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Distribuição e Ocorrência de Aranhas de Sub-Bosque de Quatro Ambientes Florestais no Planalto do Rio Grande do Sul, Brasil

RONEI BALDISSERA

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Orientadora: Dra. Sandra M. Hartz - UFRGS
Co-orientadora: Dra. Gislene Ganade - UNISINOS

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Banca Examinadora:
Prof. Dr. Glauco Machado – UNICAMP
Prof. Dr. Ricardo Ott – Fundação Zoobotânica do RS
Prof. Dr. Gilson Rudinei Pires Moreira – UFRGS

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O homem, filho desta terra, que lhe fornece o pão de cada dia e os símbolos de sua vida espiritual, sente um respeito inato perante a fisionomia desta sua mãe e pátria.

(...)

Assim, no curso de todas as culturas humanas, mais cedo ou mais tarde, surgem as tendências de proteção ativa da natureza; um povo que se descuidasse deste elemento, seria falto dum requisito essencial da verdadeira cultura humana total, e indigno da terra, com que a pródiga mão do Creador o presenteou.

Pe. Balduíno Rambo, S. J.

"Ignis Natura Renovatur Integra"
Paracelso.

Esta dissertação é dedicada aos
meus pais Plauto e Tânia.

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Resumo

Este trabalho teve como objetivo geral avaliar a riqueza, abundância e composição das assembléias de aranhas de sub-bosque em quatro ambientes florestais na FLONA de São Francisco de Paula, RS, Brasil. Essa reserva está situada no planalto do Rio Grande do Sul e, desde sua criação, explora madeira para corte. O tipo de manejo empregado é o de longo tempo de rotação dos talhões, com corte seletivo. A área se caracteriza como um mosaico da paisagem formado de quatro ambientes florestais: floresta ombrófila, plantação de araucária, plantação de *Pinus* e plantação de *Eucalyptus*. Essas diferenças na estrutura da paisagem poderiam se traduzir em diferenças na estrutura da vegetação, o que pode influenciar a distribuição e ocorrência das assembléias de aranhas na área. Portanto, os objetivos específicos desta pesquisa foram 1) comparar a estrutura das assembléias de aranhas de sub-bosque entre os diferentes ambientes e entre os talhões, assim como inferir possíveis processos que poderiam estar influenciando os padrões encontrados, 2) avaliar como características da estrutura da vegetação nos diferentes ambientes influenciam o padrão de distribuição encontrado e 3) verificar as respostas da abundância, riqueza e composição das assembléias de aranhas são diferentes levando-se em conta diferentes níveis taxonômicos. As aranhas presentes na vegetação entre 1 e 2,5 m de altura foram coletadas pelo método guarda-chuva entomológico em duas unidades amostrais (25 m × 2 m) aleatorizadas dentro de cada um de três talhões de cada tipo florestal, em seis ocasiões durante 2003 e 2004. Todos indivíduos foram identificados em nível de família e os adultos em nível de gênero e espécie. A cobertura vegetal foi estimada através de 50 medidas dos toques da vegetação em uma vara de 2,5 m de altura dentro de cada unidade amostral no inverno e no verão de 2003. Os toques da vegetação foram separados em árvores, arbustos, lianas, pteridófitas e gramíneas. Foram coletadas um total de 8440 aranhas, divididas em sete guildas, 29 famílias, 80 gêneros e 132 espécies. A área de plantação de *Eucalyptus* apresentou a menor abundância de aranhas de sub-bosque em relação aos outros ambientes para a abordagem em nível de famílias, mas a plantação de *Eucalyptus* foi diferente somente da plantação de *Pinus* para a abordagem em nível de espécie. A abundância das aranhas de sub-bosque foi a característica estrutural que mais diferiu entre os diferentes tipos ambientais durante todo estudo. Os resultados, porém, foram influenciados pela abordagem taxonômica. A diversidade de aranhas de sub-bosque não apresentou diferenças entre os ambientes, porém, houve diferença entre talhões apenas em uma estação do ano para os níveis de gênero e espécie. A abundância de aranhas de sub-bosque teve correlação positiva com a idade dos talhões. A composição das assembléias de aranhas de sub-bosque teve maior relação com as características inter-talhões do que inter-ambientes, e os tipos de vegetação influenciaram na composição das famílias de aranhas. Além disso, a abordagem taxonômica alterou os padrões de agrupamento das assembléias. Processos locais como limitação de recursos para estabelecimento e ao crescimento das populações em nível local parecem estar atuando na estruturação das assembléias de aranhas de sub-bosque nessa área. Concluiu-se que o tipo de manejo empregado (longa rotação) na área para exploração de madeira não afeta negativamente a diversidade de aranhas do sub-bosque, provavelmente por que há o desenvolvimento de estruturas da vegetação do sub-bosque que proporcionam condições para a ocorrência e o estabelecimento das assembléias de aranhas nesse local.

Abstract

This study aimed to find out how the diversity of understory spiders was distributed in four different forest habitats in a southern Brazil *Araucaria* forest. The study area encompasses a landscape forest mosaic constituted by araucaria forest, araucaria plantation, *Pinus* plantation, and *Eucalyptus* plantation. Differences in landscape could translate into differences in local vegetation community structure, which could influence the occurrence and distribution of spider assemblages. Thus, specific objectives were 1) to assess the spider assemblage structures in the different habitats and stands, and infer possible processes which could influence the composition of assemblages at local and regional scales, 2) to assess the correlation of patterns of understory spider assemblages with habitat structural characteristics, and 3) to verify whether there are different spider assemblage responses when taking different taxonomic levels into account. Spiders were collected at a height between 1-2.5 m in two sampling units in three stands of each forest habitat during six seasons. The vegetation was struck with a 1m-long stick and the fallen vegetation was collected on a 1 × 1 m canvas sheet. All specimens were identified to family level, and the adults to genera and species. Additionally, 50-point measurements were performed of vegetation touches on a 2.5 m-long pole 2.5 m in each sampling unit. The touches were separated into four types of vegetation: trees, bushes, vines, ferns, and grasses. A total of 8440 spiders were collected, divided into seven guilds, 29 families, 80 genera, and 132 species. The abundance of understory spiders was lower in the *Eucalyptus* plantation compared to the other three forest habitats taking into account the family approach, but when the species approach was used, *Eucalyptus* plantation understory spider abundance was lower than in the *Pinus* plantation. The understory spider diversities did not show differences between forest habitats. The abundance of understory spiders was correlated to stand age. The composition of understory spiders was more related to between-stands characteristics, and the vegetation cover types effectively characterized the composition of stand understory spider assemblages. In conclusion, the management practice adopted (longer rotations coupled with selective logging) was important to diminish possible

negative effects associated with logging, at least for the understory spider community. Spatial distribution of the arbustive vegetation layer follow the spatial heterogeneous landscape pattern. Therefore, dense understory vegetation was able to grow, promoting stand connectivity and providing suitable habitat conditions for the spider community in the region.

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1. INTRODUÇÃO

O grau e o modo como o homem intervém na natureza depende de uma estratégia que é atrelada ao ambiente sócio-econômico, cultural e político, tanto quanto de como o homem vê a natureza e, portanto, do grau de liberdade que ele assume na sua relação com ela (Farcy & Devillez, 2005). A utilização tradicional e o manejo dos recursos florestais foram ditados pelas necessidades humanas por madeira como matéria-prima na construção de casas, diversos utensílios e o uso de papel. A relação "cartesiana" com a natureza diz que a mesma é um objeto à disposição dos seres humanos que são externos à natureza, o que desenvolveu a visão utilitarista de que a natureza, as florestas em particular, era vista associada com o conceito de recursos (Farcy & Devillez, 2005). Entretanto, o que era considerado aceitável nas práticas de manejo florestal mudou a partir do início da década de 1970 com o desenvolvimento do movimento ambiental e da percepção do público da extensão do dano causado ao meio ambiente pelas práticas de manejo tradicionais (Vogt *et al.*, 1997).

1.1. Alterações nos ambientes e nas comunidades naturais

As mudanças nos padrões das paisagens nos ecossistemas florestais implicam em alterações na sua estrutura e funcionamento. Isso leva à necessidade de desenvolver ferramentas para acessar e, se possível, predizer as conseqüências das ações humanas sobre a diversidade biológica (Morris, 2003). O estudo dos padrões de distribuição das comunidades animais em sistemas “naturais” e “alterados” pode revelar conseqüências negativas e/ou positivas das práticas adotadas. A partir disso, possíveis ações futuras no manejo de áreas florestais podem ser indicadas, determinando, em grande parte, o sucesso das iniciativas da sociedade na conservação da diversidade florestal e na manutenção da saúde dos ecossistemas (Lindenmayer & Franklin, 2002).

Em geral, as atividades humanas criam na paisagem um conjunto de diferentes ambientes que não são discretos, mas representados por um número de manchas espacialmente heterogêneas, ou seja, um mosaico ambiental (Turner & Gardner, 1991). Nessa paisagem, a diversidade dos diferentes taxa pode não estar aleatoriamente distribuída, uma vez que características estruturais e de composição da vegetação distintas das áreas adjacentes são criadas (Lindenmayer & Franklin, 2002). Um gradiente de condições ambientais, em termos de disponibilidade de recursos, para a colonização e o estabelecimento de distintas taxocenoses é, então, criado. Por isso, podemos esperar que a diversidade aumente como resposta à complexidade estrutural do ambiente (MacArthur, 1965; Rosenzweig, 1995).

Uma comunidade pode ser definida como o conjunto de organismos que ocorrem juntos e que significativamente afetam mutuamente sua distribuição e abundância (Connell & Slatyer, 1977). Áreas manejadas potencialmente podem afetar as escolhas dos organismos pelos ambientes, inlfuenciando aspectos históricos regionais de ocupação dos mesmos, através da colonização. Além disso, as futuras interações intra- e interespecíficas em nível local também podem ser afetadas, moldando a composição das taxocenoses.

1.2. Distribuição espacial da diversidade

MacArthur (1965) já citava que a diversidade em escala local, ou o que Rosenzweig (1965) chamou de pequenas partes de uma biota, tende a se tornar saturada na medida em que a fauna total (regional) se torna mais diversa. As espécies que são incorporadas, ou o excesso da diversidade total sobre a diversidade local, tendem a se disseminar para outros ambientes, desde que estes novos locais sejam favoráveis à sua sobrevivência, ou seja, tenham recursos suficientes para sustentar suas populações. Porém, os processos que atuam sobre o limite à diversidade em nível local podem se estender em uma gama de relações entre a diversidade local e regional, desde aquelas em que a diversidade local é dependente da diversidade regional, até aquelas em que é independente (Caley & Schluter, 1997). O primeiro tipo de comunidade é chamada de insaturada, ou não-interativa, enquanto a segunda é chamada de saturada. Em geral, em comunidades insaturadas há disponibilidade de recursos, pois os tamanhos populacionais são pequenos devido a flutuações no ambiente abiótico, entre outros tipos de mortalidade densidade-independente, associados a barreiras à colonização (*invasion*) por novos indivíduos conjuntamente à pouca capacidade das populações locais de expansão dos seus nichos (Cornell & Lawton, 1992). Nas comunidades saturadas, os recursos estão sendo totalmente (ou quase) utilizados, resultando em fortes interações entre as espécies na escala local, tanto diretamente, quanto indiretamente pela divisão dos recursos e pressão predatória (Cornell & Lawton, 1992).

Extensas áreas tendem a possuir um maior número de indivíduos e maior número de tipos ambientais disponíveis, o que proporciona um maior número de espécies. Este é o chamado padrão clássico da função espécie-área (Rosenzweig, 1995), descrita em sua forma padrão como

$$Log\ S = z(logA) + c$$

Onde S = número de espécies, A = área amostrada, z = coeficiente angular da reta, c = intercepto.

As escalas local e regional, discutidas acima, são distinguíveis em termos de área, portanto, quando a área aumenta da escala local para a regional, espera-se que a diversidade também aumente. Comparando-se regiões diferentes, quando se assume que a área local e a área regional são as mesmas para cada região, a razão entre a diversidade local e regional será idêntica entre as regiões quando a inclinação da curva espécie-área "z" é idêntica entre as regiões. Isto caracteriza uma comunidade insaturada, onde as curvas espécie-área devem ser paralelas e há pouca substituição das espécies de um local para outro (beta-diversidade).

Comunidades saturadas terão diferenças nos valores de “z” entre as regiões, que irá aumentar com a diversidade regional, aumentando a beta-diversidade (Srivastava, 1999).

1.3. Conectividade e estrutura ambiental

Dois conceitos que atuam ao longo de um gradiente de escalas espaciais podem influenciar as interações em comunidades no nível regional e local. O primeiro é o conceito de conectividade, em nível da paisagem, que pode ser definido como a ligação dos ambientes, taxocenoses e processos ecológicos em diferentes escalas espaciais (Lindenmeyer & Franklin, 2002). Vários outros conceitos estão envolvidos neste, como persistência dos taxa e recolonização em áreas de corte, troca de indivíduos e genes entre sub-populações e o papel de ambientes não ótimos na manutenção de contatos com ambientes ótimos. Este conceito está implícito caso se espere que a diversidade possa aumentar do nível local para o nível regional, como descrito acima. O segundo conceito está intimamente ligado ao anterior, na medida em que será o “veículo” da conectividade. Para haver conectividade entre áreas (ou locais) ambientais adjacentes, é necessário que haja condições de recursos disponíveis adequados às necessidades das populações que venham a procurar este ambiente para colonização e estabelecimento. Cada táxon, porém, possui exigências próprias quanto ao que é adequado ou não para sua sobrevivência. O conceito de estrutura ambiental chave prevê que medidas da variabilidade estrutural em escalas espaciais específicas são de importância chave para se acessar a relação entre heterogeneidade do ambiente e diversidade de taxa (Tews, 2004). No caso de haver uma ruptura na disponibilidade de recursos estruturais entre áreas adjacentes, o que poderia ser considerado um tipo de “fragmentação”, os taxa que se beneficiam desses recursos sentiriam essa ruptura como um efeito negativo da heterogeneidade do ambiente (Tews, 2004).

Apesar dos potenciais efeitos negativos da manipulação dos ambientes pelas atividades humanas, alguns tipos de regimes de distúrbios de longa duração podem promover diversidade (Ernoult *et al.*, 2003). Particularmente em áreas florestais manejadas, Engelmark *et al.* (2001) enfatizou que a melhor maneira de preservar a diversidade poderia ser através da diminuição do corte por um longo período (longa rotação). Por outro lado, igual diversidade em comunidades com diferentes composições tem sido observada (Sax, 2002; Brown *et al.*, 2001), indicando que os impactos dos ambientes modificados pelo homem nas comunidades animais depende, em grande parte, do tipo e da freqüência de distúrbios, o que, por sua vez, está ligado às práticas de manejo adotadas.

1.4. Relação das aranhas com a estrutura do ambiente

A alta diversidade e as interações complexas associadas aos ambientes florestais colocam desafios à implantação de estudos dos processos ecológicos (Halaj *et al.*, 2000). Uma abordagem que pode ser usada para investigar sistemas compostos de vários táxons é aquela focada nos táxons dominantes, ou "assembléias chaves", as quais são potencialmente críticas para a dinâmica da cadeia alimentar da comunidade local (Polis & Strong, 1996). Aranhas são um bom exemplo de tal grupo. Esses animais são predadores intermediários abundantes e com ampla distribuição nos ecossistemas terrestres (Wise, 1993), estando entre os mais diversos grupos na Terra (Coddington & Levi, 1991), contando, atualmente, com 110 famílias e 38834 espécies (Platnick, 2005). Além disso, vários estudos demonstraram que a estrutura dos ambientes tem uma profunda influência na captação de recursos alimentares de aranhas e, por conseguinte, na estrutura da comunidade destes animais (Uetz, 1991). A escolha do ambiente pelas aranhas pode ser influenciada pela presença de inflorescências e por outros fatores correlacionados com a estrutura da vegetação, como a perda de água e dano às teias pela ação do vento (Wise, 1993; Souza & Martins, 2004). A abundância de aranhas de teia em uma área pode estar correlacionada à diversidade da vegetação, característica que oferece pontos de fixação de teias, influenciando também no sucesso de predação dos insetos (Hatley & MacMahon, 1980; McReynolds, 2000; Baldissera *et al.*, 2004). O aumento da pressão de predação sobre as aranhas por aves pode também estar ligado à estrutura ambiental (Schmidt *et al.*, 2005). Além disso, em áreas de manejo, as taxocenoses de aranhas podem apresentar diferentes padrões de distribuição e ocorrência, sugerindo respostas diferenciais às estruturas ambientais impostas pelas atividades humanas (Willett, 2001; Cattin *et al.*, 2003).

1.5. Florestas e recursos

A exploração das florestas, no Rio Grande do Sul, provavelmente iniciou desde a chegada dos primeiros colonizadores. Na primeira década do século XX, Lindman já observava o desmatamento dos pinhais para a expansão da agricultura (Lindman & Ferri, 1974). Schultz (1947) criticou o desmatamento irracional realizado no estado, citando os inúmeros danos que causava aos processos do clima e das águas e já indicava a plantação de espécies nativas e o manejo das florestas como alternativas aos impactos causados. Rambo (1956) citava que a importância principal da restituição das matas rio-grandenses devastadas está no aumento da riqueza de madeira, na proteção do solo agrícola e na conservação da fisionomia natural do "torrão rio-grandense". Quanto ao reflorestamento, dizia que iniciativas eram promissoras, mas que "por que não tentar o reflorestamento com espécies indígenas?"

