Edge effects on fern community in an Atlantic Forest remnant of Rio Formoso, PE, Brazil

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(With 3 figures)

Abstract

We have investigated how edge effects influence the fern community of Jaguarão Forest (08º 35' 49" S and 35º 15' 39" W), located in the district of Rio Formoso, Pernambuco, Brazil. A comparative analysis was made of the interior and edge of the fragment of forest, regarding the richness, abundance and diversity of ferns in the two areas. Six plots of 10 × 20 m were chosen, three in each area. A total of 381 ferns were recorded, which were distributed among 25 species, 17 genera and 12 families. The two areas (edge and interior) were found to differ, with distinct relative air humidities and temperatures ($p = 0.00254$ and $p = 0.00019$, respectively). The interior showed higher diversity ($t = 7.251$ and $p = 0.018$) and richness ($t = 6.379$ and $p = 0.023$) than the edge area, but the same abundance ($t = 1.728$; $p = 0.226$) as the edge. Regarding the composition of the flora, it was clear that the interior is a habitat completely distinct from the edge with regard to the fern community, given that only one species, *Adiantum petiolatum* Desv.*,* was common to both environments. It was concluded that the edge effect causes a decrease in richness and abundance of the fern species found in Jaguarão Forest, where the more sensitive species are being replaced by species that are tolerant to the disturbance caused by the creation of an edge.

Keywords: ferns, edge effects, fragmentation, species extinction, diversity, ecology.

Efeitos de borda na comunidade de samambaias em um remanescente de Floresta Atlântica de Rio Formoso, PE, Brasil

Resumo

Este trabalho verificou como os efeitos de borda influenciam as comunidades de pteridófitas presentes na Mata do Jaguarão (08º 35' 49" S e 35º 15' 39" W), município de Rio Formoso, Pernambuco. O estudo foi feito através de análise comparativa entre os ambientes de interior e de borda. Para verificar a riqueza, abundância e diversidade das pteridófitas nos dois ambientes, foram estabelecidas seis parcelas de 10 × 20 m (200 m^2), sendo três para cada ambiente. Foram contabilizados 381 indivíduos de pteridófitas, distribuídos em 25 espécies, 17 gêneros e 12 famílias. Os dois ambientes (interior e borda) caracterizaram-se diferentes entre si, com umidade relativa do ar e temperatura distintas ($p = 0{,}00254$ e $p = 0{,}00019$, respectivamente). O ambiente de interior apresentou maior diversidade ($t = 7{,}251$ e $p = 0{,}018$) e riqueza ($t = 6{,}379$ e $p = 0{,}023$) que o ambiente de borda, de acordo com o teste estatístico empregado (teste t pareado). A abundância, por outro lado, foi a mesma em interiores e bordas do fragmento ($t = 1{,}728$ e $p = 0{,}226$). Quanto à composição florística, ficou claro que o interior do fragmento estudado constitui um ambiente totalmente distinto da borda, no que se refere à comunidade pteridofítica, com apenas uma espécie comum aos dois ambientes, *Adiantum petiolatum* Desv. Assim, o presente estudo constatou que o efeito de borda causa diminuição na riqueza e abundancia das espécies de pteridófitas ocorrentes na Mata do Jaguarão, com a existência de substituição das espécies mais sensíveis pelas espécies tolerantes aos impactos causados por esse efeito.

Palavras-chave: pteridófitas, efeito de borda, fragmentação, extinção de espécies, diversidade, ecologia.

1. Introduction

Forests that have undergone recent fragmentation are strongly influenced by edge effects, which comprise ecological changes associated with the abrupt creation of artificial edges in forest fragments (Matlack, 1993, 1994; Murcia, 1995). Light incidence and wind speed are higher in the forest edge because the protective barriers formed by contiguous trees are eliminated, so that solar radiation and warm and dry winds are allowed to penetrate from the matrix surrounding the fragments. As a consequence, the forest microclimate is altered (Laurance, 1991; Primack and Rodrigues, 2001; Tonhasca Jr., 2005).

