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Distribution of Understorey Web Building Spiders Along an Interface Area of *Araucaria* Forest and *Pinus* Plantation in Southern Brazil

Distribuição de aranhas de teia de sub-bosque ao longo de uma área de contato entre floresta de *Araucaria* e plantação de *Pinus* no sul do Brasil

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Abstract

In southern Brazil, the native *Araucaria* forest has been tremendously cut down, which created a mosaic landscape with patches of original forest and other land uses. The Floresta Nacional de São Francisco de Paula encompasses a mosaic landscape comprised of the *Araucaria* forest, *Araucaria* plantations, *Pinus* and *Eucalyptus* plantations. This study's intention was to assess the richness and abundance of understorey web building spiders along an interface zone between an *Araucaria* and a *Pinus* patch. Spiders and other arthropods were collected by beating the vegetation inside five random plots, along five long transects parallels to the edge: one at the edge, two others 10 m and 30 m inside each patch. A randomization test was done to analyze differences in richness and abundance among distances between patches. Linear regressions were done to assess influence of the abundance of potential prey on spider richness and abundance. A total of 161 web building spiders were collected, divided in 35 morphospecies and 7 families. Four morphospecies represented around 42% of abundance. The higher abundance was of Theridiidae (17 species), followed by Araneidae (11). Richness and abundance of understorey spiders did not differ among the distances, showing presence of connectivity across the understorey vegetation of patches. Arthropod numbers positively influenced the abundance and richness of spiders. Management practices applied in this Reserve, which are selective cutting and long periods of rotations, seem to provide the growth of dense understorey vegetation along the ecotone resulting in adequate resources to support spider diversity.

Key words: edge effect, ecotone, Atlantic Forest, forest management.

Resumo

A floresta de *Araucaria* tem sido intensivamente impactada, o que possibilitou a criação de mosaicos da paisagem com manchas da floresta original e outros usos da terra. A Floresta Nacional de São Francisco de Paula, RS, abriga um mosaico composto da floresta de *Araucaria* e plantações de *Araucaria*, *Pinus* e *Eucalyptus*. Este estudo visou avaliar a riqueza e abundância das assembléias de aranhas de teia de sub-bosque ao longo de uma área de contato entre uma mancha de *Araucaria* e outra de *Pinus*. Aranhas e outros artrópodes foram coletados com guarda-chuva entomológico em cinco parcelas ao longo de cinco transectos paralelos à borda das manchas: uma na borda, duas outras a 10 m e a 30 m em cada mancha. Diferenças na riqueza e na abundância ao longo das distâncias foram analisadas por um teste de aleatorização. Foram realizadas regressões lineares para avaliar a influência da abundância de presas potenciais sobre a abundância e riqueza de aranhas de teia. Um total de 161 aranhas foi coletado (35 morfoespécies e 7 famílias). Quatro morfoespécies representaram em torno de 42% da abundância. A família mais rica foi Theridiidae (17 espécies), seguida de Araneidae (11). A riqueza e a abundância de aranhas não variaram entre as distâncias, mostrando que há conectividade entre as vegetações dos sub-bosques. A abundância de presas potenciais influenciou positivamente a abundância e a riqueza de aranhas de teia. Presume-se que o manejo executado na reserva, com corte seletivo e longo tempo de rotação, possibilite o crescimento do sub-bosque de *Pinus*, proporcionando recursos adequados para a manutenção da diversidade de aranhas.

Palavras-chave: efeito de borda, ecótono, Mata Atlântica, manejo de florestas.

Introduction

Biological communities that took millions of years to evolve have been devastated by human societies all over the world. The list of natural ecosystems that is suffering human transformations is vast. Plenty of species are subject of population numbers declining, some of them are facing the risk of eminent extinction. Predatory hunting and fishing, habitat destruction and the natural ecosystem invasion by exotic species, are among the most dangerous causes threatening species with extinction (Primack and Rodrigues, 2003).

In southern Brazil, the native *Araucaria* Forest has been tremendously cut down. The main economic activities that impact the original forest are agriculture, cattle, and more recently, timber harvesting of exotic tree species. The consequence was the creation of a mosaic landscape with patches of original forest and other land uses. *Pinus* and *Eucalyptus* are widespread exotic taxa that are being planted in Rio Grande do Sul State.