A paisagem natural do planalto rio-grandense, especialmente na parte do planalto chamada de campos-de-cima-da-serra, sempre foi composta pela associação do campo com a floresta de araucárias (Rambo, 1956; Lindman & Ferri, 1974). Porém, desde o começo da colonização até o final do século XX, grande parte da cobertura florestal original foi removida para utilização na agricultura e no pastoreio, juntamente com a exploração madeireira. Segundo o IBDF (1983), a cobertura florestal original do Rio Grande do Sul era em torno de 107.000 km^2. O inventário florestal, realizado em 1983, mostrou que havia diminuído para um valor em torno de 15.000 km^2, dos quais em torno de 1.860 km^2 eram de floresta ombrófila. A SEMA (2005) divulgou que a cobertura florestal tinha aumentado, até 2001, em torno de 12% em relação a 1983, passando para algo em torno de 49.000 km^2, com a área de floresta ombrófila pulando para 9.195 km^2.[1]

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[1] É de se estranhar esses números. Se isso for verdade a área de floresta ombrófila aumentou em torno de 500%! É muita área florestal para se desenvolver em apenas 18 anos, ainda mais sob fortes impactos humanos.

Os reflorestamentos em grande escala, no Brasil, tiveram início em 1966, com o advento de incentivos fiscais àqueles que realizassem projetos de florestamento ou reflorestamento. Em 1977, o Instituto Brasileiro de Desenvolvimento Florestal criou uma comissão encarregada de traçar diretrizes básicas para um sistema de avaliação dos recursos florestais (IBDF, 1983).

As florestas plantadas no Brasil ocupam aproximadamente 1% da cobertura vegetal, com cerca de 5 milhões de hectares. Estas florestas servem de matéria-prima para os setores de celulose e papel, chapas, aglomerados, laminados e serraria, entre outros. Os gêneros tradicionalmente mais plantados no Brasil são o *Pinus* e o *Eucalyptus*, com a *Araucaria* e a *Acacia* ocupando uma área menor de plantio. Atualmente, no Rio Grande do Sul, a área de uso das florestas plantadas é de 2.747,48 km^2, a qual teve um aumento de 0,35% nos últimos 18 anos, sendo que as principais espécies utilizadas são as de *Pinus* spp., *Eucalyptus* spp. e *Acacia mearnsi* (SEMA, 2005).

A mudança de abordagem que ocorre na prática da exploração dos recursos florestais levou governos a incentivar a prática da plantação de florestas, o que elevou a participação do setor privado no setor florestal nas últimas décadas (Landell-Mills & Ford, 1999). No Brasil, foi criado o Programa Nacional de Florestas (PNF), em 2000, que tem como objetivo estimular o reflorestamento no Brasil, não só para diminuir os números do desmatamento ilegal, como de evitar que o Brasil torne-se importador de madeira (Scarpinella, 2002).

1.6. Objetivos

Este trabalho teve como objetivo geral investigar como um mosaico formado por quatro tipos de vegetação, no Rio Grande do Sul, pode influenciar a distribuição e ocorrência de aranhas de sub-bosque. Dois objetivos específicos são:

1. Investigar como a composição, riqueza e abundância dos táxons variam entre os ambientes florestais e quais processos locais e/ou regionais poderiam estar influenciando estas características da estrutura da comunidade;

2. Investigar como a estrutura dos ambientes florestais analisados, em especial a estrutura da vegetação, poderia influenciar os padrões encontrados para a comunidade de aranhas do sub-bosque.

Essa pesquisa foi desenvolvida dentro do Laboratório de Ecologia de Populações e Comunidades, na Universidade Federal do Rio Grande do Sul – UFRGS, e esteve vinculada ao Projeto Mosaico da Paisagem, desenvolvido na Universidade do Vale do Rio dos Sinos – UNISINOS, que vem realizando pesquisas de diversidade animal, vegetal e de fungos na FLONA de São Francisco de Paula.

O trabalho está dividido em dois capítulos que apresentam os principais resultados encontrados durante a pesquisa. Os textos estão escritos em inglês e serão submetidos a dois periódicos Qualis A. O formato segue as normas dos seguintes periódicos: Capítulo I, Austral Ecology; Capítulo II, Forest Ecology and Management.

2. MATERIAL & MÉTODOS

2.1. Área de estudo

A FLONA de São Francisco de Paula (29º23’ S; 50º23’ O) possui uma área de 1.606 hectares e foi criada em 1945. A área da FLONA faz parte do planalto nordeste do Rio Grande do Sul, na região chamada de Campos de Cima da Serra. O planalto rio-grandense faz parte da Serra Geral e é formado por derrames basálticos que ocorreram durante o Mesozóico. As Florestas Nacionais são áreas florestais ou passíveis de reflorestamento, que se destinam ao cumprimento de objetivos econômicos, técnicos ou sociais. A atividade de reflorestamento na FLONA foi inicialmente direcionada para plantio de *Araucaria* e gradualmente incluiu algumas espécies de *Pinus* (IBDF, 1983). Na FLONA de São Francisco de Paula, foram plantados três talhões de *Eucalyptus* para testar a possibilidade de sua utilização comercial. A área de floresta nativa abrange em torno de 44% da área total da unidade (Ana Maria Stranz, com. pess.) (Tabela 1.1). As principais atividades são a exploração de produtos e sub-produtos florestais, como madeira (produção estimada em 7.000 m^3 ao ano) e sementes de *Araucaria*. A área total da reserva sofreu acréscimos desde sua criação. Terras adjacentes foram compradas e anexadas à FLONA. Em 1983, a área total era de 2/3 a atual. O uso da terra antes de ser convertida em plantação era basicamente para agricultura (Tabela 1.2).

Tabela 1.1 – Área estimada para os tipos vegetacionais que ocorrem na FLONA de São Francisco de Paula, Rio Grande do Sul, Brasil.

Ambiente	**Área (ha)**	**% do total**
Floresta ombrófila	712,65	45,36
Plantação de *Araucaria*	477,89	30,42
Plantação de *Pinus*	323,48	20,59
Plantação de *Eucalyptus*	20,3	1,30
Campo	36,75	2,34

Tabela 1.2– Caracterização dos talhões utilizados para as coletas de aranhas do sub-bosque na FLONA de São Francisco de Paula, Rio Grande do Sul, Brasil. Talhões: FO = floresta ombrófila, PA = plantação de *Araucaria*, PP = plantação de *Pinus*, PE = plantação de *Eucalyptus*.

Talhão	**Ano criação**	**Área aproximada (ha)**	**Uso anterior**
FO1	1945	50	-
FO2	1945	28	-
FO3	1945	24	-
PA1	1959	23	Agricultura
PA2	1947	9	Agricultura
PA3	1947	9	Agricultura
PP1	1965	9,5	Agricultura
PP2	1972	4,5	Agricultura
PP3	1968	9	Agricultura
PE1	1972	4	Agricultura
PE2	1994	2	Pastagem
PE3	1988	15	Agricultura

O clima da FLONA se enquadra dentro do grupo Cfbl de Köeppen, com chuvas durante todos os meses do ano. A precipitação média anual é de 2.252 mm. As temperaturas variaram de 4,5 a 29,5º C, no inverno de 2004 e no verão de 2003, respectivamente. A altitude na área de estudo foi de 845-916 m acima do nível do mar.

2.2. Amostragem

Na área da FLONA, foram escolhidos três talhões de cada um dos ambientes: floresta ombrófila, plantação de *Araucaria angustifolia*, *Pinus* spp. e *Eucalyptus* spp. (Figura 1.1).

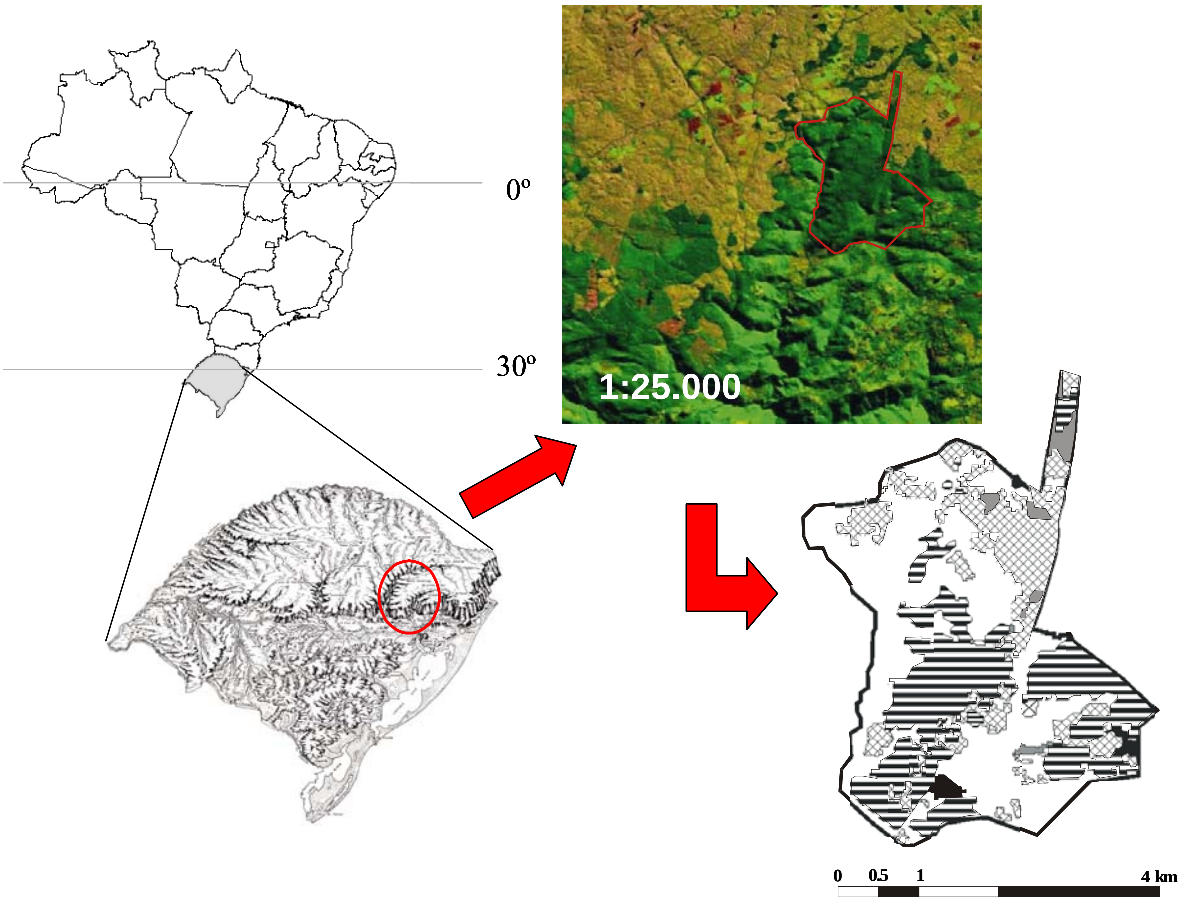

Figura 1.1 – Localização da FLONA de São Francisco de Paula. Mapa mostrando os tipos florestais que ocorrem na reserva. Branco = floresta nativa; hachurado horizontal = plantação de *Araucaria*; hachurado xadrez = plantação de *Pinus*; preto = plantação de *Eucalyptus*.

Em cada talhão, para a coleta de aranhas do sub-bosque, dois pontos foram sorteados ao longo de uma transecção de 100 m de comprimento perpendicular às estradas de acesso. Em cada ponto, foram marcadas duas parcelas permanentes de 25 m × 2 m.

O tamanho da área total amostrada por talhão foi de 100 m^2, o que é pequeno se comparado ao menor dos talhões (4 ha). A escolha dos talhões foi realizada procurando-se facilitar o deslocamento entre os mesmos. Levou-se em consideração, também, que havia somente três talhões de eucaliptoss, sendo escolhidos, então, três de cada um dos outros ambientes. A maior distância entre os talhões era de 5 km e, como não havia carro disponível para o deslocamento, foi preciso realizar um cronograma de amostragens. Foram feitas coletas em sete estações: outono de 2003 e 2004, inverno de 2003 e 2004, verão de 2003, primavera de 2003 e 2004. Em cada estação, foram realizadas três saídas ao campo, onde eram feitas amostragens de quatro talhões de ambientes diferentes. Os dados da coleta da primavera de 2003 não foram utilizados, pois houve perda de material coletado. Portanto, os resultados apresentados dizem respeito às outras seis estações.

A coleta de aranhas foi realizada pela batida da vegetação entre 1 e 2,5 m de altura dentro de cada parcela em cada estação. Escolhiam-se partes da vegetação e cada uma delas era batida 20 vezes com uma vara de 1 m de comprimento até que toda vegetação dentro da parcela tivesse sido amostrada. Portanto, o esforço amostral, aqui, não levou em consideração o tempo de batida, nem o número de batidas, já que parcelas com maior volume de sub-bosque demoraram mais para serem batidas. A unidade amostral é, por conseguinte, definida como a área de amostragem, ou seja, 50 m^2. A vegetação batida caía em um anteparo de 1 m^2 e era colocada em sacos plásticos. Em laboratório, os sacos foram abertos e as aranhas foram separadas da vegetação por coleta direta manual. Em amostragens de batidas da vegetação, em geral, se utilizam potes com álcool diretamente no campo para guardar os espécimes, ou se utiliza um aspirador para coletar os animais. Porém, não houve condições em campo para realizar estas formas de coleta.

Antes das amostragens de aranhas do inverno e do verão, foram feitas 50 medidas pontuais dos toques da vegetação em cada unidade amostral. Contavam-se os toques de qualquer estrutura vegetal em uma vara entre 1 e 2,5 m de altura. Os toques foram divididos em: árvores (toque de estrutura arbustiva acima de 2,5 m), arbustos (toque de estrutura arbustiva entre 1 m e 2,5 m), lianas, pteridófitas e gramas. Esta divisão baseou-se na observação destas estruturas como substrato para as aranhas, que as utilizam de forma diferenciada, uma vez que a densidade destas estruturas caracterizava visualmente o tipo de sub-bosque em cada talhão.

Composition and diversity of understory spider assemblages in an *Araucaria* forest mosaic in southern Brazil

Ronei Baldissera, Gislene Ganade, Antonio D. Brescovit & Sandra M. Hartz

Composition and diversity of understory spider assemblages in an *Araucaria* forest in southern Brazil

Summary

Understory spider richness, abundance and composition were accessed in four forest habitats in a landscape mosaic in southern Brazil. We aimed to find out how the diversity was distributed in these different habitats and which different understory spider taxa could be effective in describing the spider community structure. Understory spiders were collected during six seasons in two permanent plots distributed in each one of three stands of *Araucaria* forest, *Araucaria* plantation, *Pinus* plantation, and *Eucalyptus* plantation. Total abundance of understory spiders was higher in *Pinus* plantation for both family and species approach. The expected numbers of families did not show differences in any season, while expected number of genera and species showed differences in autumn 2004 with *Eucalyptus* plantation presenting lower richness. The total abundance of understory spiders was positively correlated to stand ages. Composition of understory spiders were more related to between-stand rather than between-habitat characteristics, and the taxa level approach changed the grouping pattern of habitat stands. Taking into account all four forest habitats, it appears that the understory spider community was constrained by local habitat limits to resource exploitation and/or to minimum viable population size. On the other hand, when we looked to community patterns without *Eucalyptus* plantation, regional processes seems to play the major role in structuring the community. The management practice utilized (longer rotation) in this region provides conditions to understory vegetation development, which gives available habitat structure to spider assemblages. These practices could attenuate the logging impacts on understory spider assemblages.

Key-words: Atlantic forest, forest management, local-regional diversity, landscape mosaic, habitat structure

Introduction

Today, studies of the impacts of human modified habitats on animal communities are imperative as conservation of diversity becomes a central issue on the environmental management debate. Landscape structure and floristic composition worldwide is highly determined by human activities, and the management practices used on these lands will largely determine how successfully human society will conserve forest biodiversity and maintain ecosystems health (Lindenmayer & Franklin 2002). We must, therefore, develop tools to access and predict the consequences of human actions on diversity (Morris 2003).

Human action can create a set of different habitats which are not discrete, but represented by a different number of spatially heterogeneous patches, i.e., an environmental mosaic (Turner & Gardner 1991). This mosaic contains a set of different structural habitats, which can show differences in patterns of diversity, because different species are likely to occupy different habitats (MacArthur 1965; Rosenzweig 1995).

In this paper we define a community as the set of organisms that occur together and that significantly affect each other's distribution and abundance (Connell & Slatyer 1977). The distribution of organisms could be determined by regional historical aspects, such as their capacity of dispersion and colonization, whereas the abundance of organisms within populations could be affected by the taxa interactions at local spatial scale (Cornell & Lawton 1992). Therefore, we can expect a gradient of regional/local influences acting on animal communities' composition.

Despite potential adverse effects, some long-term human disturbance regimes could promote diversity (Ernoult *et al.* 2003). Particularly in forest managed areas, Engelmark *et al.* (2001) emphasized that the best way to preserve diversity may be by diminishing the timber harvesting for a longer period (longer rotations). On the other hand, equal diversity in disparate species assemblages have been observed (Sax 2002; Brown *et al.* 2001), indicating that impacts of human modified habitats on animal communities will depend largely upon level and frequency of disturbance, which in turn is dependent on management practices.

High diversity and complex interactions pose challenges to studies of ecological processes (Halaj *et al.* 2000). One approach to investigate multi-species systems is to focus on dominant taxa, or a “key assemblage”, which is potentially critical to food-web dynamics of the local community (Polis & Strong 1996). Spiders are an excellent example of such group, because they are widespread intermediate-level predators and are among the most diverse group on earth (Coddington & Levi 1991; Wise 1993). Moreover, their distribution and occurrence are strongly influenced by habitat structure (Uetz 1991; Wise 1993; Buddle *et al.* 2000).