During recent decades, the Atlantic Forest has almost entirely been destroyed in favor of sugar cane, coffee and cacao production, reducing it to 7% or 8% of its original vegetation distributed in many fragments. The few remnants of the Atlantic Forest that currently exist, in addition to other conservation hotspots in the world, shelter more than 60% of all terrestrial species on the planet, even though they occupy less than 2% of its land surface (Myers, 1986; Galindo-Leal and Câmara, 2005).

Some studies highlight the climatic data (rainfall, relative air humidity and relative air temperature) as variables that influence fern species richness in a given environment and as determining factors for the occurrence of the group (Diéz Garretas and Salvo, 1981; Sota, 1971).

Anthropic action in forest environments and its resulting fragmentation cause changes in these determining factors through edge effects, which lead to the differentiation of edge vegetation from forest interior vegetation. Ferns reproduce independently of pollinators and dispersers, which means that effects influencing their diversity and colonizing ability can be directly attributed to environmental abiotic factors. Hence, the fern community is technically relevant for the study of edge effects.

There are a few studies in which the effects of habitat fragmentation on fern species have been investigated, such as Paciência and Prado (2004, 2005a, b) and Barros et al. (2006). It is estimated that there is a total of 13,600 ferns species in the world (Kramer and Green, 1990; Moran, 2008), among which around 3,500 species occur in the Americas (Moran, 2008). Approximately 30% of these species can be found in Brazil, which is home to centers of fern endemism and speciation for the Continent (Windisch, 1990).

The objective of the present study was to analyze edge effects on the composition, species richness, diversity and abundance of the fern community in an Atlantic Forest fragment. Other objectives included the description of ecological aspects of the species found and the identification of species rare in the region. Information about the effects of fragmentation in the process of distribution and establishment of species is indispensable for the planning of conservation efforts to manage and reestablish biological diversity in this ecosystem. Moreover, studies of this kind can indicate relevant areas for environmental preservation.

2. Material and Methods

2.1. Study site and forest composition

The study was carried out in a fragment of the Jaguarão Forest (8º 35' 49" S by 35º 15' 39" W), located in the district of Rio Formoso, State of Pernambuco, Brazil (Figure 1). The municipality is part of Pernambuco's Forest Mesoregion and Meridian Microregion, situated in the forest 91 km south of the city of Recife (IBGE, 2002).

The forest fragment is the property of the Cucaú Sugar Mill, in the rural part of Rio Formoso (16 km from its urban center and 98 km from Recife). It is a remnant of the Atlantic Rain Forest of approximately 700 ha, surrounded by sugarcane fields, showing signs of the use of its resources and forming a heterogeneous forest with various types of vegetation, composed of an extensive area of 'capoeira' (secondary growth), pioneer vegetation and late-succession forests.

The average annual rainfall and temperature in the locality are 1,798 mm and 25.2 °C, respectively (ITEP/LAMEPE, 2007). The climate is hot and humid, with one to two months of drought. By Köppen's classification, the climate is type Am with transition to type A, characterized by the absence of a defined dry season and by the annual rainfall above 1,300 mm. The vegetation type is dense ombrophilous (rain) forest, situated on a relief characterized by coastal lowland covered with Pleistocene "tabuleiros" (small, low plateaus) of the Barreiras Group. The elevation in the region seldom exceeds 100 m (FIBGE, 1985, 1992, 1995).

2.2. Field work

A total of seven visits were made to the study site between August 2006 and August 2007, during rainy and dry seasons. The first two visits were carried out to recognize the area and define sites for study plots; another visit was used to mark study plots; all other visits had the purpose of data collection.

To mark the plots, the fragment was transited to record interior and adjacent edge sites (paired data) that contained the greatest diversity of species of ferns, employing a method defined by Barros et al. (2006). The total number of sites found was six (three interior and three edge). The edge starting point was considered to be where the transect made contact with the matrix, and the ending point was 40 m from there into the fragment, following specialized literature (Paciência and Prado, 2004).

