ISSN: 2525-7412

SPECIES RICHNESS AND COMPOSITION OF FERNS IN A FRAGMENT OF DENSE HUMID FOREST IN RIO GRANDE DO SUL, BRAZIL

Eduardo Luiz Burmeister[1]
Jairo Lizandro Schmitt[2]

Recebido em 20.04.2016; Aceito 05.06.2016

Abstract

A floristic survey of fern species was conducted in a fragment of Dense Humid Forest (29°24'59.23"S, 49°54'51.09"W) in Três Cachoeiras, RS, where life forms and substrate preferences were investigated. We found 37 species in 23 genera and 11 families, approximately 10% of Rio Grande do Sul's fern species richness. Epiphytes were dominant, 14 of which were creeping. In addition, a 1ha plot in the study site was determined to compare its species richness and composition with same sized plots from different studies. In this plot we found 75% of the richness of the entire fragment. Considering this high concentration of species is recommended the inclusion of ferns, besides trees, when assessing alpha diversity for developing conservation plans for Atlantic Forest remnants. The occurrence of *Cyathea corcovadensis* (Raddi) Domin is highlighted, as it is an endangered species in the state.

Key words: floristic, seedless vascular plants, ecological aspects, Atlantic Forest, Southern Brazil.

Resumo

Foi realizado um inventário florístico das samambaias ocorrentes em um fragmento de Floresta Ombrófila Densa (29°24'59.23"S 49°54'51.09"W), no município de Três Cachoeiras, RS, analisando-se as formas de vida e o substrato preferencial das plantas. Foram registradas 37 espécies, distribuídas em 23 gêneros e 11 famílias, aproximadamente 10% da riqueza de samambaias do RS. As epífitas foram predominantes, sendo 14 delas de crescimento reptante. Além disso, foi demarcada uma unidade amostral de 1ha dentro da área de estudo, cuja riqueza e composição foram comparadas com a de outras áreas de tamanho semelhante. Nesta parcela ficou concentrado 75% da riqueza de samambaias do fragmento. Considerando essa elevada concentração de espécies, recomenda-se a inclusão de samambaias, além de árvores, quando acessar a diversidade alfa para elaboração de propostas de conservação de remanescentes de Floresta Atlântica. Destaca-se a ocorrência de *Cyathea corcovadensis* (Raddi) Domin, espécie ameaçada de extinção no Estado.

[1] School of Biological Sciences, University of Canterbury, Private Bag 4800, Christchurch 8140 New Zealand

[2] Botanical Laboratory, Biology, Feevale University. 93352-000 Novo Hamburgo, RS, Brasil. jairols@feevale.br

Palavras-chave: florística, plantas vasculares sem sementes, aspectos ecológicos, Floresta Atlântica, Sul do Brasil.

1 Introduction

The Atlantic Forest biome is indicated as one of the five most important hotspots for conservation in the world, harboring 20,000 vascular plant species (Myers *et al*. 2000) and a significant quota of Brazilian biodiversity. Originally covering approximately 150 million ha, now only 11.7% remains of the second largest rainforest in South America (Ribeiro *et al*. 2009, 2011). In Rio Grande do Sul the forest cover has been reduced to only 7,9% of its original area (Fundação SOS Mata Atlântica & INPE, 2014), and the dense humid forest, one of its phytoecological regions, occurs exclusively in the northern coastline. The plain portions of the landscape display an intense history of anthropic action, resulting in an extremely fragmented physiognomy, with most of the remnants restricted to mountainous areas (Teixeira *et al*. 1986).

Forests have high fern and lycophyte diversity (Tryon 1985). The main Brazilian biome where these plants occur is the Atlantic Forest (Prado 2003) with 840 species, of which 269 (32%) are endemic (Stehman *et al*. 2009). So far in Brazil 1.263 species of ferns and lycophytes have been identified; 370 in the state of Rio Grande do Sul (Prado & Sylvestre 2016), while the dense rain forest has the highest species richness (Sehnem 1979).

Floristic inventories provide essential information about flora composition and are valuable tools for advanced studies in the fields of ecology, geographical distribution or restoration ecology (Souza *et al*. 2009). Among the floristic surveys that include ferns in Rio Grande do Sul, those conducted in humid forest by Senna & Waechter (1997), Schmitt *et al*. (2006), Santos & Windisch (2008), Goetz *et al*. (2012) and Becker *et al*. (2013) stand out.

Specifically in 1ha pre-established plots, a survey in the Ecuatorian Amazon by Poulsen & Nielsen (1995) found 50 fern species. Galeano *et al*. (1998) recorded 78 ferns and lycophytes in 0.9 ha of wet forest in the Chocó area, Colombia. In Brazil, Dittrich *et al*. (2005) registered 76 fern species in a dense humid alpine forest in the state of Paraná. In one hectare of mixed humid forest in Rio Grande do Sul, Blume *et al*. (2010) found 40 fern species. Athayde-Filho & Windisch (2006) registered 26 species in approximately 1ha of dense humid forest, in the municipality of Xangri-Lá.