Habitat selection by spiders is influenced by factors correlated to vegetation structure and architecture, such as desiccation, wind damage to webs and the presence of inflorescences (Greenstone 1984; Souza & Martins 2004). Spider abundance can be correlated to vegetation diversity, which can provide a range of attachment points to webs, influencing on prey availability, and even affecting spider consumption by passerine birds (Hatley & MacMahon 1980; McReynolds 2000; Baldissera *et al.* 2004; Schmidt *et al.* 2005). Moreover, in managed areas, spider assemblages can present different patterns of distribution and occurrence, suggesting differential response to structural changes imposed by human activities (Willett 2001; Cattin *et al.* 2003).

In the Rio Grande do Sul state, southern Brazil, extensive plantations of exotic trees used for timber exploitation, along with grazing and agriculture, have caused the degradation of about 86% of the natural landscape of the state highlands, once formed by *Araucaria* forests interspaced with grassland relicts (Rambo 1956; Lindman & Ferri 1974). This region compose the southern limit of the geographical distribution of Atlantic Forest (*latu sensu*), which is presently considered a biodiversity hot spot (Myers *et al.* 2000). The genus *Araucaria* is found exclusively in the meridional hemisphere, and only two species are found in South America, namely *Araucaria angustifolia* and *A. araucana*. The human practices in the region have created a landscape mosaic structure that potentially influences the dynamics of animal community diversity and composition. However, to our knowledge, studies of this human modified habitat, particularly involving forest management practices in this region and their impacts on spider assemblages are absent.

This study aimed to assess the richness, abundance and composition of understory spider communities in four different forest habitats: *Araucaria* forest, *Araucaria* plantation, *Pinus* plantation, and *Eucalyptus* plantation. We also attempted to indicate what forces may be shaping the community assembly in the whole region. We expected that the native *Araucaria* forest stands could present higher diversity and lower variation in taxa composition when compared to other forest types. Disturbance regimens in plantation stands could prevent the formation of steady conditions, notably by reducing the variety of substrates and habitat (Engelmark *et al.* 2001) to taxa colonization and establishment. We also tested the influence of stand ages on understory spiders expecting that older stands could represent more heterogeneous habitats, therefore supporting more diverse spider assemblages.

Additionally, we intended to verify the influence of different taxa level approaches on the abundance, diversity and composition of understory spiders. Other studies predicted species number based on indicator taxa or higher taxa surrogates (Andersen 1995; Cardoso *et al.* 2004). We directly tested the effects of different forest habitats at three spider taxa levels: family, genera, and species in order to verify whether the communities show similar or different responses. We intended to indicate whether higher taxa approach could be valid to access possible differences in understory spider compositions.

Methods

STUDY SITE

The study was carried out at the National Forest of São Francisco de Paula (29°23'S; 50°23'W), highlands (845-916 m.a.s.l. in the study area) of Rio Grande do Sul state, southern Brazil. The reserve was created in 1945 and encompasses an area of 1,606.6 ha. It is settled over a basaltic basin, formed in Mesozoic events of lava extrusion. *Araucaria* forest is the most well represented habitat of the area. This forest is dominated by *Araucaria angustifolia* (Bertol.) Kuntze (Araucariaceae), regionally known as Brazilian-pine. *Araucaria* forest is interspaced with plantations of two exotic commercial woody species: *Pinus* spp., and *Eucalyptus* spp., as well as with plantations of *Araucaria angustifolia* (Fig. I.1). The area represents a subtropical region with mild mid-latitude climate with no dry seasons. Mean rainfall is 2,235 mm year^{-1}, with minimum and maximum temperature of 4.5 and 29ºC, respectively, during the study years of 2003 and 2004. The management of plantation stands are made by selective cut of adult trees allowing long rotation time.

SAMPLING DESIGN

The study sites encompass three areas of each forest type (Table I.1). Inside each area, we established two 100 m long transects: one principal, parallel and 10 m away from access roads, and other perpendicular to the principal. Along the secondary transect, two distances were randomized and two 25 m × 2 m permanent plots were randomly place. The sampling design was therefore characterised by a nested design with stands not-randomly nested inside habitats, and plots randomly nested inside stands.

Understory spiders were collected by striking vegetation between 1-2.5 m in height with a stick inside each plot during three excursions in each season: autumn 2003/2004, winter 2003/2004, summer 2003, and spring 2004. The fallen vegetation was collected with a 1 × 1m canvas sheet held horizontally below the vegetation and putted inside a plastic sac. Afterwards, the vegetation was analysed at laboratory, spiders were selected by hand and stored in 70% methanol. All specimens were identified to family level and adult specimens to species level wherever possible, otherwise it was utilized a morphospecies criterion. All specimens are deposited in the arachnological collection of the Instituto Butantan, São Paulo state, Brazil.

STATISTICAL ANALYSES

To analyse abundance patterns, we used a repeated measures ANOVA to compare abundances among habitats, among seasons and reveal possible interactions between these two factors. Abundance was divided in total abundance, when all specimens were analysed; and adult abundance, when only adult abundance was analysed. To analyse diversity patterns at family, genera, and species levels in each season, we utilised the PAST statistics program (Hammer *et al.* 2004) to perform a rarefaction technique. The expected number of each taxa per plot in each season was utilized in a nested design in SYSTAT 11 (2004) General Linear Model routine. The two plots were nested inside the stands [PLOTS(STANDS); 2 × 1], which were nested inside each habitat [STANDS(HABITATS) 3 × 4]. We used a nested design also because we were not allowed to sum the plot richness values, considering that richness does not have additive properties. So we were able to separate the between-stands from the between-habitat (forest types) variance. A least-squares linear regression analysis was performed to investigate whether the stand ages could explain variation of understory spider abundances.

All variables were tested for normality (Shapiro-Wilk normality test). Whenever the results of ANOVA were significant, it was performed post-hoc pairwise comparisons of the means. We utilized adjusted tests (Bonferroni and Tukey) whenever possible, otherwise, it was done Fisher's Least Squares Difference. All mean values presented in results were followed by one standard error value.

Composition of understory spiders was analyzed separately for each taxa level by a cluster analysis utilizing a euclidean distance based matrix and posterior linkage based on the average distance between all stands (UPGMA). An analysis of group partition sharpness using bootstrap resampling was done to access the stability of the groups formed by cluster analysis (Pillar 1999).

Species level analysis involved a species-area log curve for each habitat as a way to check diversity patterns and possible processes involved in the assembly of understory spider community in this region. So we were able to analyze the within-habitat beta diversities, by comparing the slopes of resulting species-area functions (Rosenzweig 1995). The arrangement of stands to perform the linear regressions were done from the one that presented the smallest richness to the greatest one. The between-habitat beta diversity was analyzed by the examination of distribution of similarity coefficients for different habitats (Magurran 1988).

Results

SPIDER ABUNDANCE

A total of 8440 spiders were collected divided in 491 males, 1030 females, and 6919 juveniles, distributed in seven guilds, and 29 families. Taking into account the 1272 adult specimens, it was possible to determine 80 genera, and 132 species (Appendix). The *Pinus* plantation showed the highest relative total abundance (N = 2638, 31%), followed by *Araucaria* forest (N = 2346, 27.8%), *Araucaria* plantation (N = 2329, 27.6%), and *Eucalyptus* plantation (N = 1127, 13%). There were differences in mean total abundances among habitats ($F_{3,8} = 14.988$, p = 0.001; Fig. I.2), but no interaction with seasons ($F_{15,40} = 1.611$; P = 0.114). Mean total abundance of understory spiders was significantly lower in *Eucalyptus* plantation (375.67±89.93 individuals). Habitat effect still significantly affected the spider adult abundance ($F_{3,8} = 5.528$, P = 0.024), but *Eucalyptus* plantation mean abundance (58.67±25 individuals) was significantly lower only from *Pinus* plantation (166.33±24.37 individuals) (Fig. I.2). Stand spider abundances variance could be explained in part by the stand ages ($R^2 = 0.47$; $F_{1,10} = 8.96$, P = 0.014. Fig. I.3).

Results of abundance analysis in each season showed significant differences in between-habitat abundances in four seasons (Table I.2). *Pinus* plantation abundance (113.67±12.78 individuals) was significantly higher than *Eucalyptus* plantation abundance (33.50±12.21 individuals), in autumn 2003. Habitat abundances were also different in winter 2003 and winter 2004 (lower abundance in *Eucalyptus* = 80.67±20.54 and 47±4.62 individuals respectively). Abundance in *Pinus* plantation (49.50±5.77) was significantly higher than in *Eucalyptus* plantation (17.50±5.51 individuals), in spring 2004.

Between-habitat adult abundance showed significant differences just in two seasons (Table I.2). In autumn 2004, abundance of *Eucalyptus* forest (5.67±3.18 individuals) was significantly lower than *Pinus* forest abundance (17±2.52 individuals). In spring 2004, *Pinus* plantation (40±13.65 individuals) showed significantly higher spider species abundances than the other three habitats. The genera abundance analysis showed the same results, once it presented the same species abundances.

FAMILY DIVERSITY

In total, it was found 29 spider families, divided into seven guilds (according to Uetz *et al.* 1999). Four families comprised around 77% of total abundance: Theridiidae (23%), Anyphaenidae (22%), Araneidae (18%), and Salticidae (14%). Foliage runners were the most abundant and rich guild in all habitats, represented by 12 families comprising 28% of total abundance. Wandering sheet/tangle weavers presented the lower abundance, less than 1% of total abundance in all habitats. The highest family richness was found in the *Eucalyptus* plantation (S=25), followed by the *Araucaria* forest (23), and both the *Araucaria* and *Pinus* plantation (21). Six families were represented by one individual: Selenopidae (*Eucalyptus*), Pisauridae (*Eucalyptus*), Philodromidae (*Eucalyptus*), Lycosidae (*Araucaria* forest), Ctenidae (*Araucaria* forest), and Segestridae (*Pinus*); and one family by two individuals: Senoculidae (*Eucalyptus* and *Araucaria* plantation).

The expected number of families did not vary between-habitats ($F_{3,8} = 2.291$; $P = 0.113$) or between-stands ($F_{8,12} = 0.754$; $P = 0.727$) (Fig. I.4-C).

GENERA AND SPECIES DIVERSITY

It was found 132 understory spider species, distributed in 80 genera (Appendix). Abundance of adult spiders was higher in *Pinus* plantation (N=497, 39%), followed by *Araucaria* plantation (N=339, 26%), *Araucaria* forest (N=255, 20%), and *Eucalyptus* plantation (N= 181, 14%).

The *Pinus* plantation showed the highest genus and species richness (S=49 and 72), followed by *Araucaria* plantation (47 and 61), *Eucalyptus* plantation (45 and 59), and *Araucaria* forest (43 and 56). Twenty-two genera showed more than one percent of abundance, representing all together around 83% of total abundance, and 16 genera were singletons (EP = 6, AP = 4, AF = 3, PP = 3). Twenty two species contributed with 74.5% of total species abundance. Linyphiidae sp.1 (22%) was the more abundant (as well as the more abundant genera), followed by *Hetschkia gracilis* (Theridiidae) (8%), *Thymoites melloleitaoni* (Theridiidae), *Orchestina* sp.1 (Oonopidae), and *Tariona* sp. (Salticidae) (5%). *Eucalyptus* plantation showed the highest number of species singletons (S=16), followed by *Pinus* plantation (S=13), *Araucaria* plantation (S=8), and *Araucaria* forest (S=7). Sixteen species were generalists, occurring in all habitats, 19 occurred in three habitats, and 30 appeared in two habitats.

The expected number of genera showed little variation between-habitats ($F_{3,8}$ = 3.083; P = 0.058) and no differences between-stands ($F_{8,12}$ = 2.482; P = 0.087) (Fig. I.4-B). A marginally significant difference in the expected number of species between-habitats was found ($F_{3,8}$ = 3.138; P = 0.055), while there was no differences between-stands ($F_{8,12}$ = 2.322; P = 0.108) (Fig. I.4-A). Spiders were not found in EP2 during autumn 2004, therefore the nested ANOVA analysis revealed a significant difference in between-stands expected numbers of genera and species (Table I.2), but not in between-habitat pattern.

SPIDER COMPOSITION ANALYSIS

Understory spider composition showed differences when taking into account different taxa levels. At species level (Fig. I.6-A), the dendrogram formed three sharp groups: 1) two *Pinus* plantation stands, influenced positively by the abundance of Linyphiidae sp.1, *Dipoena* sp.2, Linyphiidae sp.3, and *Dubiaranea* sp.; 2) two *Araucaria* plantation stands, influenced positively by the abundance of *Orchestina* sp.1, *Alpaida* sp.2, and *Micrathena brevispina*; and 3) *Araucaria* forest and *Eucalyptus* plantation stands. At the genera level (Fig. I.6-B), two sharp groups were formed: 1) two *Pinus* plantation stands and two *Araucaria* plantation stands, positively influenced by Linyphiidae gen. 1, Linyphiidae gen. 2, and *Dubiaranea*, and 2) *Araucaria* forest stands and *Eucalyptus* plantation stands, positively influenced by the abundance of the genus *Olios*. At the family level (Fig. I.6-C), two sharp groups were formed: 1) three *Eucalyptus* plantation stands, influenced by the abundance of Philodromidae, Selenopidae, Dyctinidae, and Gnaphosidae; and 2) the remaining stands, showing high abundances of Salticidae, Araneidae, Anyphaenidae, and Theridiidae in *Araucaria* forest and *Araucaria* plantation stands, and an increase in numbers of Scytodidae and Linyphiidae in *Pinus* plantation stands.

BETA DIVERSITY

Habitat species-area curves (Fig. I.5) showed that the number of species increased more rapidly in *Eucalyptus* plantation, given an equal space area, than in the other habitats. On the other hand, *Araucaria* forest, *Araucaria* plantation, and *Pinus* plantation showed very similar distributions. Species-area curves slopes that represent a measure of between-stands (within-habitat) beta diversity showed that *Eucalyptus* plantation had the highest *z*-value ($\log S = 0.975 \log A + 1.004$), so *Eucalyptus* stands had the highest species turnover. The other three habitats presented similar coefficients. Between-habitat beta diversity (Table I.3) showed the highest value between PP and PE, indicating these habitats were more dissimilar in species richness.

Discussion

Contrary to our expectations, the *Araucaria* forest stands did not show higher diversity compared to plantation stands. Therefore, our first impression was that the plantation areas could offer suitable conditions to the colonization and establishment of spider assemblages. Probably, it was due mainly to the management practices employed, notably the long rotation and selective logging. Consequently, the understory of these plantations was characterized by the presence of a dense bush cover that provides optimal habitat structure to support the bush dweeling spiders.

The number of adult spiders collected in autumn 2003 (293) was similar to the abundance found by Coddington *et al*. (1997) in an Appalachian cove hardwood forest (308) utilizing the same collection method and similar area, and although Linyphiidae was found to be the most abundant family in their study, Theridiidae was the second most common, and they also found high numbers of Salticidae. Norris *et al.* (1999) sampled low vegetation in a managed subtropical forest of *Eucalyptus* in Australia and found 72% less spiders than we collected in *Eucalyptus* plantations at the same latitude, considering the same area. They also found high numbers of Theridiidae, Araneidae and Salticidae.

In our study, the spider abundances were strongly correlated to the age of stands formation. Therefore, the older *Araucaria* forest, *Araucaria* plantation and *Pinus* plantation stands showed similar abundances of spiders. A strong correlation of web spider abundance with the vegetation richness at bush layer was found in this region (Baldissera *et al.*, 2004). The higher richness of vegetation increases the habitat architectural features, providing conditions to support more spider numbers. Therefore, we could infer that the understory of *Araucaria* and *Pinus* plantations offer the same suitable structural features to the spiders than does the *Araucaria* forest understory. Additionaly, the understory of *Araucaria* and *Pinus* areas presented fallen needles, increasing the amount of vegetation available and decreasing the space among them. This could reflect more branch and leaf surface area of the shrubs, which could be crucial to support webs of small spiders and was suggested to be the best correlate with spider abundance (Robinson, 1981; Sundberg & Gunnarsson 1994; Halaj *et al.* 2000;). On the other hand, the recently formed *Eucalyptus* plantations showed the lower spider abundance. These stands were characterized by the escarsse bush layer, which besides the lack of suitable habitat structures, could also increases abiotic factors that promote spider mortality. Some of those abiotic factors could be the wind damage to webs and exposure to insolation (Wise, 1993), the predation of spiders by birds (Gunnarsson, 1998), as well as food shortage caused by the lower abundance of arthropods (Halaj *et al.*, 1998; Schmidt *et al.*, 2005).

Equal diversity in between-habitats and between-stands were found throughout the study, although we could find different composition of spider taxa. The same pattern was found in other studies worldwide. Species richness was found to be the same in four habitat types varying from primary forest to grasslands in Orchid Island, Taiwan (Chen & Tso, 2004). Norris *et al.* (1999) also found no differences in species diversity between sites supporting different degrees of disturbance in Australia. On the other hand, differences were found in diversity of spiders inhabiting Scots and lodgepole *Pinus* plantations in Scotland, which were related to differences in abundance and diversity of field layer vegetation underneath the pines (Docherty & Leather 1997). We could observe more similarities among the species composition in the recently created *Eucalyptus* plantation and the native *Araucaria* forest, while the *Araucaria* plantation and the *Pinus* plantation showed a particular species composition. On the other hand, *Eucalyptus* plantations formed a different group based on family composition, notably due to the presence of rare families belonging to cursorial guilds. These results were opposed to the pattern of similar expected richness found at species and family levels. Our results suggest that while taxa composition may be highly variable and change in response to environmental change, species diversity is an emergent property of the ecosystem that could be maintained (Sax 2002; Brown *et al.* 2001).