A total of six 10 × 20 m (200 m^2) plots were demarcated, three situated in the edge zone and three in the interior. Each plot was surveyed and the number of ferns of each species found was counted, including epiphytes that could be collected with no technical climbing effort.

The temperature and relative air humidity was measured in each plot through the use of a thermo hygrometer, to detect possible relationships between these abiotic factors and the abundance, richness, and composition of fern species.

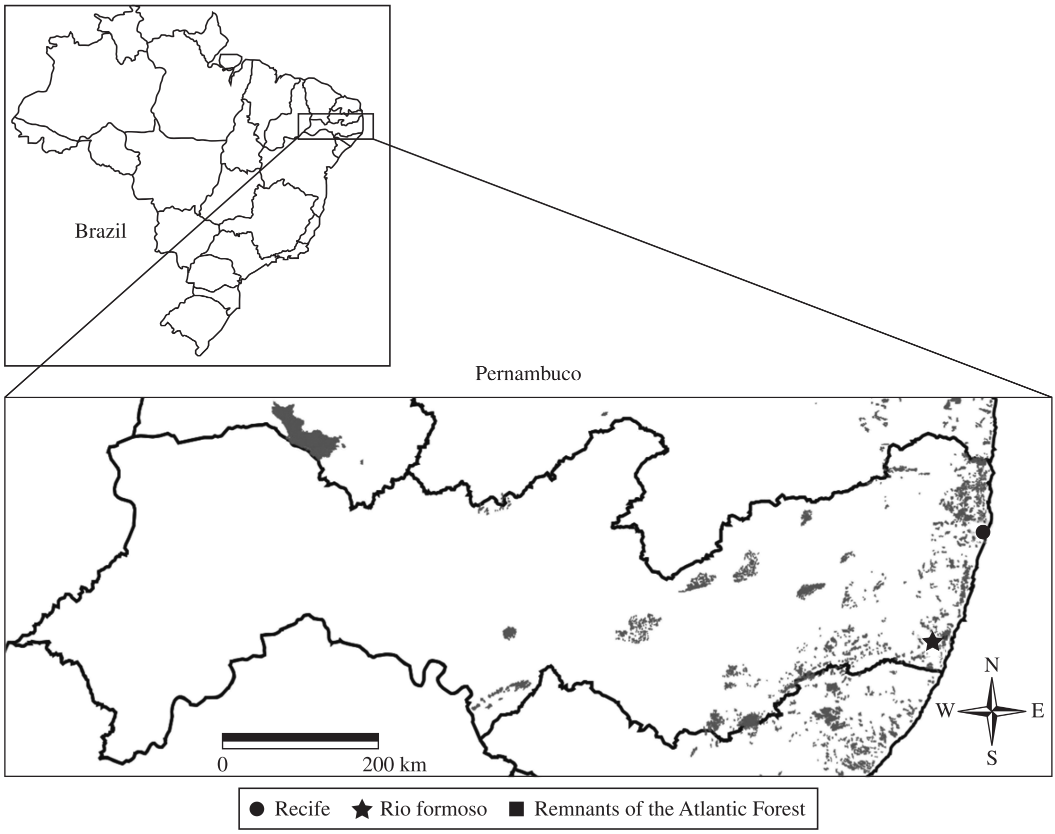

Figure 1. Location map of the municipal district of Rio Formoso, Pernambuco, Brazil.

Data collection, as described above, was performed during the rainy and dry seasons, with the addition of species or individuals that were not recorded before.

2.3. Ecological features

The ecological features analysed were: the life forms, habits, types of habitat and seasonal patterns. For this purpose, we collected information about the microhabitats of occurrence of each species, by the methods of Ambrósio and Barros (1997) with some modifications, using field notebooks. The classification of life forms followed Raunkiaer (1934), utilized and adapted to fern species by Mueller-Dombois and Ellemberg (1974) and Dzwonko and Kornás (1978). The classification of habits followed Mori et al. (1989). With respect to habitat, the species were classified according to their substrate, following the studies of Andrade-Lima (1972) and Salvo and Garcia Verdugo (1990) and the seasonal pattern classification followed Barros (1997).