The aims of this study were (1) to perform a qualitative inventory of ferns occurring in a dense humid forest fragment in Rio Grande do Sul, Brazil, as well as characterize the species according to their life forms and substrate preference; and (2) to compare the floristic composition of ferns in a 1ha plot against equivalent plots in humid forests in the Neotropics.

2 Material and methods

2.1 Study site

Field work was performed in a 6 ha fragment of dense humid forest (29°24'59.23"S 49°54'51.09"W) in the municipality of Três Cachoeiras, state of

Rio Grande do Sul (RS), southern Brazil. The area is a lowland forest with soil originated from fluvial, marine and lake sedimentation, which reflects on its peculiar forest cover (Teixeira *et al.* 1986). According to Koeppen's classification, the climate is Cfa type, humid temperate with warm summers (Peel *et al*. 2007). At the study site, the soil humidity varies from 23.25% to 96.03% and canopy openness ranges from 10.82% to 24.13% (Cappelatti & Schmitt, 2015). The mean annual temperature varies from 18.9°C to 20.4°C and annual rainfall ranges from 1342 mm to 1998 mm (Neumann *et al*. 2014).

2.2 Floristic survey

The fern community was assessed in monthly field trips over one year. The survey was divided in two steps: (1) the inventory of all species in the entire 6 ha fragment, and (2) the inventory of all species in a 1 ha plot (50 x 200 m) established within the limits of the fragment. Epiphytes were observed with the aid of binoculars. Plant samples were taken and prepared as described by Windisch (1992). Species were identified via specialized references, comparisons to material deposited in herbaria, and consultation with specialists. The classification system used was that proposed by Smith *et al.* (2006). Voucher material was deposited in the *Herbarium* Anchieta (PACA).

2.3 Life forms and substrate preference

Species were classified according to their life forms as described by Raunkiaer (1934), adapted by Mueller-Dombois & Ellenberg (1974) and Senna & Waechter (1997). Regarding the substrate, species were classified as terrestrial (species which occurs exclusively on the ground), corticicolous (species which occurs on tree bark) and hemicorticicolous (species rooted in the soil which climbs onto phorophyte). Due to lack of proper nomenclature, fern rhizome was considered as corticicolous substrate.

2.4 Statistical analysis

The floristic composition of the 1 ha plot was compared against the results of other studies in plots of equivalent size by means of a matrix of presence and absence of species. The Jaccard coefficient of similarity and cluster analysis (paired groups) were used to assess the floristic similarity between areas. The Pearson correlation test was used to analyze the relationship between species richness and rainfall of the plots via Paleontological Statistics – PAST software (Hammer *et al*. 2001).

3 Results and discussion

In the floristic inventory, 37 fern species belonging to 24 genera and 11 families were identified (Tab. 1).

Table 1 – Ferns' families and species found in a fragment of Dense Humid Forest in Três Cachoeiras, RS, and their classification regarding substrate and life forms.

