudent in the interpretation of these findings regarding the short-term nature of the study.

Higher richness of arbustive spiders in the mature area is probably due to a more diverse plant community. In the two initial successional areas, plant community is more homogeneous and trees showed lower diameters (unpublished data). For instance, the early stage area presents just one kind of low sized bush predominating (*Baccharis* spp.). One would expect a more diverse spider community structure in the intermediate stage area because the mix of plant species from the early stage area and from the mature stage area would give rise to a more diversified community structure (Connell, 1978). But this is not the case for this particular intermediate successional area. Intermediate stage vegetation structure shows mainly higher individuals of the same dominant genera found in the early stage area mixed with exotic *Pinus* and *Eucalyptus*, and fewer juveniles of other pioneer woody species indicating that the vegetation of the intermediate area is still recovering from a "soon after disturbance" [*sensu* Connell (1978)], which translates in lower plant diversity compared to mature stage area. For example, Tabarelli and Mantovani (1999) showed that only after 40 years a regenerating patch reach a diversity index close to the one presented by a mature forest. So the predominance of bushes and pioneer species reduces plant diversity and biomass, two factors known to influence spider richness (Halaj *et al.*, 2000; Baldissera *et al.*, 2004). Additionally, severe climatic conditions in the more open early stage and intermediate stage areas, mainly exposure to wind and temperature, as well as possible human disturbance could also prevent the persistence of spider species (Wise, 1993; Uehara-Prado *et al.*, 2009). On the other hand, mature area shows in the understory layer a more heterogeneous plant community structure with lianas, bushes (e.g. Piperaceae, Heliconiaceae), pteridophytes, and trees (e.g. Myrtaceae, Meliaceae, Palmae, Moraceae) (R. Baldissera, pers. obs.), which allows more diverse structures to web and retreat construction. Therefore, in spite of the lack of a systematic measurement of vegetation community, the structure of vegetation seems to be the main factor influencing spider species

Table 2. List of arbustive arthropods others than spiders found in three successional areas in Torres, RS. Early = early stage area; Intermediate = intermediate stage area; Mature = mature stage area. % = relative abundances.

Orders	Early	Intermediate	Mature	Total	%
Acarina	31	19	47	97	11.62
Blattodea	0	17	14	31	3.71
Coleoptera	23	34	82	139	16.65
Collembola	51	30	97	178	21.32
Crustacea	0	0	33	33	3.95
Dermaptera	0	0	1	1	0.12
Diptera	4	1	5	10	1.2
Hemiptera	2	3	5	10	1.2
Homoptera	73	8	10	91	10.9
Hymenoptera	3	4	4	11	1.32
Hymenoptera (Formicidae)	62	24	76	162	19.4
Mantodea	0	0	2	2	0.24
Opiliones	0	2	1	3	0.36
Orthoptera	5	0	3	8	0.96
Phasmida	1	0	0	1	0.12
Pseudoscorpiones	0	0	2	2	0.24
Psocoptera	6	15	33	54	6.47
Thysanoptera	0	2	0	2	0.24
TOTAL	261	159	415	835	100

Table 3. Results of MANOVA via randomization test (1,000 iterations) between three successional stage areas in Torres, RS. Data based on a dissimilarity matrix between plots (chord distance).

Source of variation	Sum of squares	P
Habitat		
Between groups	5.645	0.001
Early × intermediate	2.888	0.001
Early × late	2.568	0.001
Intermediate × late	3.011	0.001
TOTAL	22.434	

persistence in this Atlantic Forest fragment with prey availability playing a secondary role (Halaj *et al*., 1998). Nevertheless, a species-area relationship could also be expected to influence spider richness, either by the area per se or by the increase in habitat heterogeneity associated to the increasing area (Connor and McCoy, 2001). Maybe that could explain why intermediate stage area showed the same richness of early stage area in spite of small area, i.e., the former shows higher habitat heterogeneity than the later in a small piece of area. Compositions found in the three habitats indicate that many mature-forest species could avoid matrix habitats, a pattern also found by Gascon *et al*. (1999) for ant species that persisted in fragments and were rare from the matrix. Uehara-Prado *et al*. (2009) also found low similarity in ground-dwelling spider compositions between sites with different disturbance degrees in São Paulo state. On the other hand, other studies found *ca.* 50% similarity in the composition of spiders inhabiting different fragmented systems: clear-cutting and temperate forest fragment sites in USA, and primary forest trees on Borneo compared to isolated forest and adjacent forest trees (Coyle, 1981; Floren and Deeleman-Reinhold, 2005). In Coyle's research it was utilized four different sampling techniques and he did not perform separated analyses for each sampling procedure, therefore we are not able to ascertain if arbustive spider assemblages are more sensitive to non-forested habitats in that ecosystem as it seems to be the case for the present study. It is very possible that as time passes the spider composition of intermediate stage area becomes much more similar to the composition of mature stage area since studies showed that time since formation influence the plant diversity of secondary forest (Tabarelli and