2.4. Species identification and herborization

Samples were collected and herborized following the standard methodology for vascular plants (Mori et al., 1989).

Species were identified with the help of specialized literature such as Sehnem (1968); Tryon and Tryon (1982); Smith (1983); Proctor (1985); Mickel and Beitel (1988) and Tryon and Stolze (1989a, b, 1991, 1992, 1993).

The list of taxons was organized in alphabetic order by family, genus, species and variety. The arrangement of families and genera followed Smith et al. (2006), and the names of authors were abbreviated as in Pichi-Sermolli (1996). The core species material was deposited in the UFP herbarium (Holmgreen et al., 1990).

2.5. Rare species

Rare species followed the criteria established by Santiago and Barros (2002), who defined fern species not easily found in the State of Pernambuco as species that are documented in fewer than three administrative districts or whose occurrence depends upon the size of the collection sites.

2.6. Data analysis

The diversity of fern species was calculated for each plot through the Shannon H' (base 10) index, with the Ecological Methodology program (Krebs, 1989). To detect differences between the relative air humidity and relative air temperature at two sites (interior and edge) a paired-sample t-test was run in the Statistica 7.0 program (StatSoft Inc., 2002).

The paired t-test was also used to compare the richness, diversity and abundance of species at different sites (interior and edge).

Floristic similarity was analysed by cluster analysis, carried out with Primer Software (Clarke and Gorley, 2001), to reveal the formation of groups among fern communities.

In all analyses, differences were considered significant when $p \leq 0.05$.

3. Results

3.1. Floristics, ecological features and seasonal patterns

The floristic inventory of demarcated plots documented the occurrence of 25 fern species, distributed in 17 genera and 12 families (Table 1), all of the species belonging to the Division Monilophyta.

Saccoloma elegans, Olfersia cervina and *Thelypteris jamesonii* were three newly documented species for the Jaguarão Forest, whose floristic inventory was carried out by Silva (2007). *Thelypteris jamesonii* is highlighted as a newly documented species for the State of Pernambuco.

With regard to ecological characteristics, the majority of the species had a hemicryptophyte life-form, herbaceous habit and terricolous habitat (Table 1). Regarding seasonal patterns, most of the species were evergreen, with three active species during the rainy season, *Danaea elliptica, Pteridium arachnoideum* and *Salpichlaena volubilis*, and only one poikilohydric species, *Trichomanes pinnatum* (Table 1).

3.2. Rare species

Among species found in the present study, six were considered to be rare: *Alsophila sternbergii, Diplazium plantaginifolium, Olfersia cervina*, *Thelypteris biolleyi, Thelypteris jamesonii* and *Hemidictyum marginatum.* The first three and the last three (?) were classified by Santiago (2006) as vulnerable and critically endangered, respectively.

3.3. Richness, diversity and abundance

The interior and edge sites showed differences in relation to air temperature and relative air humidity ($t = -4.913$; $p = 0.039$ and $t = -11.000$; $p = 0.008$, respectively). The forest interior showed a lower mean temperature (27.5 °C) and higher mean relative humidity (79%) than the edge (31.3 °C and 69%).

In the interior of the fragment, 18 species were observed in the demarcated plots, while the edge plots contained only eight of the documented species. Regarding diversity, plots located inside the forest exhibited higher Shannon H' diversity indices than plots at the edge, the values being 1.013 for the forest interior and 0.587 for the edge. The application of a *t*-test showed significant differences in diversity ($t = 7,251$; $p = 0.018$) and richness ($t = 6.379$; $p = 0.023$) between the environments (Figure 2).

Concerning species abundance, 259 individuals were found in the forest interior and 122 in the edge zone. However, the *t*-test showed no difference in species abundance between the two zones under study ($t = 1.728$; $p = 0.226$) (Figure 2).