Family/Species	Classification regarding substrate	Life form
ASPLENIACEAE		
Asplenium mucronatum C. Presl[1]	Corticicolous*	Ros Epi
Asplenium scandicinum Kaulf.[1]	Corticicolous*	Ros Epi
Asplenium serra Langsd. & Fisch.	Terrestrial	Cre Hcr
BLECHNACEAE		
Blechum acutum (Desv.) Mett.[1]	Hemicorticicolous*	Sca Hep
Blechnum brasiliense Desv.[1]	Terrestrial	Cha Ros
CYATHEACEAE		
Alsophila setosa Kaulf.[1]	Terrestrial	Ros Pha
Cyathea atrovirens (Langsd. & Fisch.) Domin[1]	Terrestrial	Ros Pha
Cyathea corcovadensis (Raddi) Domin[1]	Terrestrial	Ros Pha
DENNSTAEDTIACEAE		
Pteridium arachnoideum (Kaulf.) Maxon	Terrestrial	Rhi Geo
DRYOPTERIDACEAE		
Elaphoglossum sp.[1]	Corticicolous	Cre Epi
Elaphoglossum hymenodiastrum (Fée) Brade[1]	Corticicolous	Cre Epi
Elaphoglossum luridum (Fée) Christ[1]	Corticicolous	Cre Epi
Lastreopsis amplissima (C. Presl) Tindale[1]	Terrestrial	Cre Hcr
Mickelia scandens (Raddi) R. C. Moran, Labiak & Sundue	Hemicorticicolous	Sca Cli
Polybotrya cylindrica Kaulf.[1]	Hemicorticicolous	Sca Cli
Rumohra adiantiformis (G. Forst.) Ching	Terrestrial	Cre Hcr
HYMENOPHYLLACEAE		
Polyphlebium angustatum (Carmich.) Ebihara & Dubuisson[1]	Corticicolous*	Cre Epi
Trichomanes polypodioides Raddi[1]	Corticicolous*	Cre Epi
LINDSAEACEAE		
Lindsaea lancea (L.) Bedd.[1]	Terrestrial	Ros Hcr
LOMARIOPSIDACEAE		
Lomariopsis marginata (Schrad.) Kuhn[1]	Hemicorticicolous*	Sca Cli
POLYPODIACEAE		
Campyloneurum repens (Aubl.) C. Presl[1]	Terrestrial	Cre Hcr
Campyloneurum nitidum (Kaulf.) C. Presl[1]	Corticicolous*	Cre Epi
Microgramma squamulosa (Kaulf.) de la Sota	Corticicolous	Cre Epi
Microgramma vacciniifolia (Langsd. & Fisch.) Copel.[1]	Corticicolous	Cre Epi
Pecluma paradiseae (Langsd. & Fisch.) M.G. Price[1]	Terrestrial	Cre Hcr
Pecluma pectinatiformis (Lindm.) M. G. Price[1]	Corticicolous	Cre Epi
Pecluma sicca (Lindm.) M.G. Price[1]	Corticicolous*	Cre Epi
Pleopeltis pleopeltifolia (Raddi) Alston[1]	Corticicolous*	Cre Epi
Pleopeltis hirsutissima (Raddi) de la Sota[1]	Corticicolous	Cre Epi
Pecluma chnoophora (Kunze) Salino & Costa Assis[1]	Terrestrial	Cre Hcr
Serpocaulon catharinae (Langsd. & Fisch.) A.R. Sm.[1]	Corticicolous*	Cre Epi
PTERIDACEAE		
Doryopteris sp.	Terrestrial	Ros Hcr
Vittaria lineata (L.) Sm.[1]	Corticicolous*	Cre Epi
THELYPTERIDACEAE		
Macrothelypteris torresiana (Gaudich.) Ching	Terrestrial	Ros Hcr
Thelypteris conspersa (Schrad.) A.R. Sm.	Terrestrial	Ros Hcr
Thelypteris hispidula (Decne.) C.F. Reed	Terrestrial	Ros Hcr
Thelypteris raddii (Rosenst.) Ponce[1]	Terrestrial	Ros Hcr

Geophyte (Geo); Hemicryptophyte (Hcr); Chamaephyte (Cha); Phanerophyte (Pha); Hemiepiphyte (Hep); Epiphyte (Epi); Climber (Cli); Rhizomatous (Rhi); Creeping (Cre); Rosulate (Ros); Scandent (Sca); species found in the 1ha plot ([1]); species found using other fern rhizome as substrate (*).

Species richness of this study was inferior to that found by Senna & Waechter (1997), Schmitt *et al*. (2006), Santos & Windisch (2008), Goetz *et al*. (2012) and Becker *et al*. (2013) (Tab. 2). However, Senna & Waechter (1997) found only two additional species in 400 ha of humid forest, an area 65 times larger than the present study site. Conversely, in 6.900 ha Santos & Windisch (2008) found 50 species, not a particularly high value for rainforest surveys. When compared against larger areas, the small 6 ha fragment in Três Cachoeiras is able to support a significant share of the regional diversity of ferns – 10% of Rio Grande do Sul's species. Nevertheless, the comparison between the surveyed site and previous researches do not show a clear increase of species richness as result of increase in area.

The contribution of small fragments to the conservation of the Atlantic Forest becomes substantially relevant when considering that 83.4% of its remnants are no larger than 50 ha, and represent 20.2% of the biome's current area (Ribeiro *et al*. 2009). Paciencia & Prado (2004) and Lwanga *et al*. (1998) have shown that the richness of ferns and lycophytes may not be influenced by the area of the fragment, and the latter goes further by pinpointing abiotic factors, such as precipitation, as the main driver of diversity.

The richness found in this study can be explained by the characteristics of the fragment, which has high soil moisture and low canopy openness creating a suitable microhabitat for ferns and lycophytes. Humidity and shade are essential to the establishment of ferns and lycophytes (Kessler *et al*. 2011), and the environmental variation provides a wider range of ecological opportunities for these plants (Richard & Bell, 2000).

Table 2 – Floristic surveys of ferns performed in Rio Grande do Sul and their respective authors, forest type, municipality, area and number of species found.

Municipality	Forest type	Area (ha)	Nº of species	Author
Três Cachoeiras	**DHF**	**6**	**37**	**Present study**
São Francisco de Paula	MHF	400	39	Senna & Waechter (1997)
Osório	DHF	6.900	50	Santos & Windisch (2008)
Canela	MHF	517,7	53	Schmitt *et al*. (2006)
Caraá	DHF/MHF	60	58	Becker *et al*. (2013)
São Francisco de Paula	MHF	1.200	76	Goetz *et al*. (2012)

DHF – Dense Humid Forest; MHF – Mixed Humid Forest.

