Edge Effect on Orchids of a Fragment of Semi-Deciduous Seasonal Forest in the Southeast of Brazil

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ABSTRACT – The edge effect was evaluated in a semi-deciduous seasonal forest fragment of Araras, state of São Paulo, Brazil. The sampling took place in 20 parcels at 30 m from the edge and another 20 parcels at 100 m from the edge. The general shape of the forest fragment was evaluated by the calculation of the Circularity Index, and correlations were determined between biotic and abiotic factors to test for possible relationships. A total of 346 individuals, composing of nine species and nine genera, were identified. The diversity of orchids in the studied area is low, and the abundance of species in the fragment is not distributed evenly. The edge has more species and individuals, showing it to be more beneficial for the survival of orchids, especially when associated to the watercourse. This increase in the orchid population in the edge can be related to luminosity. However, the studied forest fragment has fewer orchid species than other, better conserved fragments of Semi-Deciduous Seasonal Forest.

Key words: diversity, epiphytes, forest fragmentation, terrestrial orchids

RESUMO – **Efeito de borda em orquídeas de um fragmento florestal estacional semidecidual do sudeste do Brasil.** O efeito de borda foi avaliado em fragmento de Floresta Estacional Semidecidual em Araras, São Paulo, Brasil. A amostragem foi realizada em 20 parcelas a 30 m da borda e outras 20 a 100 m da borda. O formato geral do fragmento florestal foi avaliado pelo cálculo do Índice de Circularidade, e correlações foram determinadas entre fatores bióticos e abióticos para teste de possíveis relações. Como resultado da amostragem, 346 indivíduos, pertencentes a nove espécies e nove gêneros foram identificados. A diversidade de orquídeas na área estudada é baixa e a abundância de espécies no fragmento não ocorre de forma equitativa. A borda apresentou mais espécie e indivíduos, se mostrando mais benéfica à sobrevivência de orquídeas, especialmente quando associadas ao curso d'água. Este aumento na população de orquídeas na borda pode ser relacionado com a luminosidade. Entretanto, o fragmento florestal estudado apresenta menos espécies de orquídeas do que outras áreas melhor conservadas com Floresta Estacional Semi-Decidual.

Palavras-chave: diversidade, epífitos, fragmentação florestal, orquídeas terrestres

INTRODUCTION

The Brazilian Atlantic Rainforest is reduced to 7.5% of its original coverage (Scarano 2002) and, although it is known that this biome contains a high diversity of species and is characterized for high levels of endemism, it is highly fragmented (Morellato & Haddad 2000).

The key factors that affect the dynamics of forest fragments are: shape, isolation degree, type of neighborhood, and disturbance history (Viana *et al.* 1992). These factors are related to biological phenomena which affect the birthrate and mortality of plants; for example, the edge effect, genetic drift, and plant/animal interactions (Viana & Pinheiro 1998). Forest fragmentation alters the structure of the fragment and the interaction of the fragment with other landscape elements (Lord & Norton 1990, Putz 2001), and it is mainly due to anthropic interaction. The edge effect, therefore, is one of its consequences (Ranta *et al.* 1998).

Edge effect can be defined as an alteration in the composition and/or in the relative abundance of species at the marginal part of a forest fragment (Forman & Gordon 1986), or as the influence that the environment exerts over the forest area on its marginal part, causing physical and structural alterations (Tabanez *et al.* 1997). It can also be defined as the outcome of the interaction between two adjacent ecosystems, when they are kept apart by an abrupt transition, i.e. the edge (Murcia 1995).

For fragmented habitats, the edge effect can be considered as one of the key factors that affect vegetal and animal populations (Laurance & Bierregaard 1997). In the forest community, the ligneous and herbaceous plants suffer qualitative and quantitative alterations, depending on the type and aspect of the edge (Marchand & Houle 2005).

According to Newman *et al.* (2007), orchids are an excellent biomonitor due to their sensitivity to anthropic interference in primary forests owing to the occupation of specialized niches. Such a suggestion is corroborated by the difficulty that innumerous species of orchids have been reproduce in secondary woods, which demonstrates the importance of studies involving these plants for the better comprehension of biodiversity mechanisms found in nature (Bawa 1992).