3.4. Floristic similarity

From all fern species found in this study, only *Adiantum petiolatum* was common to both studied environments, which makes the difference in floristic composition between the forest edge and the interior quite evident. The results of the floristic similarity analysis revealed two well-defined groups, one comprising the edge zone ferns and the other including the interior zone ferns, determining typical communities for each habitat (Figure 3 and Table 1).

4. Discussion

4.1. Floristic and ecological characteristics and seasonal patterns

The number of species documented through the methods used in this study was substantial and can be compared to other ecological studies in which plots or transects are applied to fern research, as in the studies of Young and León (1989), Paciência and Prado (2004, 2005a, b), Rodrigues et al. (2004) and Barros et al. (2005, 2006).

Thelypteris jamesonii was a newly documented species for the State of Pernambuco, with previous documentation for the State of Alagoas, according to Santiago (2006) who studied ferns of the Atlantic Forest located north of the São Francisco River. The Jaguarão Forest is located on the Atlantic coast in the south of Pernambuco, near the border with the State of Alagoas; thus the vegetation complex formed by remnant fragments of the Atlantic Forest surviving in this region could have been part of one continuous forest with another, larger, forest ("Mata Maria Maior"), where the same species was collected (Pietrobom and Barros, 2006).

Some consequences of forest fragmentation are habitat loss and isolation of fragments. Local diversity deteriorates because loss and isolation of habitable areas leads to species extinction, short and long-term respectively (Pires et al., 2006). Therefore, many species become rare when communities are affected by habitat loss, and the remaining species are restricted to separate fragments and suffer the effects of isolation.

Regarding ecological features, the majority of the species exhibited the hemicryptophyte life-form, herbaceous habit and terricolous habitat, which are common among this plant group. This frequent profile is confirmed in the majority of the fern studies conducted in the State of Pernambuco (Santiago et al., 2004; Xavier and Barros, 2003, 2005; Barros et al., 2006). The seasonal patterns observed in species analyzed in this study corroborate the data reported by Barros (1997) and Kornás (1977), in which the majority of fern species studied were evergreen.

4.2. Rare species

Among the species considered rare in the present study, *Hemidictyum marginatum* is highlighted because its last collection in Pernambuco happened approximately 30 years

Table 1. Species richness, abundance, and ecological features of the ferns inventoried in Jaguarão Forest (Rio Formoso, Pernambuco, Brazil). Habit: HEB = herbaceous; ARB = arbustive; ARE = erect arbustive; ARS = scandent arbustive; ARA = arboreous. Seasonal Patterns: PE = Evergreen plants; PAR = plants active in rainy seasons; PPK = poikilohydric plants. *newly documented species for the Jaguarão Forest; ●newly documented species for the State of Pernambuco. FI= Forest Interior; FE = Forest Edge.