The study of animal community patterns in natural and altered ecosystems is able to reveal positive/negative consequences of timber practices. Typically, the conversion of native forest to plantations may affect spider individual, population, and community patterns. Changes in physical environment may affect the individual decisions like oviposition, web placement, as well as foraging (Wise, 1993). Consequently, populations may be affected by changes in abundance, due to variation in resource availability. The impact over community patterns includes changing on species composition and diversity parameters (Docherty and Leather, 1997; Willett, 2001).

Spiders are a good example of a dominant group, critical for local community food web dynamics (Polis and Strong, 1996). They are widespread intermediate-level predators and are among the most diverse group on earth (Coddington and Levi, 1991; Wise, 1993). Perhaps the most important feature of spiders is that their distribution and occurrence are strongly influenced by habitat structure (Uetz, 1991; Wise, 1993; Buddle *et al*., 2000). Spider abundance can be positively correlated with vegetation diversity, which provides a range of attachment points to webs, influences the prey availability, and affects spider consumption by birds (Hatley and MacMahon, 1980; McReynolds, 2000; Baldissera *et al*., 2004; Schmidt *et al*., 2005). In managed areas, spider assemblages can show different patterns of distribution and occurrence, suggesting differential response to structural changes imposed by human activities (Willett, 2001; Cattin *et al*., 2003).

This study's intention was to assess the richness and abundance of understorey web building spiders in an interface area between a native *Araucaria* forest and a *Pinus* plantation patch. We expected the native *Araucaria* patch to present a higher diversity compared to *Pinus* plantation patch. Disturbance regimens in plantation patches could prevent the formation of steady conditions by reducing the variety of substrates and habitat available for taxa colonization and establishment (Engelmark *et al*., 2001). Additionally, we tested the influence of potential prey abundance on web spider richness and abundance.

Methods

Study area

The study was carried out in the Floresta Nacional de São Francisco de Paula (29^{0}23'S, 50^{0}23'W), highlands of Rio Grande do Sul State, southern Brazil (845-916 m.a.s.l. in the study area). The reserve was created in 1945 and encompasses an area of 1,600 ha. *Araucaria* forest is the best represented habitat in the area. This forest is mainly composed by *Araucaria angustifolia* (Bertol.) Kuntze (Araucariaceae), and it is interspersed with plantations of two exotic commercial species of wood: *Pinus* spp. (Pinaceae) and *Eucalyptus* spp. (Myrtaceae), as well as with plantations of *A. angustifolia* (Figure 1). The area represents a subtropical region with mild-latitude climate with no dry seasons. Mean rainfall is 2,235 mm $year^{-1}$.

Sampling design

The study encompassed one patch of native *Araucaria* forest and other of *Pinus* plantation. *Araucaria* forest patch was more than 60 years old, while *Pinus* patch was 37 years old. Along the interface area between the two patches five 30 m long transects were established parallels to the edge: one at the area of contact between the patches, two others 10 m and 30 m inside each patch. Afterwards, five 1 m^2 plots were randomly assigned to each transect (Figure 1). Although the plots were randomly chosen, we avoided to sample in two contiguous plots.

Arthropod collections

Understorey spiders and other arthropods were collected during the day by beating any understorey vegetation (tree branches, leaves, bushes, and ferns) 20 times with a stick at heights between 1.0-2.0 m inside each plot. Surveys were performed during the day in one field trip in autumn 2005. The mixture of fallen vegetation and arthropods were collected with a 1 m^2 canvas sheet held horizontally below the vegetation and placed inside a plastic bag. Material collected was inspected at the laboratory, where spiders and other arthropods were selected by hand and stored in 70% ethanol. Adult and juvenile spider specimens were identified to family level. Specimens were grouped following a morphospecies criterion; afterwards the morphospecies were identified by a specialist. Arthropod were counted and identified to order level.

Data analysis

We used a randomization test with sum of squares as test statistics (Pillar, 2006) to compare the richness and abundance of understorey spiders among the five distances between *Araucaria* and *Pinus* patches. We defined three blocks: *Araucaria* forest, interface area and *Pinus* patch. Therefore, each set was defined by restricting random allocations to within the blocks (Pillar, 2006). In order to assess the influence of potential prey abundance on understorey web building spider assemblage we performed two linear regression analyses with spider richness and abundance separately as dependent variables, and potential prey abundance as independent variable.