The family Orchidaceae is the most abundant family among the vascular epiphytes typical of tropical and humid subtropical forests, averaging 70% of the total number of plants within the group (Gentry & Dodson 1987). Furthermore, a great deal of the floristic diversity of humid tropical forests comes from the epiphytic species, given these represent approximately 10% of all vascular plants (Kress 1986). These species play a role in the mechanisms of nutrient recycling (Nadkarni 1984), as well as making water, shelter, nourishment, and reproduction sites available to other organisms, and may be characterized as magnifiers of local biodiversity (Rocha *et al.* 2004). Furthermore, data on interactions of terrestrial orchids in tropical forests is scarce, insufficient, and dispersed in floristic and phytosociological research of herbaceous strata (Rocha & Waechter 2006), and not because these were not the subject of detailed study.

Therefore, the study of Orchidaceae in areas of fragmented forest in Araras can reveal the conservation state of the extant natural area in the region. And, since the edge effect is one of the most important consequences of forest fragmentation, it is important to study the responses of orchids to those effects since the analysis of those factors is fundamental to identify conservation strategies and priorities for research (Viana & Pinheiro 1998). Hence, the present work had as an objective the evaluation of the influence of the edge effect over the flora of Orchidaceae in a fragment of Semi-deciduous Seasonal Forest from *Nova Santa Cruz* farm, Araras, SP, Brazil, in order to understand if the edge alters the diversity and ecological structure of the family.

MATERIAL AND METHODS

The work was carried out from March 2009 to April 2010 in the largest municipal forest fragment belonging to *Nova Santa Cruz* farm, Araras, SP, located at 22°16’3.68” S, 47°19’22.29” W (Fig. 1).

The area has 388 ha, with 97 of these related to remnants of Semi-deciduous Seasonal Forest. The remaining area is occupied by pastures and crops of *Citrus* and sugar cane. The climate of the area corresponds, according to the classification of Köeppen, to Cwa; that is, mesothermal with a dry winter in which the average temperature of the coldest month is 18ºC. The total rainfall in the driest month does not exceed 30 mm. The temperature of the warmest month varies between 14°C and 22ºC, with the annual average temperature around 21ºC (Magini & Chagas 2003).

The fragment was classified according to the Circularity Index (CI) or Edge Index (EI) (Martins *et al.* 2002), calculated using the following formula:

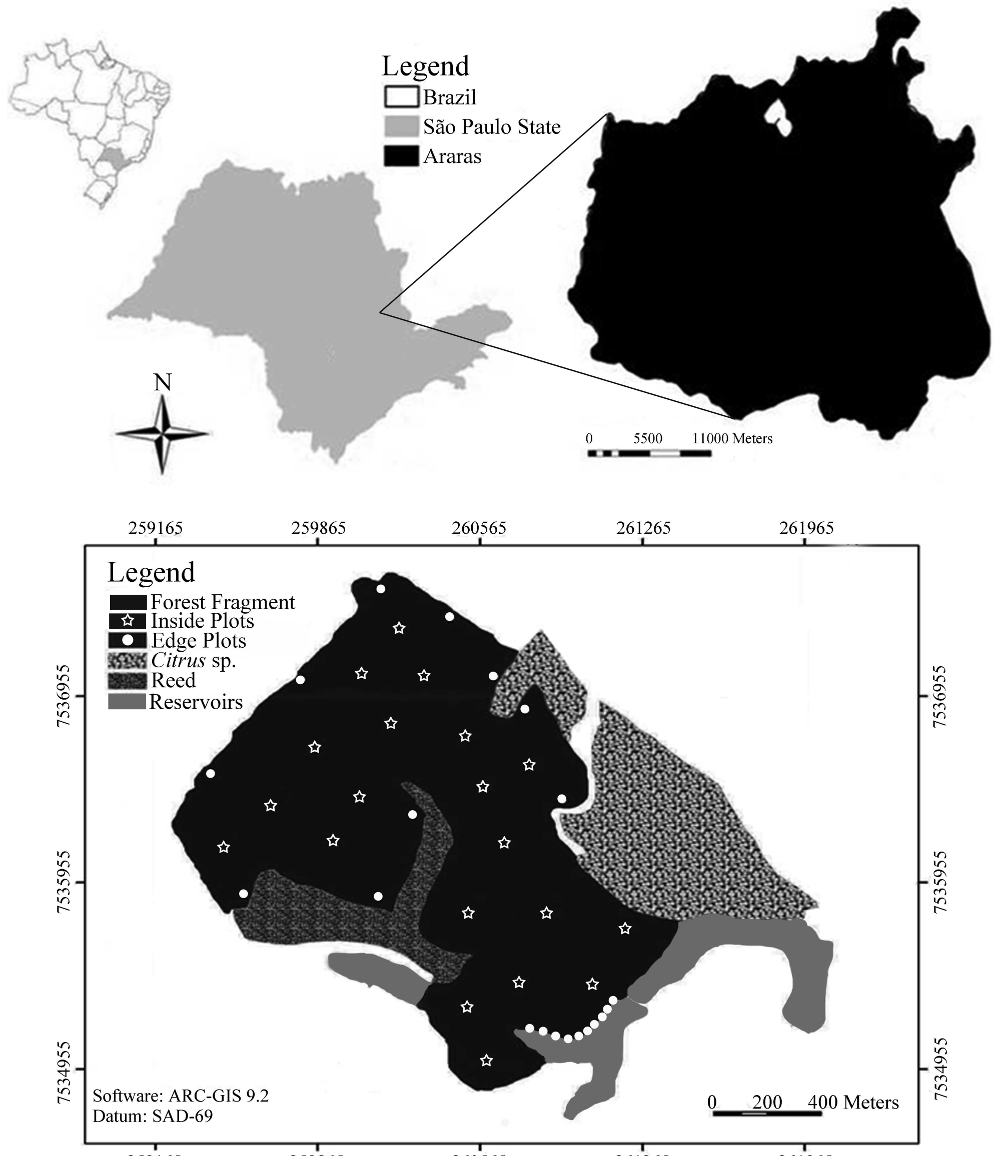

Fig. 1. Thematic map of the forest fragment belonging to *Nova Santa Cruz* farm, Araras, Sao Paulo State, Brazil.

CI or EI = K(A/P2) where K = 12.57 (constant); A = the fragment area (m^2); P = perimeter (m). Fragments whose indices are closer to 1 are more rounded and have a lower ratio between edge and interior, being subject to a lesser edge effect (Martins *et al.* 2002, Nascimento *et al.* 2006).

To study the diversity of orchids, the methodology described by Clements (1929) and adapted by Dislich & Mantovani (1998) was employed. For that, 40 parcels of 20 X 10 m in length were used, making up a total of 8,000 m^2. Among these, 20 were established to a distance of 30 meters from the edge of the fragment, as these effects are frequently more noticeable at this distance (Williams-Linera 1990). The other 20 parcels were established within the fragment at a distance of at least 100 meters from the edge (Fig. 1).

The orchids found were recorded and the material collected was herborized according to the usual procedures (Mori *et al.* 1989). Orchids occurring as a single individual had their back pseudobulbs and their inflorescences removed for herborization. The identification of the orchids occurred by consulting the works of Barbosa Rodrigues (1877, 1882), Cogniaux (1893-1896, 1898-1902, 1904-1906), Hoehne (1940, 1942, 1945, 1949, 1953), Pabst & Dungs (1975, 1977), and Sprunger *et al.* (1996). The scientific names were verified on *Lista das Espécies da Flora* *do Brasil* (Barros et al. *2015*) by studying the original descriptions of the taxa and by comparing them with the collection of *Herbario Rioclarense* (HRCB), from the Bioscience Institute from Rio Claro, *Universidade Estadual Paulista* – UNESP, where the voucher specimens were deposited. When necessary, the identification was obtained with the assistance of specialists. The species were classified into ecological categories, according to their relation to the substratum and the phorophyte, as follows: terrestrial (TER), holoepiphytes (HOL) and hemiepiphytes (HEM). Furthermore, the position of each epiphytic species on their phorophyte was also recorded.