Species-area function can serve to indicate the condition of a community. According to Cornell & Lawton (1992), an interactive community is one in which strong biotic interactions take place among species, thus accentuating the relative influence of local processes on species richness, also known as a saturated community (Srivastava, 1999). On the other hand, a non-interactive community is one in which local interactions are feeble or absent and the relative influence of regional processes on species richness is important. This is also called an unsaturated community (Srivastava, 1999). In unsaturated communities species-area curves are parallel in log-log space, thus beta diversity do not vary amongst regions, as regions have the same ratio of local to regional richness (Srivastava, 1999). The opposite pattern will hold in saturated communities, when the slope of the species-area curves vary amongst regions.

The species-area curves produced in this study indicated that the understory spider community in the region showed a tendency to the saturated pattern, and the unsuitability of local habitat is probably acting in set upper limits to niche occupation and/or in minimum viable population size (Srivastava, 1999. The beta diversity found in plantations revealed the higher turnover rates among *Eucalyptus*, *Pinus* and *Araucaria* plantations. The lower turnover rates were between *Araucaria* forest and plantations. Replacement of species within a region could reflect subtle changes in environment, limiting the presence of members of a regional species pool from a particular local assemblage (Ricklefs, 2000). We could infer that the regional species pool is able to supply spider species to the different forest habitats in the region. However, local limitations to spider populations, notably the lack of habitat structures, could set a limit to population growth, especially in recently established *Eucalyptus* stands. Therefore, the high diversity within *Eucalyptus* region probably was due to the high species turnover along spatial and temporal scales supported by the successive disposal of resources caused by low population sizes.

Srivastava (1999) emphasized that in between-habitat comparisons of local and regional richness one must needs to check for additional evidence of evolutionary and historical limits to local diversity before any conclusion can be reached. We believe that the historical pattern of disturbance in this region could act in setting limits to niche occupation especially in *Eucalyptus* plantation stands. Nevertheless, we should be careful of possible traps involving the local-regional analysis, either because we did not perform here properly saturation analysis or because the methodological constraints involving this kind of approach (see Caley & Schluter 1997; Srivastava 1999; Griffiths 1999).

Inclusion of juveniles in a monitoring program may obscure trends, or suggest trends that are misleading (Norris 1999). Relative abundance of species in a community can be changed if juveniles are weighted the same as adults. Our results confirm such suspicious in the spatial pattern of abundance of understory spiders in the four habitats. Two *Eucalyptus* stands presented no genera and species diversity in autumn 2004 because only adults were identified. Nevertheless, it was found 13 juveniles belonging to five families in these two stands. The question then arises whether it is useful for management purposes to use a family approach when handling with juveniles. Our point of view is that it will depend upon the methods and objectives of the study. In this study, our aim was to compare in the first place between-habitat patterns of diversity supporting different degrees of disturbance. In our case, we believe that species approach could indicate the particular characteristic of these *Eucalyptus* stands, the lack of bush layer, and the family level approach would have masked the pattern.

Conclusion

The spatial distribution and composition of understory spider assemblages in this forest mosaic was probably influenced by local processes. Spider abundance was the most responsive community structural characteristic that changed in the landscape, showing high correlation with the stand ages. However, diversity of understory spiders was similar among the forest habitats, suggesting that logging practices utilised in this area did not cause negative impacts on spider community. So, spider community conservation could be possible in areas of exotic tree plantation as long as the managers could provide longer rotations and selective logging. When suitable habitat structure is provided, spiders perceive the connectivity of different habitats, therefore fragmentation of spider populations is prevented and the diversity could be maintained.

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Table I.1 – Forest stand characteristics of four forest habitats in a southern Brazil *Araucaria* forest: mean elevation (averaged from the two sampling unit measurements), habitat boundaries distant at most 100 m from the two plots, year of formation (for AF stands, it is the year of Reserve formation). AF = *Araucaria* forest; AP = *Araucaria* plantation; PP = *Pinus* plantation; EP = *Eucalyptus* plantation

Stand	**Elevation (m.a.s.l)**	**Year**	**~ Size (ha)**	**Site boundaries**
AF1	875	1945	50	*Araucaria* forest + grassland
AF2	916	1945	28	*Araucaria* forest + *Pinus* plantation
AF3	872	1945	24	*Araucaria* forest + *Pinus* plantation
AP1	867	1959	23	*Araucaria* plantation + *Araucaria* forest + *Pinus* plantation
AP2	864	1947	27	*Araucaria* plantation
AP3	862	1947	27	*Araucaria* plantation
PP1	885	1965	9.5	*Pinus* plantation + *Araucaria* plantation
PP2	876	1972	4.5	*Pinus* plantation + *Araucaria* forest + *Araucaria* plantation
PP3	905	1968	9	*Pinus* plantation + *Araucaria* forest + *Araucaria* plantation
EP1	885	1972	4	Eucalypt plantation + *Araucaria* plantation + *Pinus* plantation
EP2	909	1994	2	Eucalypt plantation + *Pinus* plantation + *Araucaria* forest + grassland
EP3	875	1988	15	Eucalypt plantation + *Araucaria* forest + *Araucaria* plantation

Table I.2 – Results of nested ANOVA tests on understory spider total abundances (all specimens), understory species abundances (only adults) and expected number of families, genera, and species (rarefaction) found in a southern Brazil *Araucaria* forest, during six seasons in 2003 and 2004.

	Habitats (d.f. = 3,8)		**Stands (Habitats) (d.f. = 8,12)**	
	F	**P**	**F**	**P**
Autumn 2003				
Total abundance	4.780	**0.017**	6.166	**0.003**
Adult abundance	1.659	0.252	12.822	**0.000**
Expected number of families	2.753	0.112	1.213	0.368
Expected number of genera	3.220	0.083	1.042	0.458
Expected number of species	3.280	0.080	0.995	0.485
Winter 2003				
Total abundance	6.356	**0.016**	0.588	0.741
Adult abundances	0.366	0.780	3.165	**0.037**
Expected number of families	2.019	0.190	1.445	0.273
Expected number of genera	1.353	0.325	2.367	0.086
Expected number of species	1.283	0.344	2.383	0.085
Summer				
Total abundance	3.822	0.057	0.938	0.521
Adult abundance	2.146	0.173	1.142	0.516
Expected number of families	0.157	0.922	1.254	0.349
Expected number of genera	0.396	0.759	0.996	0.485
Expected number of species	1.633	0.257	0.744	0.654
Autumn 2004				
Total abundance	1.623	0.259	2.290	**0.044**
Adult abundance	3.647	**0.038**	0.933	0.642
Expected number of families	0.943	0.464	0.860	0.572
Expected number of genera	1.165	0.381	3.115	**0.038**
Expected number of species	1.212	0.366	3.178	**0.035**
Winter 2004				
Total abundance	7.785	**0.009**	1.811	0.171
Adult abundance	1.331	0.281	3.428	**0.027**
Expected number of families	0.438	0.732	0.644	0.729
Expected number of genera	0.928	0.470	1.418	0.282
Expected number of species	0.990	0.445	1.415	0.283
Spring 2004				
Total abundance	6.294	**0.017**	1.024	0.468
Adult abundance	12.613	**0.000**	0.873	0.675
Expected number of families	1.476	0.293	1.639	0.212
Expected number of genera	2.979	0.096	0.495	0.838
Expected number of species	3.193	0.084	0.492	0.840

Table I.3 – Measures of turnover coefficients of understory spider species collected in four different habitats in a southern Brazil *Araucaria* forest.

	***Araucaria* forest**	***Araucaria* plantation**	***Pinus* plantation**
***Araucaria* forest**	0		
***Araucaria* plantation**	76.65	0	
***Pinus* plantation**	81.70	85.50	0
***Eucalyptus* plantation**	77.98	88.42	90.39

Figure I.1 – Landscape mosaic of National Forest of São Francisco de Paula (29º23' S; 50º23' W), in a southern Brazil *Araucaria* forest and the representation of the field design utilised to sample understory spiders. AF = *Araucaria* forest stands; AP = *Araucaria* plantation stands; PP = *Pinus* plantation stands; PE = *Eucalyptus* plantation stands.

Figure I.2 – Mean + 1S.E. of total understory spider abundances (white bars) and spider species abundances (black bars) collected in four habitats, during six seasons in 2003 and 2004, in a southern Brazil *Araucaria* forest. Different letters indicate significant mean differences. Upper case letters = total abundances; lower case letters = species abundances.

Figure I.3 – Plot of relationship between total understory spider abundances and stand formation age (years) of four forest habitats in a southern Brazil *Araucaria* forest. Curvilinear lines are 95% confidence interval.

Figure I.4 - Curves of expected numbers of spider species (A), genera (B) and families (C) in four forest habitats in a southern Brazil *Araucaria* forest; circles = *Araucaria* forest, losangles = *Araucaria* plantation, triangles = *Pinus* plantation, squares = *Eucalyptus* plantation. The results show individual-based rarefaction curves for each habitat.

Figure I.5 – Plot of species-area relationship for four forest habitats in a southern Brazil *Araucaria* forest; circles = *Araucaria* forest, losangles = *Araucaria* plantation, triangles = *Pinus* plantation, squares = *Eucalyptus* plantation. Resulting equations: AF: $LogS = 0.259logA + 0.747$; AP: $LogS = 0.163logA + 0.941$; PP: $LogS = 0.152logA + 1.076$; EP: $LogS = 0.975logA - 1.004$.

Figure I.6 – Cluster analysis dendrograms of four forest habitats in a southern Brazil *Araucaria* forest based on understory spider abundances. The analysis was based in three taxa levels: A – species; B – genera; C – family. Based on euclidean distance between forest stands and UPGMA grouping criterion. The resulting groups were tested for sharpness significance by bootstrap technique. Stands are: AF1, AF2, AF3 = *Araucaria* forest; AP1, AP2, AP3 = *Araucaria* plantation; PP1, PP2, PP3 = *Pinus* plantation; EP1, EP2, EP3 = *Eucalyptus* plantation.

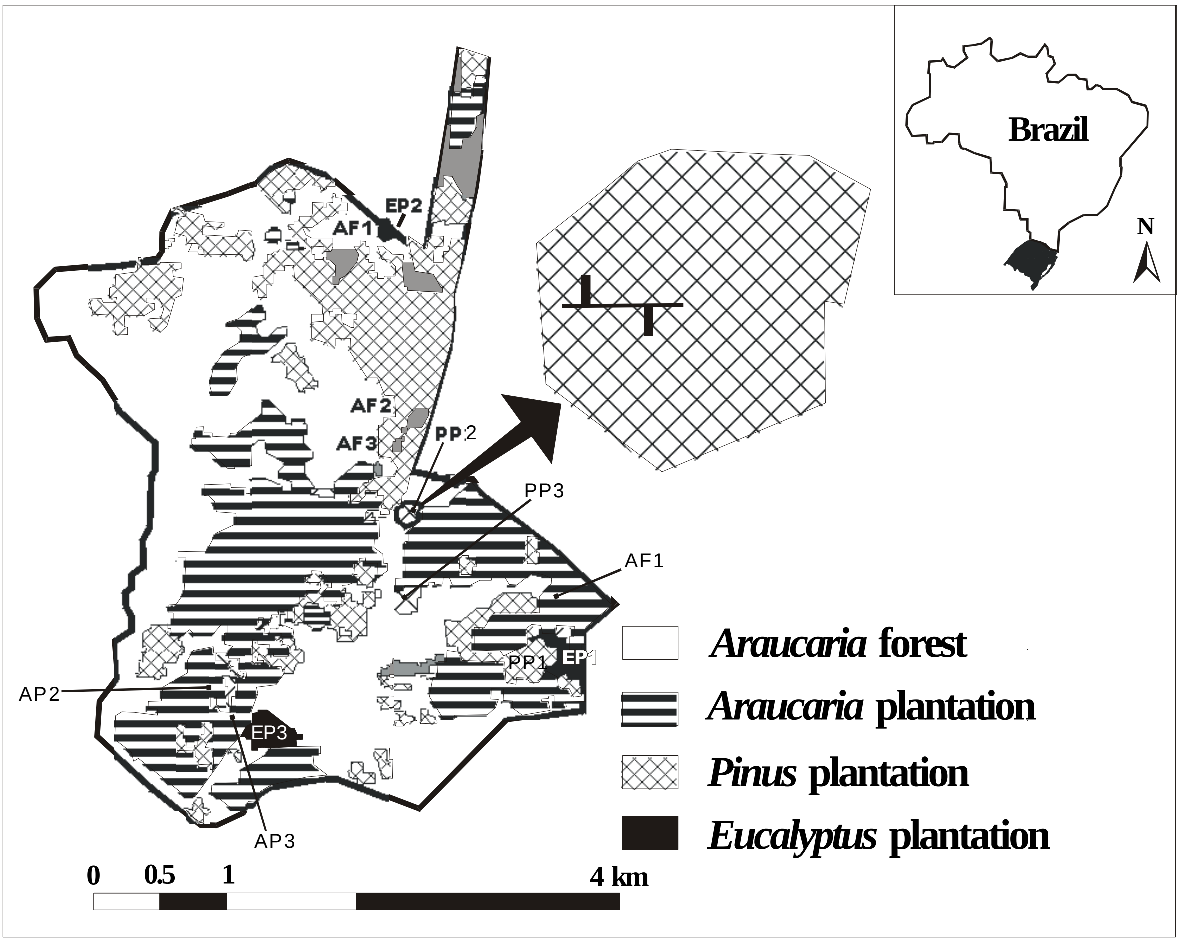
Brazil
N
EP2
AF1
AF2
AF3
PP2
PP3
AF1
PP1
EP1
AP2
EP3
AP3
Araucaria forest
Araucaria plantation
Pinus plantation
Eucalyptus plantation
0
0.5
1
4 km

Fig. I.1

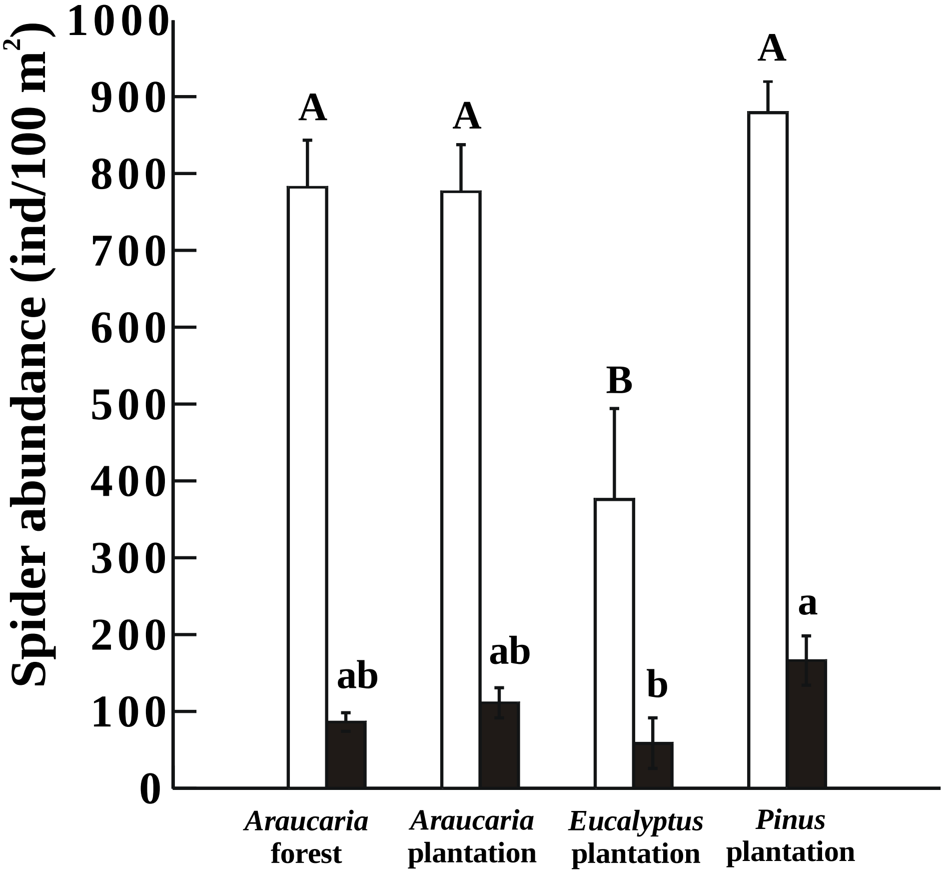
Spider abundance (ind/100 m^2)
1000
900
800
700
600
500
400
300
200
100
0
A
A
B
A
ab
ab
b
a
Araucaria forest
Araucaria plantation
Eucalyptus plantation
Pinus plantation