The richest families were Polypodiaceae (11) and Dryopteridaceae (seven), comprising 48% of species. Polypodiaceae was also the richest family in all studies presented on Table 2. Most species of this family (73 %) were found on epiphytic environment. Epiphytes represent an important component of Neotropical flora (Benzing 1990), which is composed by a variety of fern species, including families in which most species are adapted to the aerial habitat (Otto *et al*. 2009), such as Polypodiaceae (Schneider *et al*. 2004a,b), which probably facilitates a generalized occurrence.

Terrestrial species (46 %) were dominant, followed by corticicolous (43 %) and hemicorticicolous (11%). The prevalence of terrestrial species is common for

most of the fern and lycophyte communities in Rio Grande do Sul, as observed in studies by Schmitt *et al*. (2006), Santos & Windisch (2008), Blume *et al*. (2010) and Becker *et al*. (2013).

Of the 16 corticicolous species, nine developed on rhizome of other ferns, sometimes exclusively, like *Polyphlebium angustatum* and *Trichomanes polypodioides.* All hemicorticicolous species were found on arborescent ferns, besides tree bark.

Considering all recorded species, 30% of them interact with tree ferns, establishing themselves on caudices or using it as support after germinating on the soil. The caudices of *Alsophila setosa*, *Cyathea atrovirens* and *C. corcovadensis* are formed by the remains of the petiole bases with aculeus or spines (Fernandes, 2003; Lehnert & Weigand, 2013), producing a non-smooth surface for other plants to explore. Thus, arborescent species provide suitable conditions for other epiphytic (Schmitt *et al*. 2005) and climbing ferns, as well as other plant groups (Roberts *et al*. 2005), contributing as specific or preferential microhabitat to other species. This significant interaction was observed between *T. polypodioides*, *Polybotrya cylindrica* and *Cyathea atrovirens,* respectively epiphytic, climber and arborescent ferns.

Regarding the life forms, 16 epiphytic species were found, of which 14 had creeping growth and two had rosulate growth; 12 are hemicryptophytes, six of which are creeping and six are rosulate, followed by three scandent climbers, three rosulate phanerophytes, one rhizomatous geophyte, one scandent hemiepiphyte and one rosulate chamaephythe. In Rio Grande do Sul the predominance of epiphytic life form in fern and lycophyte communities is unusual, being also the richest category in the survey by Senna & Waechter (1997). According to these authors, the high specific richness of epiphytes suggests a tropical feature of the dense and mixed forests, as this life form is typical of tropical humid regions. Only therophyte species were not found. The broad spectrum of life forms found in the study site indicates that the fragment provides favorable conditions for the establishment of ferns.

Rosulate growth, which was the most common type found among terrestrial species, facilitates occupation of substrate and light capture in understory (Pereira-Noronha 1989). On the other hand, creeping species were predominant in epiphytic environment. Creeping root ramification allows great occupation of substrate on host plant (Senna & Waechter 1997), as observed in *Micrograma squamulosa*, *M. vacciniifolia* and *Pecluma sicca*. The root ramification is the most common vegetative propagation of ferns and lycophytes (Pereira-Noronha 1989).

Blechnum acutum, which was the only hemiepiphyte registered, is usually found in floristic inventories in Rio Grande do Sul from different areas of dense (Santos & Windisch 2008) and mixed humid forest (Fraga *et al*. 2008). However, considering the three scandent climber species of the fragment, only *P. cylindrica* was found by Athayde-Filho & Windisch (2006), in dense humid forest at the northern coastline of Rio Grande do Sul. Hemiepiphytes and climbers are important and frequent components in tropical humid forest, disappearing in mountain rain forest (De La Sota 1971). *B. acutum* needs to be in a higher

canopy level in the forest to produce fertile leaves (Dittrich *et al*. 2005) such as *P. cylindrica.* Besides the individual's position in the forest stratum, the appearance of fertile leaves, at the end of the rhizome of scandent species such as *Lomariopsis marginata*, *P. cylindrica* and *B. acutum* might be related to the age of the plants (De La Sota 1971).

3.1 One hectare plot

In the plot 28 species were found, representing 75% of the richness of ferns in the fragment. This richness is lower than that found in 1 ha plots in Neotropical forests by Poulsen & Nielsen (1995) (n=50), Dittrich *et al*. (2005) (n=76), and Blume *et al*. (2010) (n=40). Only Athayde-Filho & Windisch (2006) found fewer species (n=26) than the present study, both in lowland forests.

The mean annual precipitation of these sites were strongly correlated with their respective richness (r=0.895; p=0.039). The result shows a clear increase of species with greater rainfall. Dittrich *et al*. (2005) recorded the highest species richness among the studied areas precisely in the site with the greatest annual rainfall, 215% more than the present study. The richness of ferns is most influenced by climatic conditions (Kessler *et al*. 2011).The increase of rainfall also reflects in a gain of epiphytic richness (Kornaś 1977, Nieder *et al*. 1996-1997) however, this trend was not statistically significant between the five plots (r=0.811; p=0.095).