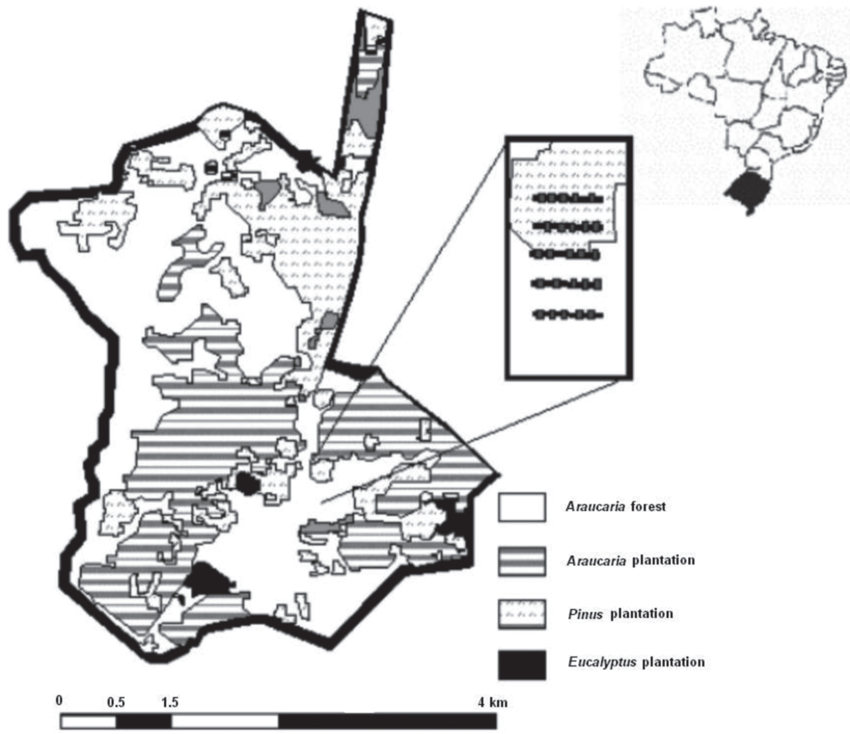

Figure 1. Landscape mosaic of Floresta Nacional de São Francisco de Paula (29°23'S; 50°23'W), in a southern Brazil *Araucaria* forest and the representation of the field design used in understorey web spider samplings.

Results

A total of 161 web building spiders were collected, divided in 35 morphospecies and 13 families (Table 1). Four morphospecies represented around 42% of total abundance: Linyphiidae sp.1, Theridiidae sp.2, Theridiidae sp.6, and Theridiidae sp.8. Six morphospecies occurred only in the *Araucaria* patch, seven only in the *Pinus* patch, and five only in the interface area. Nine morphospecies were common occurring in all habitats (Table 1). The most speciose family was Theridiidae (17 species) followed by Araneidae (11). Theridiidae was also the most abundant family with 79 individuals.

The richness (SS = 24.24; P = 0.53) and abundance (SS = 150.16; P = 0.643) of understorey spiders did not differ among the distances.

Potential prey abundance influenced positively the understorey spider abundance ($F_{1,23}$ = 17.208, P = 0.000; R^2 = 0.428; first order autocorrelation = 0.149; Figure 2) and understorey spider richness ($F_{1,23}$ = 7.171, P = 0.013; R^2 = 0.238; first order autocorrelation = 0.149; Figure 3).

Discussion

Contrary to our expectations, the *Araucaria* patch did not show higher understorey web spider richness and abundance compared to *Pinus* patch. Similar richness patterns between areas suppor-

Table 1. List of understorey spider morphospecies collected along an interface area of *Araucaria* forest and *Pinus* plantation in southern Brazil, Autumn 2005.