Fig. I.2

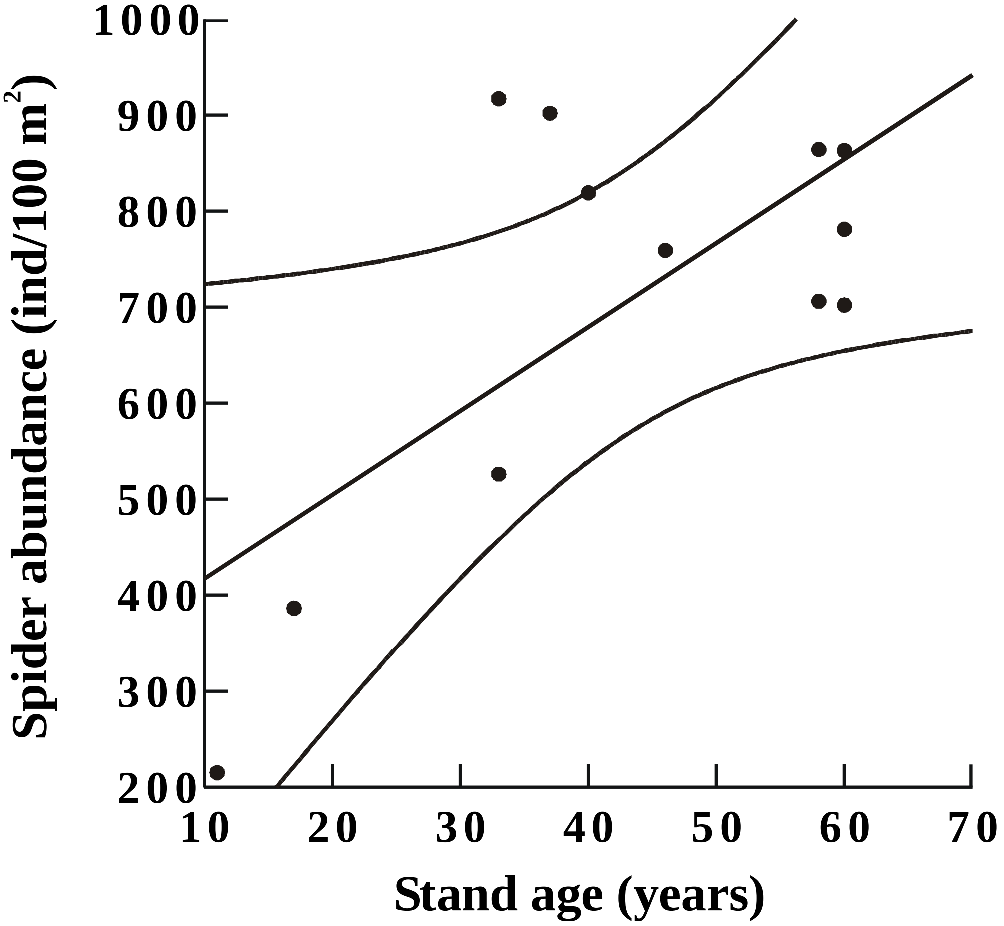
1000
900
800
700
600
500
400
300
200
Spider abundance (ind/100 m^2)
10
20
30
40
50
60
70
Stand age (years)

Fig. I.3

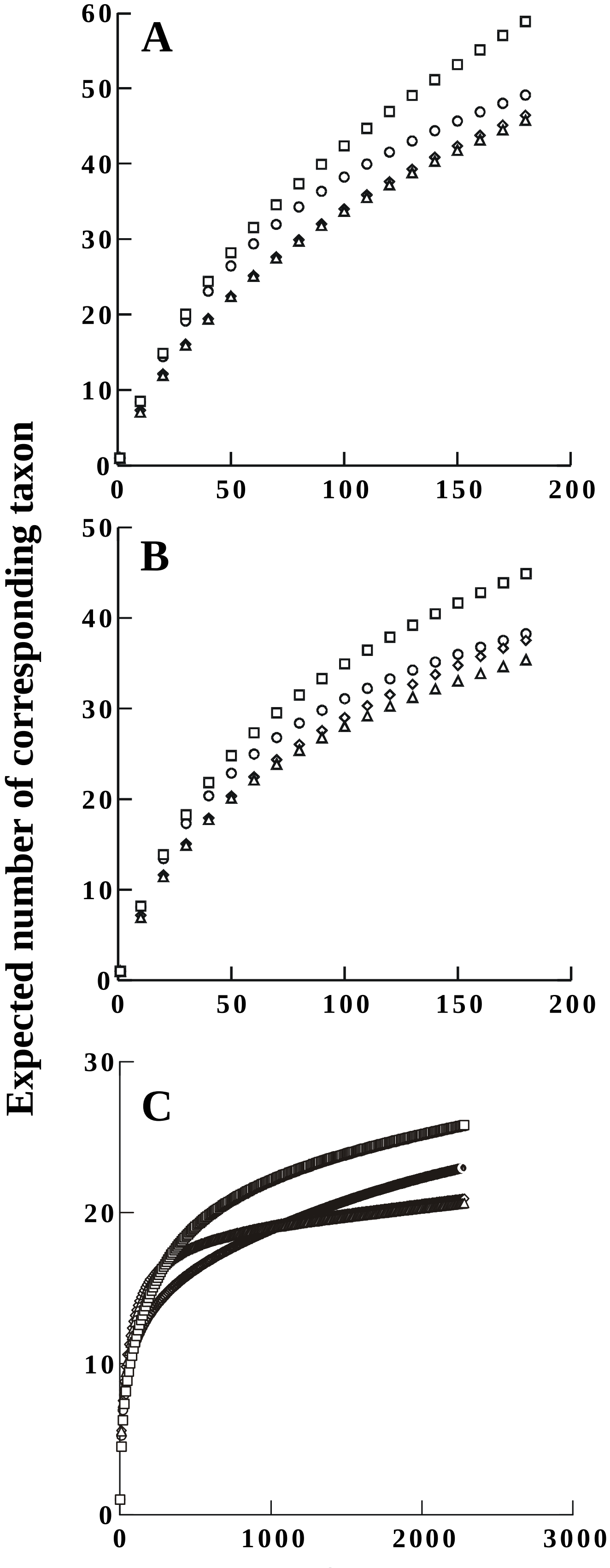
Expected number of corresponding taxon
A
0
10
20
30
40
50
60
0
50
100
150
200
B
0
10
20
30
40
50
0
50
100
150
200
C
0
10
20
30
0
1000
2000
3000
Number of individuals

Fig. I.4

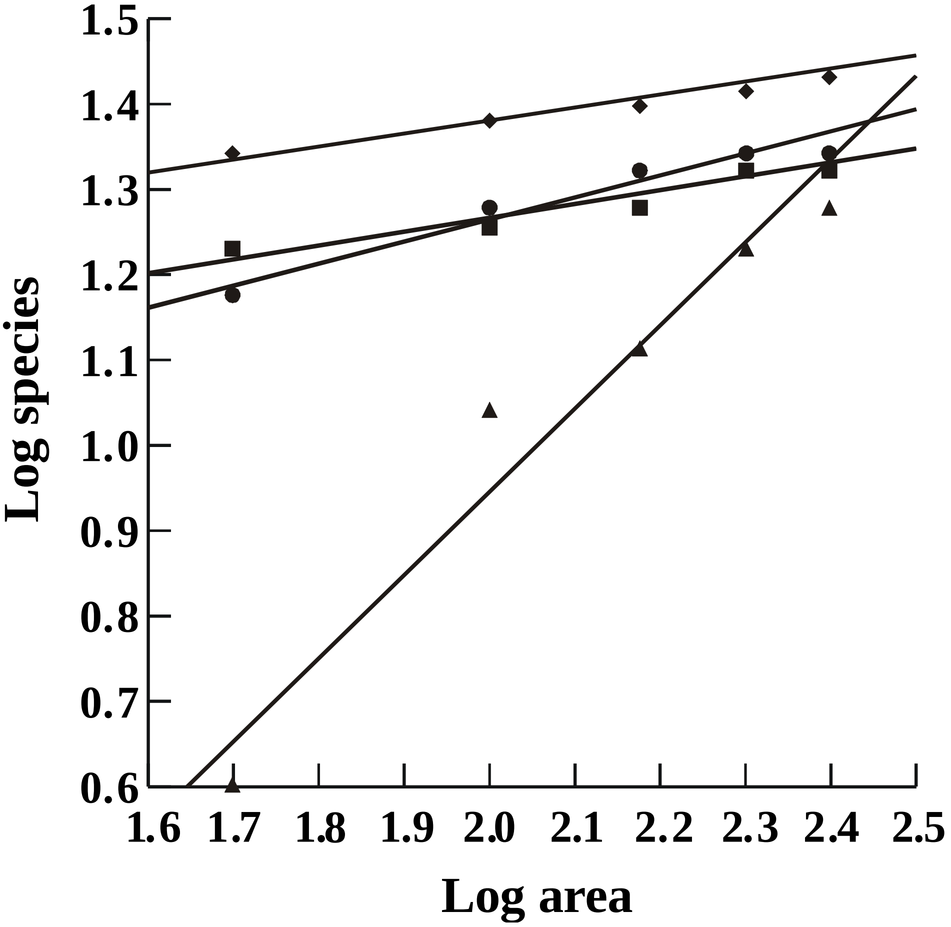
Log species
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
1.6
1.7
1.8
1.9
2.0
2.1
2.2
2.3
2.4
2.5
Log area

Fig. I.5

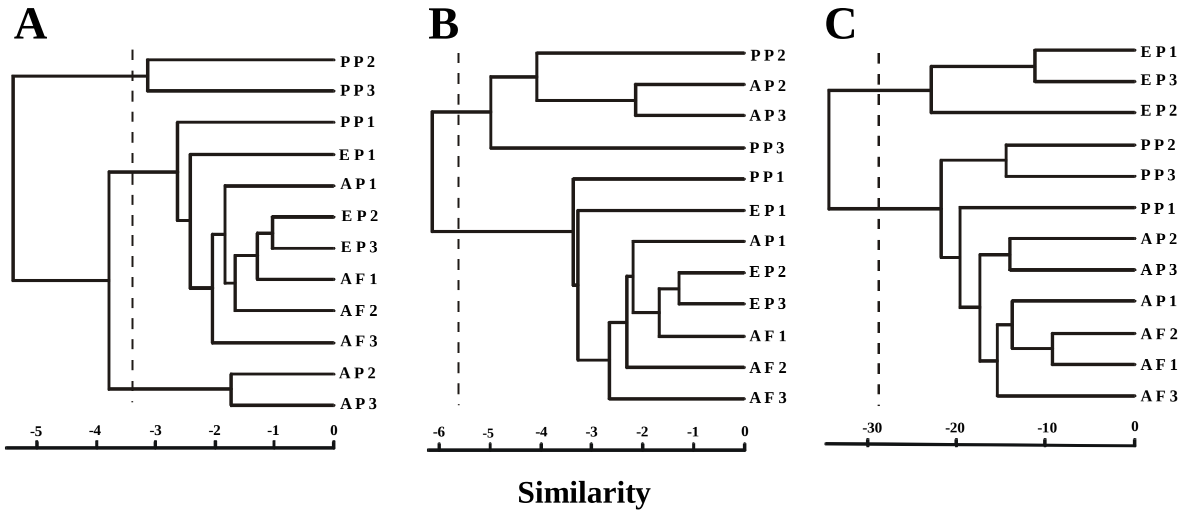
A
PP2
PP3
PP1
EP1
AP1
EP2
EP3
AF1
AF2
AF3
AP2
AP3
-5
-4
-3
-2
-1
0
B
PP2
AP2
AP3
PP3
PP1
EP1
AP1
EP2
EP3
AF1
AF2
AF3
-6
-5
-4
-3
-2
-1
0
C
EP1
EP3
EP2
PP2
PP3
PP1
AP2
AP3
AP1
AF2
AF1
AF3
-30
-20
-10
0
Similarity

Fig. I.6

Appendix – Total list of species with number of individuals collected in each forest habitat.

Family (guild*) **Species**	***Araucaria*** **forest**	***Araucaria*** **plantation**	***Pinus*** **plantation**	***Eucalyptus*** **plantation**
Amaurobiidae (shwb)				
Retiro sp.2	1			
Retiro sp.1				1
Anyphaenidae (fr)				
Aysha borgmeyeri		1		
Aysha gr. *brevimana*	2		1	
Aysha ericae	7	1		
Aysha gr. *helvola*	12	16	4	9
Aysha lisei			1	
Aysha zenzesi		3	14	2
Aysha sp.			1	
Aysha tertulia		2		
Oxysoma sp.	2			
Patrera sp.1	3	9	3	4
Patrera sp.2	1	1	3	
Sanogasta x-signata				1
Tasata sp.	3	2		1
Araneidae (ow)				
Acacesia villalobosi			1	
*Alpaida gray*i				1
Alpaida sp.2		2		
Araneus sp.	1		1	
Eustala gr. *fuscovittata*				1
Eustala sp.1			1	
Eustala sp.2			1	
Hypognatha cambara	6	2		
Mangora sp.	5			1
Micrathena brevispina		2		
Micrathena sp.1				1
Micrathena sp.2	1			1
Parawixia audax				2
Scoloderus cordatus	3	4	7	
Testudinaria sp.		1		
Verrucosa sp.	6		2	
Wagneriana eupalaestra				1
Corinnidae (fr)				
Corinna sp.1			1	
Corinna sp.2			1	
Trachelas sp.			1	
Ctenidae (fr)	1			
Deinopidae (ow)				
Deinopis sp.				1
Dictynidae (swb)				

Dictynidae sp.	1			
Gnaphosidae (fr)				
Apodrassodes sp.				1
Hahniidae (shwb)				
Hahniidae sp.1		2	3	
Hahniidae sp.2	1			
Linyphiidae (wstw)				
Brattia sp.		1	2	
Dubiaranea sp.		1	3	
Linyphiidae sp.1	30	86	158	7
Linyphiidae sp.2	1	2	19	2
Linyphiidae sp.3			10	
Linyphiidae sp.4	6		1	
Linyphiidae sp.5	3		3	6
Linyphiidae sp.6			2	4
Linyphiidae sp.7	3			
Linyphiidae sp.8			1	1
Lycosidae (fr)	1			
Mimetidae (s)				
Ero sp.3		2		
Ero sp.2				1
Gelanor sp.		1		
Miturgidae (fr)				
Radulphius sp.			4	
Mysmenidae (ow)				
Maymena sp.1		2	16	
Maymena sp.2			1	
Trogloneta sp.	5	2	4	5
Oonopidae (fr)				
Oonopinae sp.		1		
Orchestina sp.1	8	39	8	9
Orchestina sp.2			3	
Orchestina sp.3			1	
Philodromidae (a)				1
Pholcidae (ow)				
Tupigea paula	1		16	2
Pisauridae (a)				1
Salticidae (s)				
Bellota sp.1			1	1
Bellota sp.2		1	1	
Coryphasia sp.		3		
Cotinusa sp.1	2	3	5	3
Cotinusa sp.2	5		1	1
Cotinusa sp.3		1	1	
Cotinusa sp.4		4	6	1
Cotinusa sp.5				1
Cylistella sp.		1	1	

Dendryphantinae sp.1				2
Dendryphantinae sp.2		2		
Dendryphantinae sp.3	1			
Euophrynae sp.1	3			
Euophrynae sp.4			1	
Euophrynae sp.5		1		
Lyssomanes nigrofimbriatus		1	1	
Noegus sp.	1		1	1
Salticidade sp.1				1
Tariona sp.	17	29	17	5
Zygoballus sp.			2	1
Scytodidae (fr)				
Scytodes gracilis				1
Scytodes sp.	6	4	2	7
Segestridae (fr)			1	
Selenopidae (fr)				1
Senoculidae (fr)		1		
Sparassidae (fr)				
Olios sp.1	1	1		1
Olios sp.2				1
Tetragnathidae (ow)				
Chrysometa sp.1	1	10	2	
Chrysometa sp.2		1		
Leucauge sp.1			4	1
Leucauge sp.2			1	
Tetragnatha sp.			1	
Theridiidae (swb)				
Argyrodes sp.	6	2	3	
Chrysso sp.1		1	3	
Chrysso sp.2	1			1
Dipoena alta	5	3	16	10
Dipoena sp.2	2	4	6	
Dipoena sp.3	1	1		2
Dipoena sp.4	6	1		6
Dipoena sp.5			2	
Episinus sp.1	1	10	2	
Episinus sp.2			2	
Episinus sp.3			2	
Hetschkia gracilis	21	17	34	28
Phoroncidia sp.				1
Rhomphaea sp.	5	2		
Stemmops sp.		1		
Spintharus gracilis		2	9	8
Tekellina guaiba	3	8	6	5
Thwaitesia affinis	2	10	13	5
Thymoites melloleitaoni	24	1	34	7
Thymoites sp.2		6		

Wirada sp.	1			
Theridiosomatidae (ow)				
Naatlo sp.1		1		
Naatlo sp.2		7		
Thomisidae (a)				
Acentroscelus sp.		4		
Deltoclita sp.1	9		1	1
Deltoclita sp.2		6		1
Epicadus sp.	1	1		
Misumenops sp.1				2
Misumenops sp.3				1
Misumenops sp.4				1
Sidymella sp.				2
Tmarus sp.2	3	2	5	1
Tmarus sp.3	2			
Tmarus sp.4	3		1	
Tmarus sp.5	1		1	
Tmarus sp.6			4	1
Tmarus sp.7	1		1	
Tmarus sp.8	1			
Tmarus sp.9	1			
Uloboridae (ow)				
Miagrammopes sp.	1	2	1	1

* a = ambushers; fr = foliage runners; ow = orb weavers; s = stalkers; shwb = sheet web builders; swb = space web builders; wstw = wandering sheet/tangle weavers.

Understory spider community response to spatial structural features of native and managed forest habitats

Ronei Baldissera, Gislene Ganade, Antonio D. Brescovit & Sandra Hartz

Spider community composition response to spatial structural features of native and managed forest habitats

Abstract

We investigated how a landscape mosaic composed of four forest habitats could influence understory spiders composition in a National Forest in southern Brazil. The heterogeneity created by different stands of tree plantations could be perceived by understory spiders as limiting or facilitating factors once different vegetation structures could influence their habitat selection decisions. To access the possible effects of forest habitat type on the expected numbers of spider families, abundance, and composition, we sampled understory spiders in two seasons in three replicated stands of four forest types: *Araucaria* forest, *Araucaria* plantation, *Pinus* plantation, and *Eucalyptus* plantation. We collected data on stand age and at five categories of vegetation cover: trees, bushes, vines, ferns, and grasses. We have found that *Pinus* plantation presented the highest vegetation cover density, with great abundance of ferns. *Araucaria* forest showed the highest amount of trees, while grasses were found only in *Eucalyptus* plantations. The expected numbers of understory spider families did not vary between habitats. Spider abundance was higher in *Araucaria* plantation and Araucaria forest compared to eucalypt plantation. Stands age explained much of the variance in understory spider abundances. A CCA model was highly significant in accessing similarities in understory spider composition across the vegetation cover categories. The stands formed four groups, and we were able to characterize the composition of understory spider assemblages linked to each formed group of vegetation cover stands. We concluded that at least for understory spider community the management procedures of long rotations and selective logging applied in these stands were important in diminishing possible negative effects associated to the conversion of native forest to tree monocultures. Dense understory vegetation was able to growth in all stand types, promoting connectivity between stands and providing suitable habitat conditions for spider community in this region.