The dendrogram of floristic similarity revealed three main branches which can be organized according to their geographical characteristics (Fig. 1). The first group has the greatest similarity index. It is comprised of the two surveys in lowland forests in Rio Grande do Sul's coastal plain - Athayde-Filho & Windisch (2006) and the present study – which share 11 species. Both study sites belong to the same phytoecological region (Dense Humid Forest) and are 47 km apart in a straight line. The second group includes the studies by Dittrich *et al*. (2005) in Dense Humid Forest and Blume *et al*. (2010) in Mixed Humid Forest, even though both areas belong to different forest types and are far apart. They share 16 species despite having less similarity. The survey in the Dense Humid Forest in Ecuador is represented in a single branch as expected, given its geographical distance from the four Brazilian sites. Dittrich *et al*. (2005) found exclusive occurrence of 48 species, and was followed by Poulsen & Nielsen (1995) with 37, Blume *et al*. (2010) with 19, Athayde-Filho & Windisch (2006) with 10, and this study with eight species.

Only one epiphytic species (*Vittaria lineata*) was found in all plots, and two species (*Campyloneurum nitidum* and *Pleopeltis hirsutissima*) were shared between the four studies in Brazil. *V. lineata* has widespread distribution in the Neotropics, and occurs in US, Mexico, Mesoamerica, Antilles, Trinidad, Colombia, Venezuela, The Guianas, Ecuador, Peru, Bolivia, Brazil, Paraguay and Uruguay (Schwartsburd & Labiak, 2007).

Macrothelypteris torresiana was found by Blume *et al*. (2010) and the present study. This species is introduced in Brazil (Santiago & Barros, 2003) and subspontaneous in the Tropical America (Smith, 1992). It can be used as

bioindicator of environmental degradation and restoration (Figueiredo & Salino, 2005).

The tree fern *Cyathea corcovadensis* was exclusive to this study and is considered vulnerable in the list of endangered species indigenous to Rio Grande do Sul, according to the Decree 52.109/2014 (Rio Grande do Sul, 2014). This species' distribution in the state is small and limited to the northern coastal region, in a latitudinal range from 29°17' to 30°00' S (Gonzatti et al. 2016). In addition to the southern region, *C. corcovadensis* also occurs in the northeast and southeast of Brazil (Windisch & Santiago, 2015) in the Atlantic Forest.

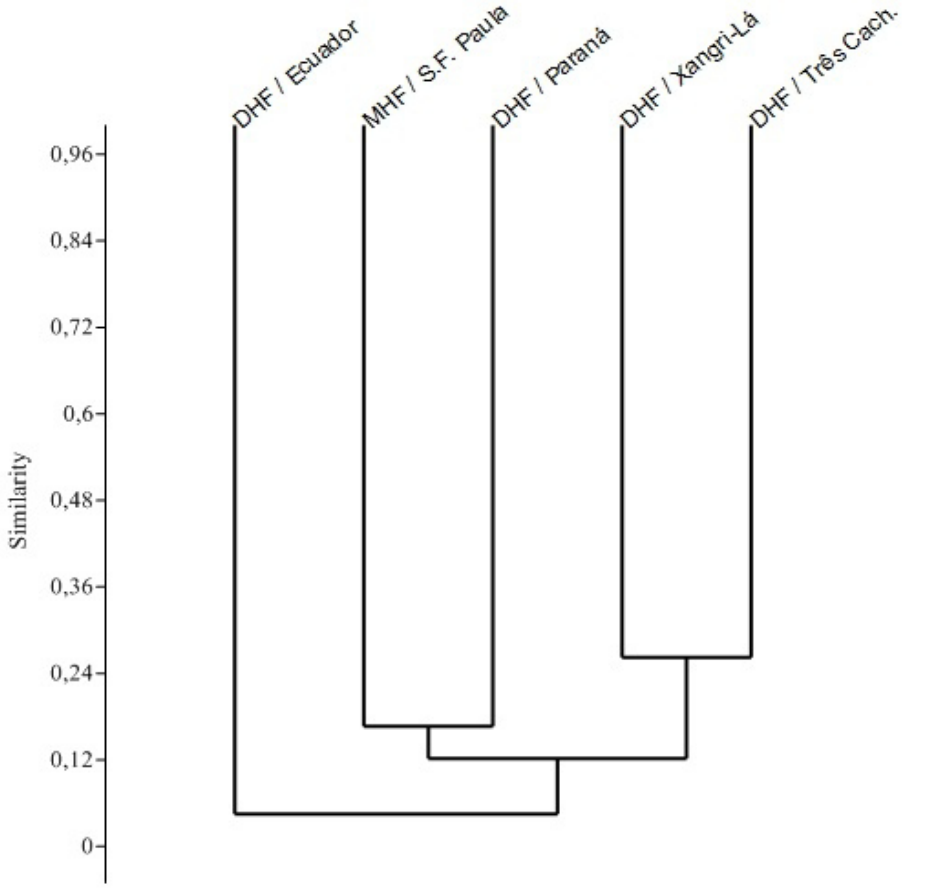

Figure 1 – Dendrogram of floristic similarity among surveys including ferns in areas ca. 1ha. Ecuador by Poulsen and Nielsen (1995), São Francisco de Paula by Blume *et al*. (2010), Paraná by Dittrich *et al*. (2005), Xangri-Lá by Athayde-Filho and Windisch (2006); DHF-Dense Humid Forest; MHD-Mixed Humid forest