Family	Species	Site of occurrence (species abundance)		Life form	Habitat	Habit	Seasonal patterns
		FI	FE				
Blechnaceae	*Salpichlaena volubilis* (Kaulf.) J. Sm.	1	-	Hemicryptophyte	Terricolous	HEB	PAR
Cyatheaceae	*Alsophila sternbergii* (Sternb.) D.S. Conant	17	-	Phanerophyte	Terricolous	ARA	PE
	Cyathea praecincta (Kunze) Domin	32	-	Phanerophyte	Terricolous	ARA	PE
Dennstaedtiaceae	*Pteridium arachnoideum* (Kaulf.) Maxon	-	46	Geophyte	Terricolous	ARE	PAR
Dryopteridaceae	*Cyclodium heterodon* (Schrad.)	-	15	Hemicryptophyte	Terricolous	HEB	PE
	Cyclodium meniscioides (Wild) C. Presl	7	-	Hemicryptophyte	Terricolous	HEB	PE
	Olfersia cervina (L.) Kunze*	2	-	Hemicryptophyte	Terricolous	HEB	PE
	Polybotrya cilindrica Kaulf.	6	-	Hemiepiphyte	Hemicorticicolous	ARS	PE
Hymenophyllaceae	*Trichomanes pinnatum* Hedw.	-	5	Hemicryptophyte	Terricolous	HEB	PPK
Lygodiaceae	*Lygodium volubile* Sw.	-	3	Hemicryptophyte	Terricolous	ARS	PE
Marattiaceae	*Danaea elliptica* Sm.	69	-	Hemicryptophyte	Terricolous	HEB	PAR
Pteridaceae	*Adiantum dolosum* Kunze	-	6	Hemicryptophyte	Terricolous	HEB	PE
	Adiantum obliquum Willd.	1	-	Hemicryptophyte	Terricolous	HEB	PE
	Adiantum petiolatum Desv.	1	2	Hemicryptophyte	Terricolous	HEB	PE
Saccolomataceae	*Saccoloma elegans* Kaulf.*	4	-	Hemicryptophyte	Terricolous	HEB	PE
Tectariaceae	*Tectaria incisa* Cav.	8	-	Hemicryptophyte	Terricolous	HEB	PE
	Triplophylum funestum (Kunze) Holttum	-	10	Hemicryptophyte	Terricolous	HEB	PE
Thelypteridaceae	*Thelypteris biolleyi* (Christ) Proctor	3	-	Hemicryptophyte	Terricolous	HEB	PE
	Thelypteris hispidula (Decne.) C.F. Reed.	-	35	Hemicryptophyte	Terricolous	HEB	PE
	Thelypteris jamesonii (Hook.) R.M. Tryon*●	40	-	Hemicryptophyte	Terricolous	HEB	PE
	Thelypteris macrophylla (Kunze) C.V. Morton	16	-	Geophyte	Terricolous	ARB	PE
	Thelypteris sp.	11	-	Hemicryptophyte	Terricolous	HEB	PE
Woodsiaceae	*Diplazium cristatum* (Desv.) Aslton	2	-	Hemicryptophyte	Terricolous	HEB	PE
	Diplazium plantaginifolium (L.) Urb.	13	-	Hemicryptophyte	Terricolous	HEB	PE
	Hemidictyum marginatum (L.) C. Presl	15	-	Hemicryptophyte	Terricolous	ARE	PE

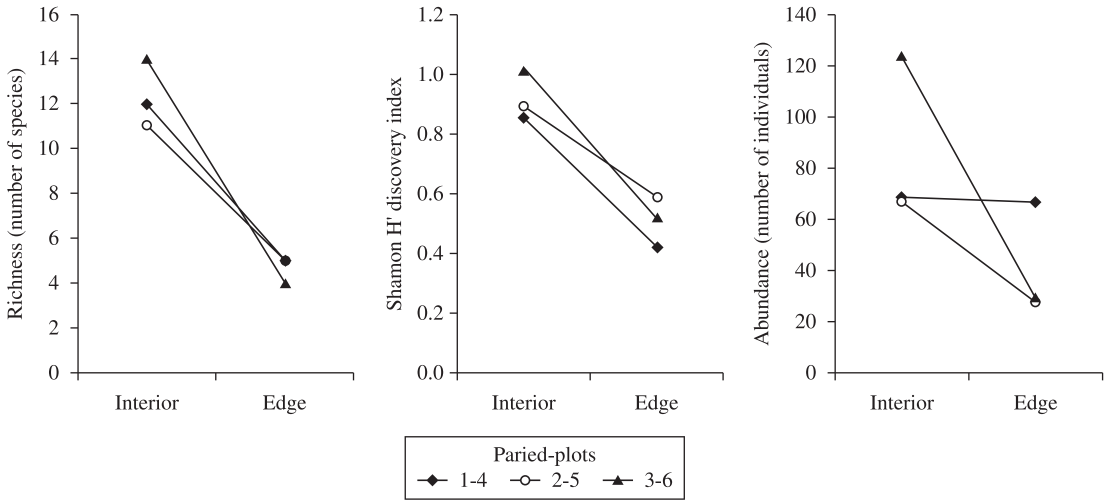

Figure 2. Differences in richness (t = 6.379 and p = 0.023), diversity (t = 7,251 and p = 0.018) and abundance (t = 1.728 and p = 0.226) between the studied interior and edge areas of the Jaguarão Forest, Rio Formoso, Pernambuco, Brazil.