Keywords: *Araucaria* forest; *Pinus* plantation; *Eucalyptus* plantation; Forest management; Landscape mosaic.

1. Introduction

Forest ecosystems worldwide have been suffering spatial transformations by human activities. In temperate and subtropical regions large areas have been historicaly heavily exploited, and these regions relay on vegetation remnants outside protected reserves to conserve its diversity, which is a major concern for resource managers and conservationists (Lindenmayer and Franklin, 2002). The traditional land uses and management of forest resources have been dictated by the demands for, e.g., fuel wood and paper production. During the early years of timber exploitation, public supported increased harvesting. But public perception to what was considered acceptable for forest management practices began to change in the early 1970's (Vogt et al., 1997).

Forests are not static systems; therefore, management practices ultimately must be adapted to follow their developmental changes over time. To preserve biological diversity, managers need to plan and manage over very long time-frames for the range of forest ages and successional stages to be maintained in the landscape (Brown et al., 2001). Thus, relating human activities such as managed forests use to taxa activities pattern and activity is one of the key issues for managing diversity (Ernoult et al., 2003). A range of habitat conditions to the colonization and establishment of animal communities are given by the the human created environmental mosaic composed of patches of distinct forest composition and/or structure (Lindenmayer and Franklin, 2002). This is mostly because different species are likely to occupy different habitats and a particular group of habitats may therefore support more diversity (MacArthur, 1965; Rosenzweig, 1995).

Changes in animal arthropod communities were related to managed forests in areas of Africa, and Sweden (Engelmark et al., 2001; Nummelin and Zilihona, 2004). Managed forests also influenced the diversity of spiders in Scotland and Taiwan (Docherty and Leather, 1997; Chen and Tso, 2004). Indeed, spiders could serve as an excellent group to access animal community changes in spatial heterogeneous areas, because they are widespread intermediate-level predators and are among the most diverse group on earth (Coddington and Levi, 1991; Wise, 1993). Additionaly, their distribution and occurrence are strongly influenced by habitat structure (Robinson, 1981; Scheidler, 1990; Uetz, 1991; Wise, 1993; Buddle et al., 2000; Baldissera et al., 2004).

In Rio Grande do Sul state, southern Brazil, the original landscape pattern of the north-eastern highlands was composed by areas of *Araucaria* forests interspaced with grassland (Rambo, 1956; Lindman and Ferri, 1974). This forest is characterised by the canopy dominance of *Araucaria angustifolia* (Araucariaceae) and is inserted in the Atlantic forest biome (*latu sensu*), thus being considered from a global perspective as a biodiversity hotspot for conservation priorities (Myers et al., 2000). However, since the beginnings of human colonization in the region, the *Araucaria* forest suffered heavy timber exploitation, and habitat lost due to cattle and agriculture expansion. These practices caused the degradation of about 86% of the natural landscape. In the 1960’s, large scale reforestation began (IBDF, 1983), mainly with *Eucalyptus*, *Pinus*, and *Acacia* species. This practice persists until today, creating a heterogeneous landscape mosaic structure, which potentially influences the dynamics diversity and composition of animal communities. However, to our knowledge, studies of these human modified habitats, particularly involving forest management practices, and their impacts on spider assemblages are absent.

This study investigates how the diversity patterns of understory spider community respond to habitat structural features of four forest stands, namely *Araucaria* forest, *Araucaria* plantation, *Pinus* plantation and *Eucalyptus* plantation.

2. Material and methods

2.1. Study site

The study was carried out at the National Forest of São Francisco de Paula (29°23'S; 50°23'W), highlands (841-916 m.a.s.l. in the study area) of Rio Grande do Sul state, southern Brazil. The reserve encompasses an area of 1606.60 ha and is settled over a basaltic uniform basin, formed in Mesozoic events of lava extrusion. The native forest is dominated by *Araucaria angustifolia* (brazilian-pine) (Araucariaceae) patches interspaced with plantations of *Pinus* spp., *Eucalyptus* spp., and *Araucaria angustifolia* (Figure II.1). The area represents a subtropical region, showing a mild mid-latitude climate with no dry seasons. Mean rainfall is 2235 mm year^{-1}, with minimum and maximum temperatures of 4.5 and 29 °C during the study.

At the time of reserve creation in 1945, great part of actual tree plantation areas were managed for agriculture practice, and the reserve size had ⅔ of today's total area (IBDF, 1983). Along its historical formation, pieces of land were added to form the actual reserve area, so the plantation stand ages varied from 11 to 58 years old. Therefore, the area is a characteristic landscape mosaic, comprised by four forest types (or habitats) of different sizes and ages (Figure II.1 and Table II.1). The management of plantation stands was made by selective logging of adult trees. Once this stage was finished, the stand was left behind with the remaining trees and other stand was chosen. This longer rotation practice increases light penetration as well as decreases the amount of monotypic litter, allowing understory plant colonization and growth. Therefore, the majority of plantation stands show a well-established bush layer.

2.2. Sampling design

The study sites encompass three replicated stands of each forest type. Inside each stand, we established a 100 m long transect where two 25 m × 2 m permanent plots (sampling units) were randomly placed, characterizing a nested design with stands not-randomly nested inside habitats, and plots randomly nested inside stands.

Understory spiders were collected by beating the vegetation between 1-2.5 m in height inside each plot during three excursions during winter 2003 and three excursions during summer 2003. The fallen vegetation was collected with a 1 × 1 m canvas sheet. All fallen vegetation was putted inside plastic sacs. Spiders were selected from the vegetation by hand at the laboratory.

Inside each sampling unit, we measured two habitat structure characteristics. Vegetation cover was surveyed by taking 50 point measurements of vegetation cover at 1 m horizontal intervals and between 1-2.5 m in height. Each measurement consisted of counting the number of vegetation touches to a 2.5 m stick (Baldissera *et al.*, 2004). For each measurement, we divided the touches into five vegetation cover types: trees (any touch of arbustive plant structure higher than 2.5 m); bushes (arbustive plant structure between 1-2.5 m in height); vines; ferns; and grasses. We believe that the different types of vegetation cover could offer a diverse structural substrate for understory spiders, thus influencing their habitat selection.

2.3. Statistical analyses

To investigate differences in habitat structure, an ANOVA was performed using the total vegetation cover of stands. An ANOVA was still used to verify differences in Shannon diversity index of vegetation cover types in each stand. We also performed separate ANOVAs to compare each vegetation cover type between the four habitats. Additionally, it was done a least-squares simple regression analysis between stand age and vegetation cover in order to analyze whether the vegetation cover could be explained by the years since stand creation.

To analyze how the abundance of spider community could change across the four forest habitats, it was first performed a repeated measures ANOVA to check for season effects and possible interactions between habitats and seasons. The results showed that abundance of understory spiders varied between habitats, but not between seasons and there was no interaction between the two factors. Thus, we pooled together the abundances of winter and summer and used it in an ANOVA to analyze possible differences in total abundance between habitats.

The diversity of understory spiders was measured as expected numbers of families using rarefaction techniques (Hammer et al., 2004). Spider diversity did not vary between-habitats and between-stands in winter or summer, therefore, we tested for possible differences in habitat diversities by performing a nested ANOVA pooling winter and summer expected numbers of families.

To understand how the vegetation cover types could affect the composition of understory spiders, a canonical correspondence analysis (Makarenkov and Legendre, 2001) was performed to relate the data table of response variables abundance of spider families to the data table of explanatory variables estimated vegetation cover. CCA is an extension of Correspondence Analysis that maximizes the correlation between family scores and stand scores. The stand scores are constrained to be linear combinations of explanatory variables. Therefore, we could access the association between spider families and vegetation cover type and how this association describes the forest stands. It was performed 1000 permutation tests to access the significance of the resulting CCA model (Makarenkov and Legendre 2001).

3. Results

3.1. Habitat characterization

The vegetation cover of *Pinus* plantation (402.3±48.7 touches) was significantly higher than vegetation cover of *Araucaria* forest (189.3±7.2 touches) and *Eucalyptus* plantation (164±84.6 touches) ($F_{3,8} = 4.18$; $p = 0.047$. Fig. II.2). *Araucaria* plantation vegetation cover was similar to the other three habitats. The *Pinus* plantation (88±16.2 touches) and *Araucaria* forest (99.3±8.5 touches) trees cover were significantly higher than the *Eucalyptus* plantation trees cover (35.6±17.9 touches) ($F_{3,8}$ = 4.04; P = 0.051). The mean ferns cover of *Pinus* plantation (51±16) was seven times the mean of the other three habitats ($F_{3,8}$ = 19.27; P = 0.001). Grasses were found only in two stands of *Eucalyptus* plantation (14±7. $F_{3,8}$ = 3.97; P = 0.053). A significant correlation between vegetation cover and stand ages was not found (R^2 = 0.039; $F_{1,10}$ = 0.406; P = 0.538). Nevertheless, the variable trees cover alone was correlated to stand ages (R^2 = 0.35; $F_{1,10}$ = 5.36; P = 0.043).

3.2. Spider diversity

A total of 3424 spiders were collected in the two seasons, divided in 23 families and seven guilds (according to Uetz et al., 1999). Foliage runners were the more diverse (seven families) and abundant guild (28%). The web sheet/tangle weavers showed the lowest diversity (one family) and the sheet web builders showed the lowest abundance (0,2%) (Table II.2). Nine families contributed with 95% of total abundance. Anyphaenidae and Theridiidae were the most abundant families, each one contributing with 24% of total abundance, followed by Araneidae (16%) and Salticidae (14%). Amaurobiidae and Pisauridae were represented by one individual and were found only in *Eucalyptus* habitat. *Araucaria* plantation showed the highest abundance of understory spiders (N=1037), followed by *Araucaria* forest (N=955), *Pinus* plantation (N=899), and *Eucalyptus* plantation (N=533). On the other hand, *Eucalyptus* plantation showed the highest family richness (S=22), followed by *Pinus* plantation (S=19), *Araucaria* plantation (S=18), and *Araucaria* forest (S=17).

The abundance of understory spiders was significantly lower in *Eucalyptus* plantation (177.6±39.4 individuals) compared to *Araucaria* forest (318.3±33.5 individuals) and *Araucaria* plantation (345.6± 24.7 individuals) ($F_{3,8}$ = 6.56; P = 0.015. Fig. II.3). Regression analysis revealed that stand ages explain much of the variance of understory spider abundances (R^2 = 0.63; $F_{1,10}$ = 17.16; P = 0.002. Fig. II.4). The resulting model was s*pider abundance* = 128.4 + 3.7*stand age*.

The expected number of understory spider families neither showed between-habitat differences ($F_{3,8}$ = 1.14; P = 0.341) nor between-stand differences ($F_{8,12}$ = 1.042; P = 0.572) (Fig. II.5).

3.3. Canonical analysis

The analysis produced five canonical axes that explained 57.6% of total variance. The first two canonical axes accounted for 33.8% of the variance. The CCA model was highly significant in accessing the understory spider composition along the vegetation types (P = 0.007). The triplot showed clearly two opposite groups of vegetation covers (Fig. II.6). One characterized by trees and ferns, and a second by grasses, bushes and vines, although we could take grasses as a third distinct group. One group of sites was composed by AF3, PP2 and PP3. The second was distributed nearby the origin and was represented by AF1, AF2, and EP3. The third group was composed by EP1 and EP2 and was positioned in the third quadrant. The fourth group was composed by AP2, AP3, and PP1. The most abundant families Theridiidae, Araneidae, Anyphaenidae, and Salticidae were positioned at the centre of the graphic, related to AF1 and EP3. Pholcidae, Uloboridae and Tetragnathidae were positioned at the top of the plot, related to AF3, PP2 and PP3. Thomisidae, Anyphaenidae, Deinopidae, Coriniidae, Theridiosomatidae, and Hahniidae appeared in the fourth quadrant, along with AP1, AP2, and PP1. Amaurobiidae, Pisauridae, Gnaphosidae, and Dictynidae were positioned in the inferior part of the third quadrant in the grasses direction, and were correlated to EP1 and EP2. Mimetidae and Sparassidae were correlated mostly to PA3 and PE1.

4. Discussion

In this *Araucaria* forest mosaic region, the canopy oppening after plantation stands management (selective logging and long rotations) increased light availability on the forest floor, favouring the growth of the understory vegetation (Nummelin and Zilihona, 2004; Engelmark et al., 2001). Nevertheless, higher cover density was found in older coniferous plantation stands. The lack of correlation between vegetation cover and stand ages could indicate different degrees of responses of the understory vegetation communities to the disturbance, suggesting a rapid development of understory vegetation after logging operation. On the other hand, the development of a higher extrata (tree cover) was only possible in older stands. The high tree cover found in *Araucaria* forest, *Pinus* plantation and *Araucaria* plantation shows that the plantation stands seem to provide suitable environment to the growth of understory vegetation. Because we did not specified the identity of the tree touches, it is difficult to infer whether the understory plantation stands presented a regenerative extrata composed by tree juveniles. On the other hand, the tree cover of *Araucaria* forest was characterised by the presence of a regeneration extrata composed by juveniles of inhabiting trees (pers. obs.). The development of a fern cover extrata in *Pinus* stands could be due to the darker environment, increasing humidity. Grasses occurred only in two *Eucalyptus* stands, and these plants could reach almost 2 m in height. One of this *Eucalyptus* stands was 11 years old and the understory is dominated by grasses, and in the other stand the grasses were found in a gap nearby a brook where no *Eucalyptus* was planted.

The higher density of spiders in this study was found in native forest and no differences were found in spider diversity between habitats. Chen and Tso (2004) also found the same pattern in Orchid Island, Taiwan, in managed areas composed of native forest and three different disturbed areas (although they utilized spider species richness). The longer rotation provided the development of a dense understory vegetation cover that maintained key biological processes for spider community, notably the aerial dispersal potential, and the interaction between patch connectivity and area (Bonte et al., 2004; Tews et al., 2004). On the other hand, the lowest abundance of spiders in our study was found in *Eucalyptus* stands, that also showed the lowest density of vegetation cover types. These results suggested that density and heterogeneity of understory vegetation could be important to support high spider numbers. Indeed, correlations between spider densities and foliage biomass were found in

Oregon forests and Switzerland hay meadows respectively (Halaj et al., 1998; Schwab et al., 2002).

Although we have found no differences in expected numbers of families among habitats, the direct gradient analysis of spider community composition showed the presence of of spider families associated to particular vegetation cover types. The most abundant spider families were positioned around the origin of CCA graphic; therefore they did not show tight correlations to vegetation cover types. Nevertheless, Tetragnathidae, Pholcidae, Uloboridae, and Mysmenidae spider families were associated to the presence of trees and ferns at two *Pinus* stands and one *Araucaria* forest stand. These spider families were orb web builders. Tetragnathidae and Mysmenidae presented high numbers at the two habitats. On the other hand, Uloboridae presented high numbers at the *Araucaria* stand whereas Pholcidae numbers were higher at *Pinus* stands. Pholcids seem to take advantage of the architectural more closed structure of ferns to wave the irregular mazes of tridimensional webs (Halaj et al., 2000).

One stand of *Araucaria* plantation and other of *Pinus* plantation were associated to vines, which influenced the occurrence of the more diverse group of spiders: two families of orb web weavers, Theridiosomatidae and Deinopidae; three families of cursorial ones, Anyphaenidae, Oonopidae and Corinnidae; and one family of sheet web builders, Hahniidae. In fact, both variables vines and bushes appeared in high numbers in the same stands. In our methodological approach of understory vegetation, the bushes resembled the trees, except for the height of the structures, while vines provide highways through the understory. Therefore, the association of these two vegetation types aggregate structural features that allow for the establishment of distinct spider groups.

The rare families appeared in two *Eucalyptus* stands correlated to grass cover. Gnaphosidae could be positioned into the ground runner guild, and its presence indicated that individuals were able to climb the grasses. An imature individual of Pisauridae was found in a stand correlated to a brook in one *Eucalyptus* stand.

5. Conclusion

We have found that the choice of management technique employed in forestry practices in this subtropical forest could diminish the deleterious effects that are traditionally associated to native forest conversion to tree monocultures, at least for understory spider communities. Because this kind of management provides the development of dense understory vegetation, the stands connectivity were promoted and understory spider families did not perceive the habitat as being patchiness, but as a continuous suitable habitat. Nevertheless, at smaller spatial scales, the relative abundance of different types of understory vegetation structures in distinct forest habitats can lead to the colonization of distinct understory spider assemblages. Therefore, this study can serve to stimulate future research of spider communities in disturbed landscapes in Brazil. It demonstrated that even the simplest assessment of within-habitat structural features can be used to access spider community responses to human created landscapes.

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Table II.1 – Forest stand characteristics of four forest habitats in southern Brazil *Araucaria* forest: mean elevation, habitat boundaries distant at most 100m from the two plots, year of formation (for AF stands, it is the year of Reserve formation). Stands are: AF = *Araucaria* forest, AP = *Araucaria* plantation, PP = *Pinus* plantation, EP = *Eucalyptus* plantation.