This study shows that small remnants can significantly contribute to conservation of ferns. The small 6 ha fragment supports 10 % of the richness of ferns in Rio Grande do Sul, including the endangered species *Cyathea corcovadensis*, whose range is very limited in the state. The current state of conservation of the Atlantic Forest and how its remaining fragments are distributed, combined with the diversity and endemism rate of ferns in this biome, renders areas such as this study site particularly important for conservation of biodiversity. The comparison of surveys in plots equivalent to 1 ha suggests that rainfall and environmental variation are key drivers of ferns richness, and the arrangement of species can be determined by geographical and ecological aspects. We recommended the inclusion ferns, besides trees, when assessing the alpha diversity for conservation proposals of Atlantic Forest remnants.

Acknowledgment

The authors wish to thank Claiton Luis Mosmann for the assistance in the field work and Dr. Maria Angélica Kieling-Rubio for solving taxonomic issues in *Thelypteris* and *Elaphoglossum*.

References

ATHAYDE-FILHO, F.P. & WINDISCH, P.G. 2006. Florística e aspectos ecológicos das pteridófitas em uma floresta de Restinga no estado do Rio Grande do Sul, Brasil. *Iheringia Série Botânica* 61: 63-71.

BECKER, D.F.P.; CUNHA, S.; GOETZ, M.N.B.; KIELING-RUBIO, M.A. & SCHMITT, J.L. 2013. Florística de samambaias e licófitas em fragmento florestal da Bacia Hidrográfica do Rio dos Sinos, Caraá, RS, Brasil. *Pesquisas, Botânica* 64: 273-284.

BENZING, D.H. 1990. *Vascular epiphytes*. Cambridge: Cambridge University Press.

BLUME, M.; FLECK, R. & SCHMITT, J.L. 2010. Riqueza e composição de filicíneas e licófitas em um hectare de Floresta Ombrófila Mista no Rio Grande do Sul, Brasil. *Revista Brasileira de Biociências*, Porto Alegre 8(4): 336-341.

CAPELATTI, L. & SCHMITT, J. L. 2015. Spatial distribution and population structure of palms (arecaceae) in a forest fragment of lowland dense humid forest in south Brazil. *Ciência Florestal* 25: 817-825.

DE LA SOTA, E.R.El 1971. epifitismo y las pteridofitas en Costa Rica (America Central). *Nova Hedwigia* 21: 401-465.

DITTRICH, V.A.; WAECHTER, J.L. & SALINO, A. 2005. Species richness of pteridophytes in a montane Atlantic rain forest plot of Southern Brazil. *Acta Botanica Brasilica* 19: 519-525.

FERNANDES, I. 2003. Taxonomia dos representantes de Cyatheaceae do nordeste oriental do Brasil. *Pesquisas, Botânica* 53(1): 7-53.

FIGUEIREDO, J. B. & SALINO, A. 2005. Pteridófitas de quatro Reservas Particulares do Patrimônio Natural ao Sul da Região Metropolitana de Belo Horizonte, Minas Gerais, Brasil. *Lundiana* 6(2): 83-94.

FRAGA, L.L.; SILVA, L.B. & SCHMITT, J.L. 2008. Composição e distribuição vertical de pteridófitas epifíticas sobre *Dicksonia sellowiana* Hook. (Dicksoniaceae), em floresta ombrófila mista no sul do Brasil. *Biota Neotroprica* 8(4): 123-129.

FUNDAÇÃO SOS MATA ATLÂNTICA & INPE - INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS. 2014. *Atlas dos remanescentes florestais da Mata Atlântica - período 2012-2013. Relatório técnico*. São Paulo: Sosma/INPE.

GALEANO, G.; SUÁREZ, S. & BALSLEV, H. 1998. Vascular plant species count in a wet forest in the Chocó area on the Pacific coast of Colombia. *Biodiversity and Conservation* 7: 1563-1575.

GOETZ, M.N.B.; FRAGA, L.L. & SCHMITT, J.L. 2012. Florística e aspectos ecológicos de samambaias e licófitas em um parque urbano do Rio Grande do Sul, Brasil. *Pesquisas, Botânica* 63:: 165-176.

GONZATTI, F.; MACHADO, L. & WINDISCH, P. G. 2016. Distribution patterns of ferns and lycophytes in the Coastal Region of the state of Rio Grande do Sul, Brazil. *Acta Botanica Brasilica* 30: 239-253.