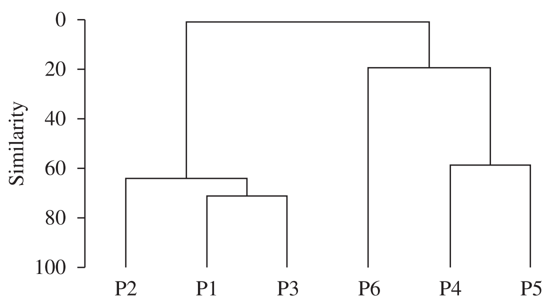

Figure 3. Result of cluster analysis based on the pairing of plots (P1-P4, P2-P5 and P3-P6), showing the formation of two distinct groups, where P1, P2 and P3 refer to plot areas located at the forest edge, and P4, P5 and P6 to plots in the interior of the Jaguarão Forest, Rio Formoso, Pernambuco, Brazil.

ago, only documented for the Northeast Region of Brazil in the states of Pernambuco and Alagoas (Pietrobom, 2004). Santiago (2006) elaborated an inventory of endangered ferns and considered this cited species as probably extirpated from areas in the State of Pernambuco. *Thelypteris jamesonii* also deserves some attention as it is a newly recorded species for Pernambuco (according to Arantes et al. (2007) it also occurs in the States of Mato Grosso do Sul, Minas Gerais and São Paulo) and its distribution is restricted to South American rain forests alone (Ecuador, Peru, Bolivia, and Brazil).

The publication of endangered species inventories by state is highly appropriate, considering that in a country of continental dimensions like Brazil, the "sectoring" of these studies can facilitate conservation strategies (Santiago, 2006). Given that the Jaguarão Forest fragment is not currently under any evident environmental conservation policy, action in this sense is necessary, since the area is considered potentially vulnerable to species loss in fern communities.

4.3. Richness, diversity and abundance

The observed differences in temperature and relative air humidity in both habitats were expected, given that the studied edge areas were more exposed, having more open vegetation, enabling higher incidence of wind, light and external disturbances from the matrix (Murcia, 1995). In the edge zone, the lower relative air humidity may also be related to the slope of the land, given that most edges in the studied fragment were in rather steep areas, which would promote fast runoff, leading to less retention of water in the soil. Burke and Nol (1998), while studying edge effects in a deciduous forest in Ontario, found that the influence of such effects could extend up to 20 m away from the edge. Matlack (1993), during a similar study of a deciduous forest in Pennsylvania, observed that the relative air humidity influenced areas up to 50 m from the edge of the fragment.

The higher species richness found in the fragment interior agrees with the findings of Paciência and Prado (2004), who studied edge effects on ferns in various forest fragments in South Bahia, and observed that species richness increased towards the interior of the fragment. Studying bryophytes and lichens in a Canadian boreal forest, Gignac and Dale (2005) affirmed that distance from the edge and habitat heterogeneity are positively correlated, both being important in determining the species richness of both bryophytes and lichens. During the same study, these authors found edge distance to be important for species diversity of both bryophytes and lichens, where both groups were found to be more diverse the farther they were from the edge of the fragments studied. Paciência and Prado (2005b) found similar results for fern diversity, observing higher species diversity in the interior of the studied fragments, corroborating the present study.

Biological diversity accompanies environmental heterogeneity and availability of ecological niches, such that the more complex the habitat the higher will be its diversity (Ricklefs, 2001). The interior of the studied fragment exhibited a high diversity of microhabitats, with varying microenvironments (in terms of vegetation, soil types, luminosity, humidity, and other variables) and large water availability. On the other hand, the edge zone was characterized as a more homogeneous habitat with less water available. Therefore, the high diversity of ferns found in the fragment interior is probably associated with the features explained above.