Morphospecies	Families	*Araucaria* forest	Edge	*Pinus* plantation	TOTAL
Theridiidae sp.3	Theridiidae	1	-	-	1
Dipoena sp.1	Theridiidae	1	-	-	1
Tetragnathidae sp.1	Tetragnathidae	1	-	-	1
Araneidae sp.5	Araneidae	1	-	-	1
Argyrodes sp.	Theridiidae	2	-	-	2
Araneidae sp.5	Araneidae	2	-	-	2
Dipoena sp.2	Theridiidae	-	1	-	1
Araneidae sp.7	Araneidae	-	1	-	1
Araneidae sp.8	Araneidae	-	1	-	1
Araneidae sp.6	Araneidae	-	2	-	2
Araneidae sp.10	Araneidae	-	2	-	2
Pholcidae sp.	Pholcidae	-	-	1	1
Euryopis sp.	Theridiidae	-	-	1	1
Theridiidae sp.10	Theridiidae	-	-	2	2
Theridiidae sp.7	Theridiidae	-	-	4	4
Deinopidae sp.	Deinopidae	-	-	6	6
Theridiidae sp.9	Theridiidae	-	-	6	6
Theridiidae sp.8	Theridiidae	-	-	11	11
Theridiidae sp.1	Theridiidae	2	-	1	3
Thymoites sp.	Theridiidae	2	-	1	3
Helvibis sp.	Theridiidae	1	-	3	4
Theridiidae sp.5	Theridiidae	1	-	4	5
Araneidae sp.2	Araneidae	5	-	1	6
Araneidae sp.3	Araneidae	3	-	4	7
Tetragnathidae sp.2	Tetragnathidae	-	1	1	2
Araneidae sp.9	Araneidae	-	1	1	2
Theridion sp.	Theridiidae	1	1	0	2
Araneidae sp.1	Araneidae	1	1	1	3
Theridiidae sp.4	Theridiidae	2	1	1	4
Araneidae sp.4	Araneidae	2	1	1	4
Theridiosomatidae sp.2	Theridiosomatidae	1	2	2	5
Theridiosomatidae sp.1	Theridiosomatidae	2	1	5	8
Theridiidae sp.6	Theridiidae	1	3	9	13
Theridiidae sp.2	Theridiidae	1	8	7	16
Linyphiidae sp.1	Linyphiidae	5	5	18	28
TOTAL		**38**	**32**	**91**	**161**

ting different degrees of impact were found in studies worldwide. These include lack of variation in shrub dwelling spiders, leaf-litter invertebrates, amphibians, and birds, which show that diversity could be nearly equivalent over space if sufficient connectivity between patches is provided (Norris, 1999; Sax, 2002; Cattin *et al*., 2003; Bonte *et al.*, 2004; Chen and Tso, 2004). In fact, Baldissera *et al*. (2008) also found no differences among understorey spider richness patterns in the four forest habitats present in this same Reserve. The connectivity between the understorey habitats seems to be provided by the management applied to *Pinus* patch. Long periods of rotation and selective logging seem to provide the resources needed to maintain understorey spider populations (Baldissera *et al*., 2008). These resources encompass the growth and establishment of understorey vegetation that allows fixation points to webs, and potential prey populations, which provide food to support web spider populations (Uetz, 1991; Wise, 1993).

On the other hand, the lack of differences in understorey spider richness between the two areas could be a result of a mixing of distinct faunas at habitat edges, giving rise to a zone of overlap (Ewers and Didham, 2006). Therefore, we might consider the hypothesis that we could find differences in understorey spider richness if we had sampled in further distances from the contact area. However, the further distance inside *Pinus* was positioned nearby the centre of the patch, because it had a small size and was embedded on an *Araucaria* forest matrix (Figure 1). Therefore, if *Pinus* was expected to present poor habitat conditions to su-