HAMMER, Ø.; HARPER, D.A.T. & RYAN, D.P.D. 2001. PAST: Paleontological Statistics Software Package for Education and Data Analysis. *Palaeontologia Electronica* 4(1): 1-9.

KESSLER, M.; KLUGE, J.; HEMP, A. & OHLEMÜLLER, R. 2011. A global comparative analysis of elevational species richness patterns of ferns. *Global Ecology and Biogeography* 20: 868–880.

KORNAŚ, J. 1977. Life-forms and seasonal patterns in the pteridophytes in Zambia. *Acta Societatis Botanicorum Poloniae* 46(4): 669-690.

LEHNERT, M. & WEIGAND, A. 2013. A proposal to distinguish several taxa in the Brazilian tree fern *Cyathea corcovadensis* (Cyatheaceae). *Phytotaxa* 155: 35-49.

LWANGA, J.S.; BALMFORD A. & BADAZA R. 1998. Assessing fern diversity: relative species richness and its environmental correlates in Uganda. *Biodiversity and Conservation* 7: 1387-1398.

MUELLER-DOMBOIS, D. and ELLENBERG, H. 1974. *Aims and methods of vegetation ecology*. New York: Wiley International.

MYERS, N.; MITTERMEIER, R.A.; MITTERMEIER, C.G.; FONSECA, G.A.B. & KENT, J. 2000. Biodiversity hotspots for conservation priorities. *Nature* 403: 853-858.

NEUMANN, M.C.; SCHNEIDER, P. H. & SCHMITT J. L. 2014. Phenology, caudex growth and age estimation of *Cyathea corcovadensis* (Raddi) Domin (Cyatheaceae) in a subtropical forest in southern Brazil. *Acta Botanica Brasilica* 28: 274-280.

NIEDER, J.; IBISCH, P. L. & BARTHLOTT, W. 1996-97. Biodiversidad de epífitas: una cuestión de escala. *Revista del Jardín Botánico Nacional* 17/18: 59-62.

OTTO, E.M.; JANβEN, T.; KREIER H.P. & SCHNEIDER, H. 2009. New insights into the phylogeny of *Pleopeltis* and related Neotropical genera (Polypodiaceae, Polypodiopsida). *Molecular Phylogenetics and Evolution* 53: 190-201.

PACIENCIA, M.L.B. & PRADO, J. 2004. Efeitos de borda sobre a comunidade de pteridófitas na Mata Atlântica da região de Una, sul da Bahia, Brasil. *Revista Brasileira de Botânica* 24(4): 641-653.

PEEL M.C; FINLAYSON B.L. & MCMAHON T.A. 2007.Updated world map of the Köppen– Geiger climate classification. *Hydrology and Earth System Science* 15(5): 1633-1644.

PEREIRA-NORONHA, M.R. 1989. *Formas de vida e reprodução em pteridófitas*. Tese (Doutorado em Biologia). UNESP, Rio Claro.

POULSEN, A.D. & NIELSEN, I.H. 1995: How many ferns are there in one hectare of tropical rain forest? *American Fern Journal* 85(1): 29-35.

PRADO, J. 2003. Revisões e monografias como base para a análise da diversidade, o quanto conhecemos sobre nossa flora. In: JARDIM, M.A.G.; BASTOS, M.N.C.; SANTOS, J.U.M. (Eds.). *Desafios da Botânica Brasileira no Novo Milênio: Inventário, Sistematização e Conservação da Diversidade Vegetal*. Belém: MPEG, UFBRA; EMBRAPA, Brasil/Museu Paraense Emílio Goeldi.

PRADO, J. & SYLVESTRE, L. 2016. *Samambaias e Licófitas in Flora do Brasil 2020 em construção*. Jardim Botânico do Rio de Janeiro. Disponível em: http://floradobrasil.jbrj.gov.br/reflora/floradobrasil/FB128483. Acesso em: 15 Abr. 2016.

RAUNKIAER, C. 1934. *The life forms of plants and statistical plant geography*. London: Oxford University Press.

RIBEIRO, M. C.; METZGER, J. P.; MARTENSEN, A. C.; PONZONI, F. J. & HIROTA, M. M. 2009. The Brazilian Atlantic Forest: How much is left, and how is the remaining forest distributed? Implications for conservation. *Biological Conservation* 142: 1141–1153.

RIBEIRO, M. C.; MARTENSEN, A. C.; METZGER, J. P.; TABARELLI, M.; SCARANO, F. & FORTIN, M. J. 2011. The Brazilian Atlantic Forest: A Shrinking Biodiversity Hotspot. In: ZACHOS, F.E. & HABEL, J.C. (eds.). *Biodiversity Hotspots*. p. 20-32.

RICHARD, M.; BERNHARDT, T.; & BELL, G. 2000. Environmental heterogeneity and the spatial structure of fern species diversity in one hectare of old-growth forest. *Ecography* 23: 231–245.