Stand	**Year**	**Elevation (m.a.s.l.)**	**Site boundaries**
AF1	1945	875	*Araucaria* forest + grassland
AF2	1945	916	*Araucaria* forest + *Pinus* plantation
AF3	1945	872	*Araucaria* forest + *Pinus* plantation
AP1	1959	867	*Araucaria* plantation + *Araucaria* forest + *Pinus* plantation
AP2	1947	864	*Araucaria* plantation
AP3	1947	862	*Araucaria* plantation
PP1	1965	885	*Pinus* plantation + *Araucaria* plantation
PP2	1972	876	*Pinus* plantation + *Araucaria* forest + *Araucaria* plantation
PP3	1968	905	*Pinus* plantation + *Araucaria* forest + *Araucaria* plantation
EP1	1972	885	*Eucalyptus* plantation + *Araucaria* plantation + *Pinus* plantation
EP2	1994	909	*Eucalyptus* plantation + *Pinus* plantation + *Araucaria* forest + grassland
EP3	1988	875	*Eucalyptus* plantation + *Araucaria* forest + *Araucaria* plantation

Table II.2 –Number of individuals of understory spiders collected in four forest understory habitats in southern Brazil *Araucaria* forest. Spider guilds are: swb = space web builders; fr = foliage runners; shwb = sheet web builders; a = ambushers; ow = orb weavers; s = stalkers; wstw = web sheet/tangle weaver.

Family	***Araucaria* forest**	***Araucaria* plantation**	***Pinus* plantation**	***Eucalyptus* plantation**
Amaurobiidae (shwb)				1
Anyphaenidae (fr)	237	249	219	139
Araneidae (ow)	132	192	140	92
Corinnidae (fr)	2	6	2	5
Deinopidae (ow)		1	1	2
Dictynidae (swb)				3
Gnaphosidae (fr)				3
Hahniidae (shwb)	1	1	3	
Linyphiidae (wstw)	30	52	95	15
Mimetidae (s)	1	13	6	5
Miturgidae (fr)	7	7	4	3
Mysmenidae (ow)	3	2	4	1
Oonopidae (fr)	3	9	3	7
Pholcidae (ow)	1		10	1
Pisauridae (a)				1
Salticidae (s)	146	159	118	70
Scytodidae (fr)	26	14	7	11
Sparassidae (fr)	3	6	2	2
Tetragnathidae (ow)	19	9	20	4
Theridiidae (swb)	255	225	209	142
Theridiosomatidae (ow)		17	8	2
Thomisidae (a)	58	68	34	19
Uloboridae (ow)	31	7	14	5
TOTAL	955	1037	899	533

Figure II.1 – Landscape mosaic of National Forest of São Francisco de Paula (29º23' S; 50º23' W), in a southern Brazil *Araucaria* forest with the representation of the field design utilised on understory spiders sampling and habitat structure measurements. AF = *Araucaria* forest stands; AP = *Araucaria* plantation stands; PP = *Pinus* plantation stands; PE = *Eucalyptus* plantation stands.

Figure II.2 – Mean ± 1S.E. of total estimated understory vegetation cover (total vegetation touches) found in four forest understory habitats in a southern Brazil *Araucaria* forest, showing the relative contribution of vegetation cover types density. Different letters indicate significant differences.

Figure II.3 – Mean ± 1S.E. of total understory spider abundances (number of individuals) found in four forest habitats in a southern Brazil *Araucaria* forest. Different letters indicate significant mean differences.

Figure II.4 – Plot of relationship between understory spider total abundances (number of individuals) found in four forest habitats in a southern Brazil *Araucaria* forest, and years since stand creation. Curvilinear lines are 95% confidence interval.

Figure II.5 – Curves of expected numbers of spider families in four forest habitats in a southern Brazil *Araucaria* forest. The results show individual-based rarefaction curves for each habitat.

Figure II.6 – CCA triplot for the spider family data sampled in four understory forest habitats in a southern Brazil *Araucaria* forest. AF = *Araucaria* forest stands, AP = *Araucaria* plantantion, PP = *Pinus* plantation, EP = *Eucalyptus* plantation. Spider families are: am = Amaurobiidae, pi = Pisauridae, gn = Gnaphosidae, di = Dictynidae, ph = Pholcidae, ul = Uloboridae, ha = Hahniidae, ts = Theridiosomatidae, de = Deinopidae, co = Coriniidae, oo = Oonopidae, te = Tetragnathidae, my = Mysmenidae, sc = Scytodidae, mi = Mimetidae, sp = Sparassidae, li = Linyphiidae, th = Theridiidae, sa = Salticidae, to = Thomisidae, an = Anyphaenidae, ar = Araneidae, mt = Miturgidae.

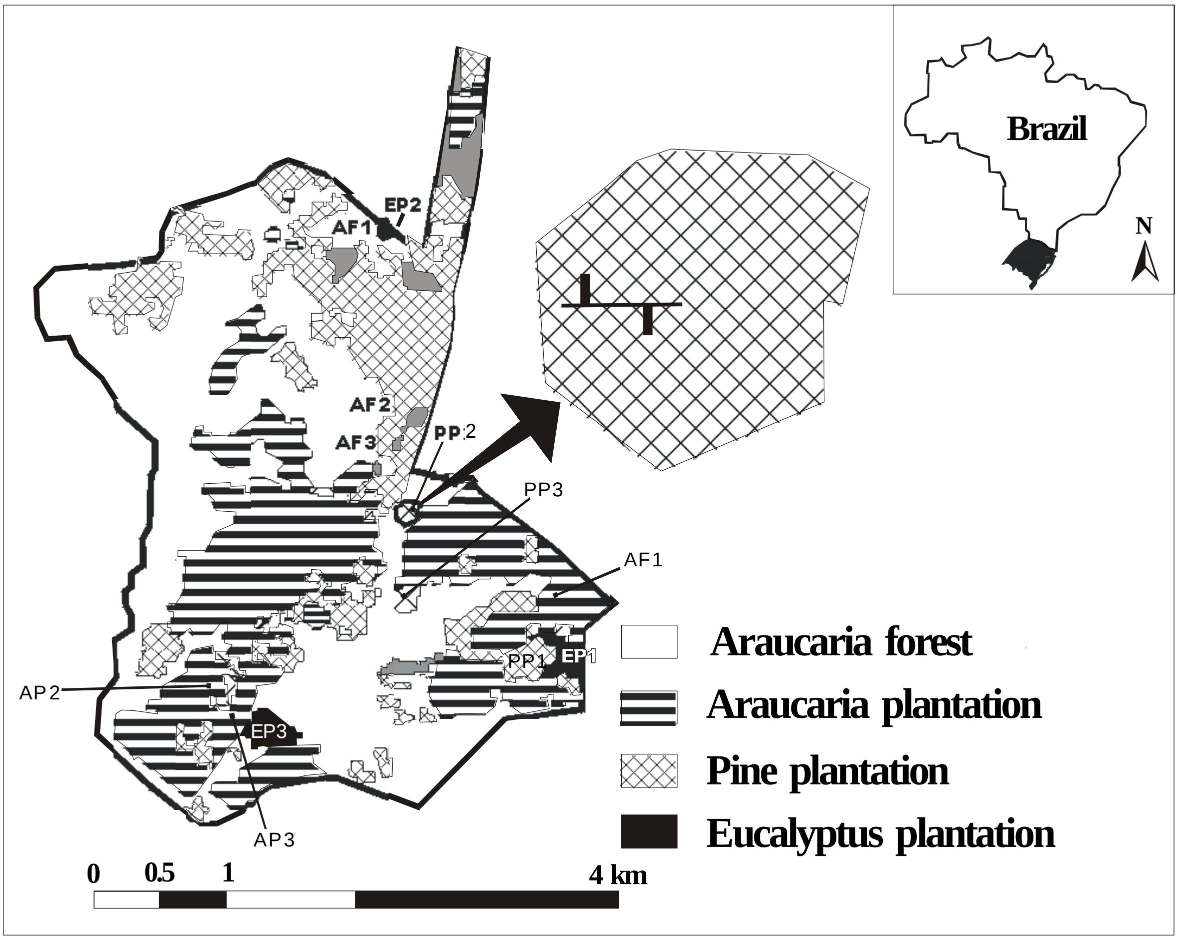
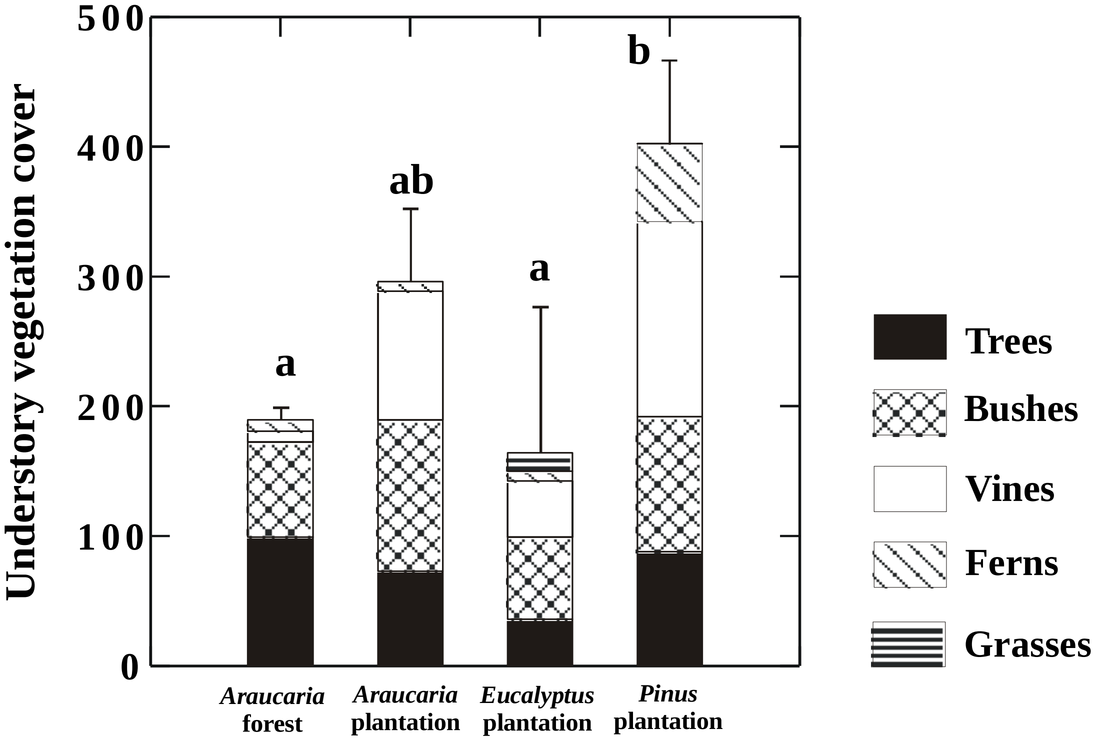

Brazil
N
EP2
AF1
AF2
AF3
PP2
PP3
AF1
PP1
EP1
AP2
EP3
AP3
Araucaria forest
Araucaria plantation
Pine plantation
Eucalyptus plantation
0
0.5
1
4 km

Fig. II.1



Understory vegetation cover
500
400
300
200
100
0
b
ab
a
a
Trees
Bushes
Vines
Ferns
Grasses
Araucaria forest
Araucaria plantation
Eucalyptus plantation
Pinus plantation

Fig. II.2

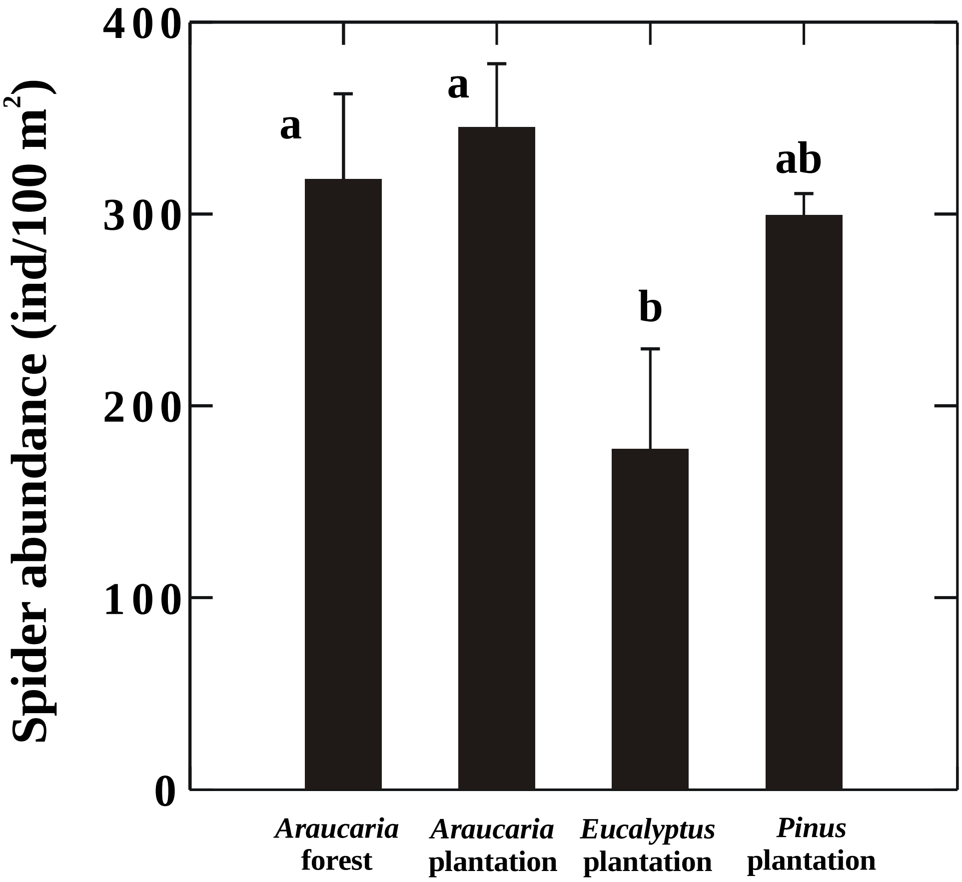
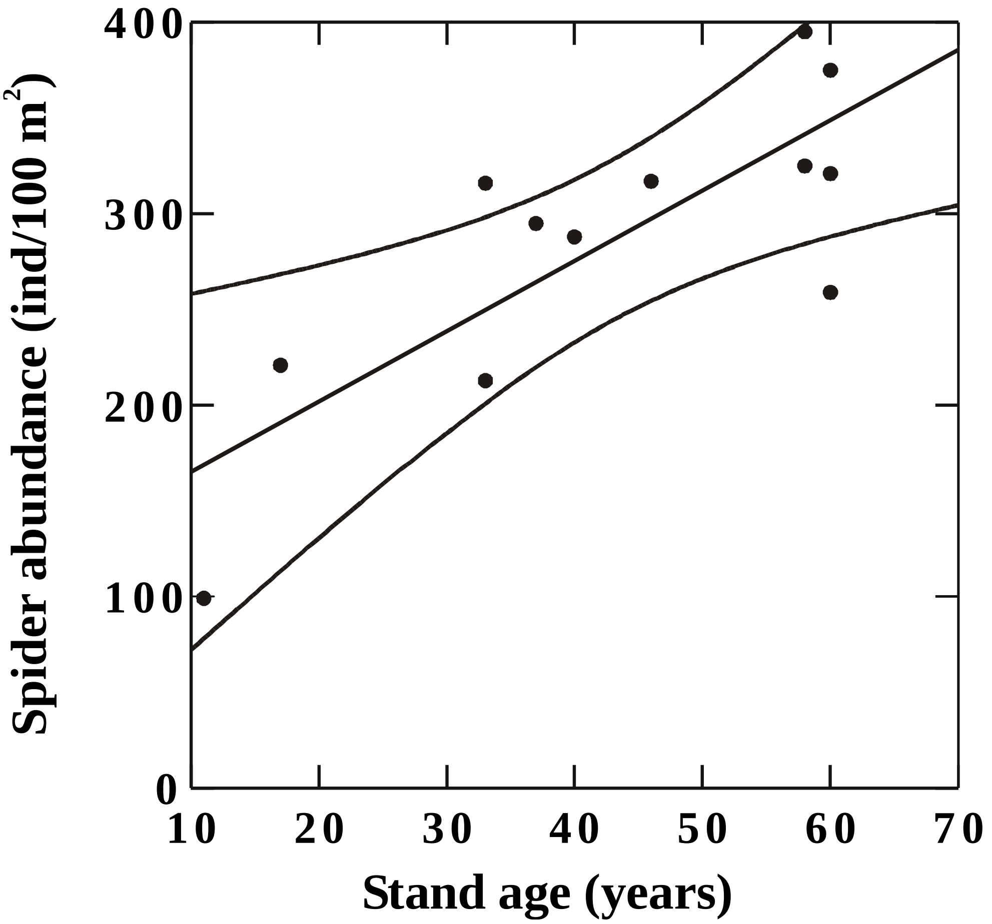

400
300
200
100
0
Spider abundance (ind/100 m²)
a
a
b
ab
Araucaria forest
Araucaria plantation
Eucalyptus plantation
Pinus plantation

Fig. II.3



400
300
200
100
0
10
20
30
40
50
60
70
Spider abundance (ind/100 m²)
Stand age (years)