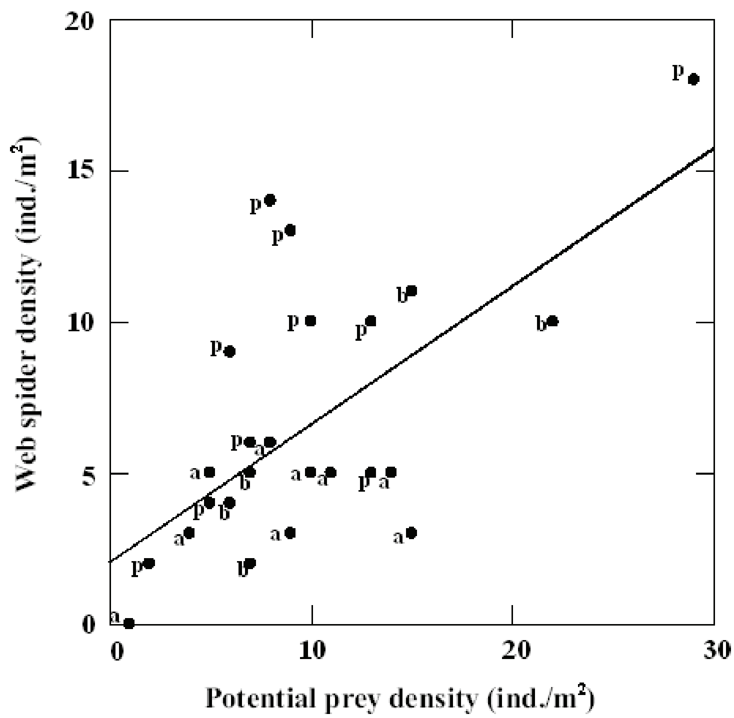

Figure 2. Plot of relationship between understorey web building spider abundance and understorey potential prey abundance in a southern Brazil *Araucaria* forest. *Araucaria* forest = **a**; *Pinus* patch **= p;** edge **= b.**

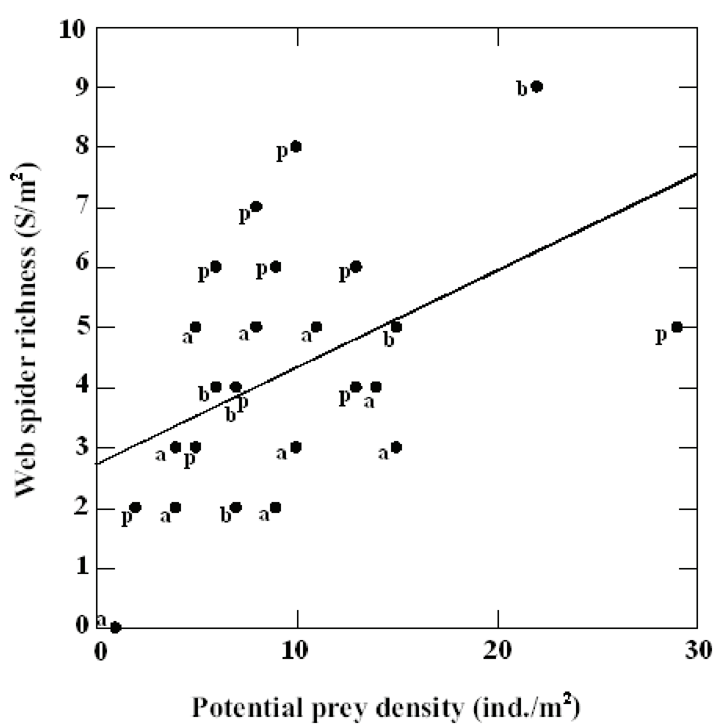

Figure 3. Plot of relationship between understorey web building spider richness and understorey potential prey abundance in a southern Brazil *Araucaria* forest. *Araucaria* forest = **a**; *Pinus* patch = **p**; edge = **b**.

pport web spiders, it would function as a sink area (Gotelli, 1995). Thus, we judged the distances chosen suitable to present possible habitat impacts in *Pinus* patch that translate into negative responses in web spider assemblages. Potential prey abundance could explain much of web building spider assemblage variation. Contrary to the findings of Halaj *et al*. (2000) on Douglas-fir canopies (USA), our results showed potential prey availability could be a good predictor of web building spider abundance on this Reserve. On the other hand, potential prey abundance was not so good in predicting web building spider richness. Hymenoptera and Orthoptera were the most abundant orders found in our study. Other studies showed these orders were important components of web building species diet (Brown, 1981; McReynolds, 2000). Additionally, McReynolds (2000) inferred that spiders select web-sites that increase the frequency of encounter and capture of higher flying Hymenoptera increasing the total number of prey captured.

Therefore, the diversity of understorey web building spiders in this area could be maintained because management practices allow understorey vegetation regeneration, which supports high arthropod numbers rendering adequate resources to support spider populations.

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