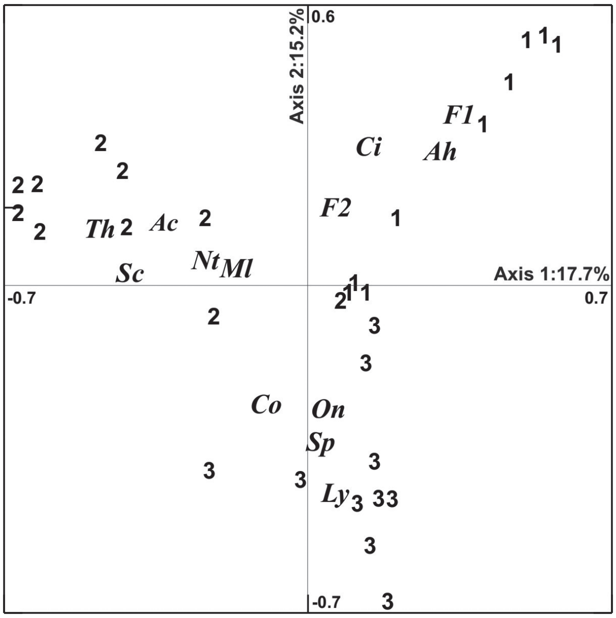

Figure 4. Ordination diagram based on Principal Coordinates Analysis of sampling units in mature stage area (3), intermediate stage area (2), and early stage area (1) described by 30 arbustive spider (morpho-)species. The species more correlated with the first and second ordination axes are disposed proportionally in the diagram, where *Ac = Anodoration claviferum, Ah = Achaearanea hirta, Ci = Cheiracanthium inclusum, Co = Cotinusa* sp.*, F1 = Fissidentati* sp.1*, F2 = Fissidentati* sp.2*, Ly = Lygarina* sp.*, Ml = Mopiopia labyrinthea, Nt = Neospintharus trigonum, On = Onoculus sp., Sc = Scytodes sp., Sp = Sphecozone* sp.*, Th = Thymoites* sp. Significance of ordinations axes after randomization test (1,000 iterations) are: axis 1: P = 0.41; axis 2: P = 0.27.

Mantovani, 1999), which in turn would affect spider assemblage structure (Yanoviak *et al*., 2003; Floren and Deeleman-Reinhold, 2005). The probability of short-term colonization of a patch could be affected both by its quality and its level of connectivity (Bonte *et al*., 2003). It could be expected that secondary forest represents a filter with large pore in the landscape allowing great animal movement due to structural similarity with mature forest (Tabarelli and Gascon, 2005). This pattern was fairly found in our study; we observed little overlap in spider species composition between the more compositionally similar habitats (mature and intermediate). Additionally, matrix habitats could be subjected to frequent disturbance, either natural or anthropogenic, which can be an important source of variation in spider assemblage compositions in fragmented landscapes (Bonte *et al*., 2002). Although the short-term level nature of the present study, our findings outpoint to a habitat-selective spider assemblage in this Atlantic Forest fragment highlighting the importance of protecting Atlantic forest fragments to conserve arbustive spider assemblages. Moreover, intermediate stage areas contiguous to forest fragments could be important to some forest dwelling species and also needs attention.

Further studies must increase the number of Atlantic Forest fragments and associated matrix habitats in order to verify whether there are specific spider species that can serve as indicator species of forest successional stage. Moreover, studies are needed to access the spider population level responses (e.g. phenology, dispersal, and microhabitat selection) to patch and surrounding habitats in order to understand the factors influencing spider habitat selection. These approaches will be crucial to conserve Atlantic Forest spider diversity and to manage matrix surrounding forest fragments.

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