Fig. II.4

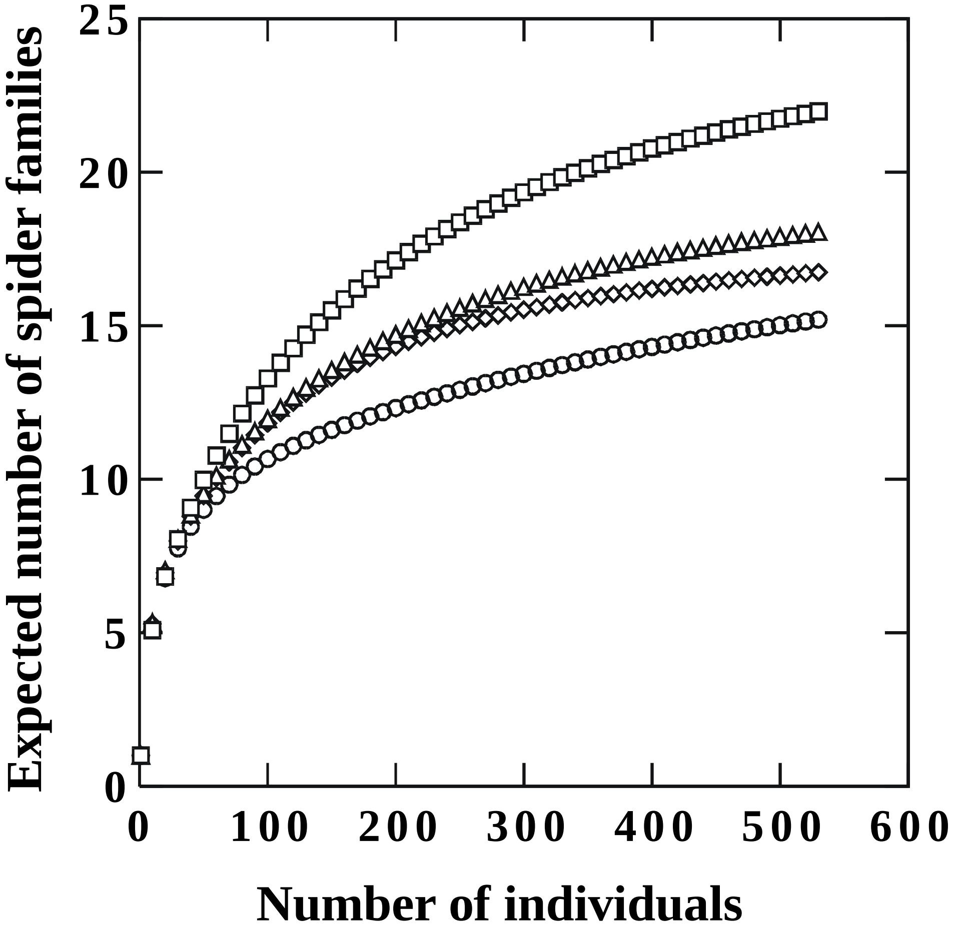

Expected number of spider families
0
5
10
15
20
25
0
100
200
300
400
500
600
Number of individuals

Fig. II.5

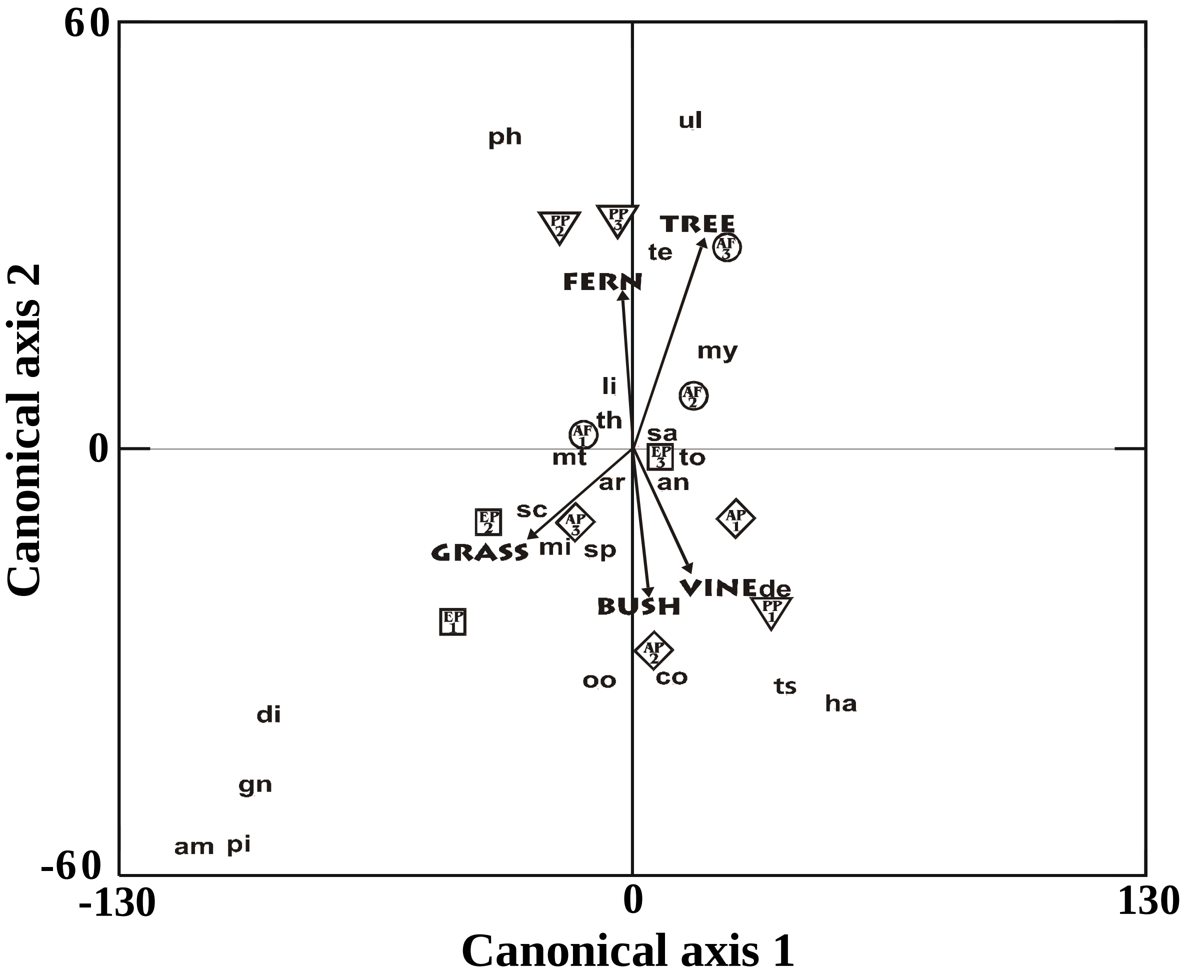

60
0
-60
-130
0
130
Canonical axis 1
Canonical axis 2
ul
ph
PP 2
PP 3
TREE
AF 3
te
FERN
my
li
AF 2
th
AF 1
sa
EP 3
to
mt
ar
an
sc
EP 2
AP 3
AP 1
GRASS
mi
sp
VINE
de
BUSH
PP 1
EP 1
AP 2
oo
co
ts
ha
di
gn
am
pi

Fig. II.6

5. CONSIDERAÇÕES FINAIS

5.1. Amostragem e análises

A determinação do número de unidades amostrais na análise das assembléias de aranhas do sub-bosque se baseou em uma amostragem piloto realizada nas áreas. Levando em consideração a análise hierárquica utilizada, duas unidades amostrais foi o mínimo para realizar as análises de variâncias. Os ambientes amostrados foram considerados uniformes em sua composição vegetal, o que não é necessariamente verdade. Portanto, a determinação de um número maior de unidades amostrais com tamanhos menores poderia ter revelado algum tipo de heterogeneidade em termos de microambientes que, fisionomicamente, não era aparente.

Outra observação importante diz respeito à utilização de parcelas permanentes. Este tipo de amostragem pode alterar o uso de recursos para as aranhas, principalmente por se tratar de batidas na vegetação. Além disso, o sorteio de parcelas em cada estação poderia captar as possíveis variações microambientais que pudessem existir. Apesar disso, as variações na abundância das assembléias durante as estações de coleta indicam que houve, pelo menos, três picos de abundância (Figura 5.1). Os ambientes de plantações de eucaliptos e araucária mostraram abundâncias maiores no verão de 2003, depois de já terem passado por três amostragens. As abundâncias da floresta nativa e das plantações de *Pinus* tiveram uma queda após a primeira amostragem. A alteração da estrutura ambiental, ao longo do tempo, pela ação do coletor não possibilita uma análise temporal confiável dos resultados, que poderiam simplesmente estar refletindo o impacto causado. Por outro lado, não era objetivo deste trabalho abordar concisamente variações temporais nas taxocenoses de aranhas de sub-bosque.

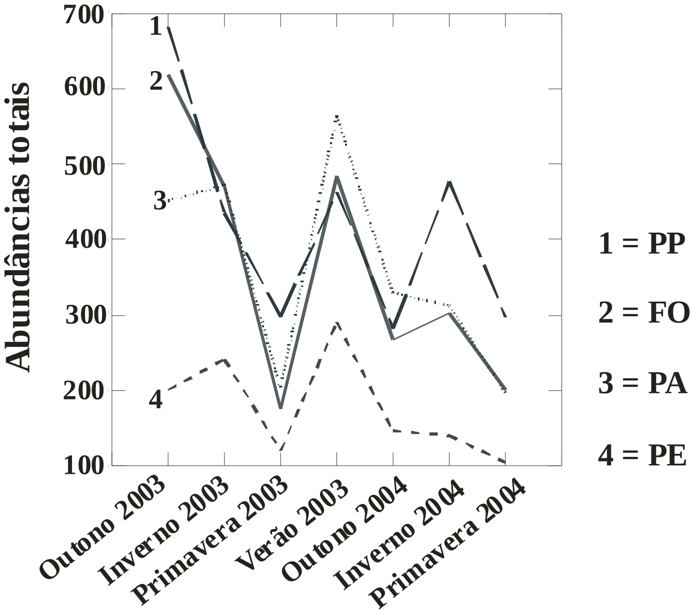


Figura 5.1 – Variação temporal da abundância de aranhas de sub-bosque (seis estações) em quatro ambientes florestais na FLONA de São Francisco de Paula, Rio Grande do Sul, Brasil. PP = plantação de pinus; FO = floresta ombrófila; PA = plantação de araucárias; PE = plantação de eucaliptoss.

5.2. Estrutura da comunidade

A falta de uma estreita correlação entre a densidade total do sub-bosque nas áreas estudadas e a estrutura das taxocenoses de aranhas indica que as áreas estudadas proporcionam condições similares para o seu estabelecimento. Por outro lado, na medida em que uma análise na escala mais fina da estrutura da vegetação é realizada (tipos de toques da vegetação), encontramos grupos de famílias de aranhas associadas com determinados "tipos" de vegetação (ver, por exemplo, Halaj *et al.*, 1998, 2000). A diferença na abundância de aranhas entre os ambientes indica que características locais podem estar influenciando a composição das taxocenoses na região.

Grande parte dos trabalhos realizados, até hoje, mostra que a resposta das aranhas à estrutura do ambiente é mais concisa quando se utilizam variáveis ambientais nas menores escalas, como biomassa de folhas e galhos, manipulação da estrutura de galhos, associações entre determinadas espécies vegetais e a comunidade de aranhas e estratificação vertical. No presente estudo, o sucesso da abordagem em termos de tipos de toques de vegetação e composição das taxocenoses indica que, caso se queira acessar as variáveis ambientais que influenciam a distribuição das assembléias de aranhas em áreas florestais, é necessário medidas de microestrutura espacial, se possível com experimentos de manipulação. Além disso, para acessar as forças que moldam a estrutura das taxocenoses é preciso abordar aspectos chaves para sua composição, como capacidade de dispersão entre os ambientes, capacidade de colonização, e interações como competição e predação. Desta forma, poderia se ter não somente uma idéia dos processos por trás da composição das taxocenoses, mas também subsídios para se ampliar as teorias de formação e manutenção das comunidades animais em ambientes florestais.

Se a riqueza pode não ser afetada pelas características próprias de cada ambiente, estas podem afetar a composição das taxocenoses, o que fica comprovado a partir dos resultados apresentados e coaduna com estudos realizados em outros locais do mundo (ver Brown *et al.*, 2001 para referências). Como as guildas de aranhas foram constantes nos quatro ambientes, pode-se esperar que as diferenças de composição não se traduzam em diferenças nas relações funcionais que as taxocenoses têm nas cadeias tróficas.

O suposto papel dos processos locais na estrutura das taxocenoses de aranhas de sub-bosque encontrado se deve às diferenças encontradas para as plantações de eucaliptos. A limitação ao crescimento das populações nas áreas de eucaliptos poderia se dever a processos como as condições abióticas, falta de estruturas ambientais, notadamente arpara colonização (principalmente para as aranhas de teia), carência de alimento e predação. As condições abióticas que poderiam estar influenciando na estrutura da comunidade nas áreas de plantação de eucaliptos são o vento e a insolação. Áreas de plantação em estágios iniciais com menos quantidade de sub-bosque estão mais sujeitas à entrada de luz solar, o que pode causar dessecação nas aranhas. O vento é outro fator que pode limitar o estabelecimento, principalmente de aranhas de teia, mas também de jovens que estão dispersando das áreas próximas. Na área de estudo, ventos fortes foram observados durante o outono e primavera. Além disso, na FLONA de São Francisco de Paula não é raro se registrar geadas e, até mesmo, neve, o que pode causar mortalidade em áreas mais desprotegidas. A baixa presença de estruturas nos ambientes de eucaliptos foi comprovada pela baixa presença de estruturas da vegetação.

O papel de processos ligados às interações entre os taxa não foi testado, mas a menor quantidade de estruturas da vegetação nos eucaliptos providencia menor oportunidade para o estabelecimento de insetos herbívoros que se alimentam das partes externas das plantas, o que limita também o número de presas disponíveis para as aranhas. Além disso, a baixa diversidade vegetal se traduz em poucas inflorescências, diminuindo a ocorrência de insetos voadores, o que pode limitar o alimento para aranhas de teia e também para aranhas, como os thomisídeos, que se alimentam de insetos polinizadores. A predação por aves é outro fator que pode aumentar a mortalidade das aranhas e, portanto, restringir o estabelecimento nas áreas com menos quantidade de estruturas no sub-bosque, uma vez que aumenta a probabilidade das aranhas serem detectadas pelos predadores.

Este estudo mostrou que é importante se levar em consideração o nível taxonômico quando se analisam alterações na estrutura das taxocenoses de aranhas. A falta de um critério claro para se classificar os jovens influencia os resultados encontrados nos estudos pelo mundo afora. Normalmente, os jovens são descartados das amostras quando não podem ser morfotipados. Os estudos citam esta limitação, mas não exploram as possíveis implicações para a estrutura das comunidades (ver, porém, Norris, 1999). Os resultados aqui apresentados mostram que é indicado trabalhar com a abundância total da comunidade em pesquisas com este tipo de abordagem, o que mostra mais fielmente os padrões de flutuação das populações. Neste caso específico, diferenças entre os ambientes foram mais claramente acessadas a partir da abundância total. Por outro lado, a diferença na diversidade de espécies encontrada em apenas uma estação se deveu exatamente à não determinação dos juvenis presentes. Será que se poderia assumir que estes jovens não iriam se tornar adultos e compor a assembléia futura? A estrutura da comunidade só é descrita pelos adultos? É assim que é feito atualmente, pelo menos na maioria dos trabalhos analisados.

Hoje em dia, os estudos de ecologia de comunidades estão em estreita relação com os estudos dos ecossistemas e seus funcionamentos. É clara a importância de toda estrutura etária dentro de um ecossistema. Jovens se alimentam, servem de alimento e exploram a estrutura dos ambientes. Estudar comunidades de aranhas só de adultos é ceifar a história da composição destas comunidades e ignorar a importância destes animais jovens na estrutura e funcionamento dos ecossistemas nos quais estão inseridos.

Conclusão

Futuras pesquisas de comunidade de aranhas em florestas mistas devem levar em consideração a resposta desses animais à microestrutura ambiental. Experimentos de manipulação a partir de mudanças microestruturais podem revelar mais diretamente os fatores influenciando os padrões de composição das comunidades e devem ser privilegiados.

A relação entre diversidade regional e local e o modo como o *pool* regional de espécies influencia na composição das comunidades de aranhas necessitam atenção em futuros estudos. Há indícios, atualmente, de que a saturação da diversidade local pode não acontecer, mesmo que haja um incremento constante na diversidade regional, ao contrário do que pensava MacArthur (1965) (para discussão, ver Ricklefs, 2000). Ou seja, o padrão de saturação de espécies não dependeria somente de restrições para utilização de recursos por exclusão competitiva ou predação. Variações ambientais entre os ambientes também poderia limitar a sua ocupação pelas espécies. Além disso, somente agora está se dando atenção aos processos interativos de facilitação, que podem influenciar na exploração dos recursos.

Por isso, a fim de se acessar os processos que moldam a composição da comunidade de aranhas em ambientes florestais é necessário, também, realizar estudos do potencial de dispersão e colonização, aliado a estudos de escolha de hábitat. Como vimos nessa pesquisa, as comunidades de aranhas podem persistir caso haja conectividade entre ambientes díspares, desde que microestruturas ambientais estejam disponíveis. Uma vez que o ambiente foi selecionado pelos organismos, são necessários estudos de impactos de predação e limitação de recursos alimentares sobre o estabelecimento das taxocenoses.

Finalmente, essa pesquisa indicou que a escolha do tipo de manejo de corte empregado em áreas de exploração madeireira é importante para a conservação da diversidade de aranhas de sub-bosuqe. A longa rotação nos talhões, aliado ao corte seletivo proporcionam condições de conectividade, através de estruturas ambientais chaves para a comunidade de aranhas de sub-bosque. O corte seletivo abre o dossel para a entrada de luz e a vegetação pode desenvolver-se, criando condições estruturais para a colonização pelas aranhas. A manutenção das populações pode ser, então, possibilitada pela disponibilidade de presas, principalmente populações de insetos que também podem ser responsivos à estrutura de sub-bosque. Por outro lado, a composição das taxocenoses pode sofrer alterações que não aparecem em uma análise baseada na riqueza. Ou seja, as taxocenoses de aranhas podem responder de maneiras diferentes à microestrutura ambiental (arquitetura da vegetação). Portanto, a conservação das aranhas de sub-bosque em florestas subtropicais mistas manejadas depende da adoção de práticas de manejo que proporcionem a conservação da heterogeneidade estrutural dos ambientes.

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