The results regarding abundance disagree with the findings of Pereira (2007), who compared fern abundance in the interior and edge habitats of montane forests, observing significantly higher abundance of such species in the forest interior. Higher fern species abundance in the forest interior is also associated with the fact that these plants prefer humid, shaded environments with good water availability, conditions commonly found in the interior of a forest fragment. Fern species establish themselves in shaded and humid forest areas, which offer an appropriate microclimate for their sexual reproduction, since they use flagellated gametes for external fertilization (Pausas and Sáez, 2000). Although a higher abundance would be expected in the forest interior than at the edge, our results did not show such a difference, which may be explained by the environmental heterogeneity within each area.

It was found that, in both edge and interior environments, there were some species with large populations, while others were restricted to a few individuals, and some were represented in the plot by only one specimen. This can be attributed to the fact that some species have preferences regarding the environment they inhabit. As an example, *Pteridium arachnoideum* is a resistant pioneer species that prefers to occupy open areas with limited sources of water (Kornás, 1985; Silva-Matos and Belinato, 2010) and in this study it was found in large populations in the edge zone and did not occur in the interior of the fragment. On the other hand, species such as *Alsophila sternbergii, Cyathea* sp., *Danaea elliptica*, *Thelypteris jamesonii*, *Diplazium plantaginifolium,* and *Hemidictyum marginatum* are very demanding about shading and humidity, and are always associated with environments that are well preserved (Barros, 1997), being found in large abundance in the interior of the studied fragment.

The species *Cyclodium meniscioides* and *Polybotrya cilíndrica* were found in the interior of fragments in both this study and studies performed by Paciência and Prado (2004, 2005a, b) in which plots were used. Conversely, the species *Trichomanes pinnatum* was exclusively observed in the fragment edge, where the number of individuals was high, while only five individuals were documented in the plotted area. This species is poikilohydric, exhibiting plasticity to colonize environments with great water restrictions, being commonly found in edge areas in other related studies, as cited in Pietrobom and Barros (2003), Paciência and Prado (2004, 2005a, b).

4.4. Floristic similarity

Similar results were found in studies by Paciência and Prado (2004, 2005a), who observed that interior forest habitats possessed different communities from those found in the edge, which has an environment responsible for selecting species that are able to colonize it. All of the changes that occur in the edge act as selective factors for communities able to become established and utilize the edges as development areas, following the necessary adaptations for these species to succeed in occupying these ecotones (Willson and Crome, 1989; Malcolm, 1994).

Edge effects reduce the areas of original species occupation within the forest fragment (Gignac and Dale, 2005; Santos-Filho et al., 2008). As the fragment shrinks, it can reach a critical point where the entire fragment is dominated by edges, eliminating shade-tolerant species and decreasing local diversity (With and Crist, 1995; Moulton and Magalhães, 2003; Alho et al., 2002). Therefore, the increase of edge areas causes the replacement of species and can lead to the disappearance of other species, resulting in diversity loss and/or loss of characterization of the local native flora. The possible causes of floristic and structural differences (spatial distribution of populations for example) between the edge and interior of fragments can be clarified by the study of their microclimate conditions. Nevertheless, it seems that there is no clear pattern in which point microclimatic changes at the edges can be perceived inside the fragment (Kapos et al., 1997; Nascimento and Laurance, 2006).

5. Conclusion

The Jaguarão Forest is an important Atlantic Forest remnant with respect to fern species, containing rare species and also a new record for the State of Pernambuco.

The communities of ferns located in the forest interior are different from those found in the edge of the fragment. The edge functions as a selective environment of species able to colonize it, where individuals that are more adapted have greater chances of survival and succeed in reproducing. Furthermore, the proliferation of edges leads to a gradual replacement of species, impairing the local biodiversity.

Edge effects cause changes in the physical environment such as alterations of temperature and relative air humidity. During the present study, edge effects were observed to have a negative influence on richness, diversity and abundance of fern species, the forest edge showing a loss of species when compared to the interior environments.

The fragment interior provided better conditions for the development of the fern flora, offering higher water availability, more shading and higher microhabitat diversity.

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