RIO GRANDE DO SUL. 2014. Decreto Estadual nº 52.109, de 01 de dezembro de 2014. Declara as espécies da flora nativa ameaçadas de extinção do Estado do Rio Grande do Sul. Diário Oficial [do] Estado, Porto Alegre, RS, n. 223, 02 dez. 2014.

ROBERTS, N.R.; DALTON, P.J. & JORDAN, G.J. 2005. Epiphytic ferns and bryophytes of Tasmanian tree-ferns: A comparison of diversity and composition between two host species. *Austral Ecology* 30: 146-154.

SANTIAGO, A. C. P. & BARROS, I. C. L. 2003. Pteridoflora do refúgio ecológico Charles Darwin (Igarassu, Pernambuco, Brasil). *Acta Botanica Brasilica*. 17(4): 597-604.

SANTOS, A.C.C. & WINDISCH, P.G. 2008. Análise da Pteridoflora da Área de Proteção Ambiental do Morro da Borússia (Osório-RS). *Pesquisas Botânica* 59: 237-252.

SCHWARTSBURD, P. B. & LABIAK, P. H. 2007. Pteridófitas do Parque Estadual de Vila Velha, Ponta Grossa, Paraná, Brasil. *Hoehnea* 34(2): 159-209.

SCHMITT, J.L.; BUDKE, J.C. & WINDISCH, P G. 2005. Aspectos florísticos e ecológicos de pteridófitas epifíticas em cáudices de *Dicksonia sellowiana* hook. (Pteridophyta, Dicksoniaceae), São Francisco de Paula, RS, Brasil. *Pesquisas, Botânica* 56:161-172.

SCHMITT, J.L.; FLECK, R.; BURMEISTER, E.L. & RUBIO, M.A.K. 2006. Diversidade e formas biológicas de pteridófitas da Floresta Nacional de Canela, Rio Grande do Sul: contribuições para o plano de manejo. *Pesquisas, Botânica* 57: 275-288.

SCHNEIDER, H.; SCHUETTPELZ, E.; PRYER, K.M.; CRANFILL, R.; MAGALLÓN, S. & LUPIA, R. 2004a. Ferns diversified in the shadow of angiosperm. *Nature* 428: 553-557.

SCHNEIDER, H.; JANβEN, T.; HOVENKAMP, P.; SMITH, A. R.; CRANFILL, R.; HAUFLER, C. H. & RANKER, T. A. 2004b. Phylogenetic relationships of the enigmatic Malesian fern *Thylacopteris* (Polypodiaceae, Polypodiidae). *International Journal of Plant Sciences* 165: 1077-1087.

SEHNEM, A. 1979. Semelhanças e diferenças nas formações florestais do Sul do Brasil. *Acta Biologica Leopoldensia* 1:111-135.

SENNA, R.M. & WAECHTER, J.L. 1997. Pteridófitas de uma Floresta de Araucária. 1. Formas Biológicas e padrões de distribuição geográfica. *Iheringia Série Botânica* 48: 41-58.

SMITH, A. R. 1992. Thelypteridaceae. In: R. M. Tryon & R. G. Stolze. Pteridophyta of Peru. Part III. 16. Thelypteridaceae. *Fieldiana Botany* 29: 1-80.

SMITH, A. R.; PRYER, M. K.; SCHUETTPELZ, E.; KORALL, P.; SCHNEIDER, H. & WOLF, P. G. 2006. A classification for extant ferns. *Taxo*n 55: 705–731.

SOUZA, M. C.; KAWAKITA, K.; SLUSARSKI, S. R. & PEREIRA, G. F. 2009. Vascular flora of the Upper Paraná River floodplain. *Brazilian Journal of Biology* 69: 735-745.

STEHMANN, J. R; FORZZA, R. C.; SALINO, A.; SOBRAL, M.; COSTA, D. P. & KAMINO, L. H. Y. (eds.) 2009. *Plantas da Floresta* Atlântica. p. 515.

TEIXEIRA, M.B.; COURA-NETO, A.B.; PASTORE, U. & RANGEL-FILHO, A.L.R. 1986. Vegetação. In: *Levantamento de recursos naturais*. Rio de Janeiro: IBGE 33: 541-620.

TRYON, R.M. 1985. Fern speciacion and biogeography. In: DYER, AF.; PAGE, CN. (Ed.). *Biology of pteridophyte*. The Royal Society of Edimburg.

WINDISCH, P.G. 1992. *Pteridófitas da Região Norte-Ocidental do Estado de São Paulo - Guia para excursões*. 2ª ed. São José, do Rio Preto: UNESP.

WINDISCH, P.G. & SANTIAGO, A.C.P. 2015. *Cyatheaceae* in Lista de Espécies da Flora do Brasil. Jardim Botânico do Rio de Janeiro. Disponível em: <http://floradobrasil.jbrj.gov.br/jabot/floradobrasil/FB90866>. Acesso em 21 setembro 2015.