The parameters of absolute (AD) and relative density (RD), and absolute (AF), and relative frequency (RF) were calculated for terrestrial species (Matteucci & Colma 1982) and the importance value index (IVI) was measured (adapted Mueller-Dombois & Ellenberg 1974). For the epiphytic species the absolute frequency (AFe) and relative frequency (RFe) were calculated in intervals of sampled height, using the formulas: $AFe = (sn \,.\, ns^{-1})$ and $RFe = (sn \,.\, (\Sigma sn)^{-1}) . 100$ where sn = stratum number with occurrences of epiphytic species and ns = total number of sampled stratum. The formula employed to estimate the absolute and relative frequencies over the phorophytes (NAi and NRi) were: NAi = 100 (Nfi / Nsf) and NRi = 100 (Nfi / Σ Nfi) where Nfi = total number of phorophyte individuals with the species *i* of orchid and Nsf = total number of sampled phorophyte individuals. To calculate the absolute frequency (SAi) and relative frequency (Sri) of the orchid *i* over the phorophyte species, the formulas: SAi = 100 (Sfi / Sfs) and Sri = 100 (Sfi / Σ Sfi) were used, where Sfi = total number of phorophyte species with the species *i* of orchid and Sfs = total number of sampled phorophyte species (Waechter 1998). Besides these analyses, the EIV (epiphytic importance value) was calculated using the formula: EIV = (NRi + Sri) / 2. The similarity analyses were performed using the StatistiXL 1.8 software (Roberts & Withers 2009).

The temperature, relative air humidity (Termo-higrometer Instrutemp, model: ITHT-2200) and light intensities (Luximeter Instrutherm, model: LD-300) were measured at five different points in each established parcel and their averages calculated. Measurements were obtained at approximately 1.5 meters above the ground. During dry days of February 2010, data were collected quickly, to avoid changes arising from the time of collection, starting from the parcels of the edge and going to the interior, (Bernardi & Budke 2010). To analyze relationships between biotic data and the abiotic variables an analysis of Pearson linear correlation (r) was carried out. As a reference of the intensity, the correlation coefficients were considered of low intensity when r values varied between 0.30 and 0.40 (both positive and negative) and of high intensity when r values were greater than 0.40 (both positive and negative) (adapted from Brun *et al.* 2007).

RESULTS

The Circularity Index obtained of the fragment was 0.28, indicating that it has an elongated shape.

The average light intensity, relative air humidity, and temperature obtained on the edge parcels of the fragment were 282.5 µmol m^{-2} s^{-1}, 54.14%, and 29.4 ºC, respectively. In that area, the abundance of orchids showed high intensity correlations with the abiotic factors, these being positive relative to temperature ($r = 0.9380$ / $p < 0.01$) and light intensity ($r = 0.7608$ / $p < 0.01$), and negative torelative to air humidity ($r = -0.5118$ / $p < 0.05$). Among the abiotic factors, the light intensity was positively correlated with the temperature ($r = 0.6875$ / $p < 0.01$) and negatively with the humidity ($r = -0.5014$ / $p < 0.05$), this last one presenting a negative correlation with the temperature as well ($r = -0.7690$ / $p < 0.01$). All abiotic factors had high-intensity correlations.

The average light intensity, relative air humidity, and temperature measured in the parcels situated within the forest were 181.9 µmol m^{-2} s^{-1}, 62.22%, and 26.3 ºC, respectively. The analyses of correlation of these abiotic factors with the abundance of orchids were not significant ($p > 0.05$). However, significant high-intensity correlations were obtained when the factors were analyzed between themselves. The light intensity correlated negatively with the humidity ($r = -0.5535$ / $p < 0.05$) and positively with the temperature ($r = 0.6439$ / $p < 0.05$), with the correlation temperature/ humidity being negative ($r = -0.6876$ / $p < 0.01$).

For the whole area, 346 individuals, distributed between nine genera and nine species, were recorded. The epiphytic species found were *Acianthera pubescens* (Lindl.) Pridgeon and M.W. Chase, *Baptistonia cornigera* (Lindl.) Chiron and V.P. Castro, *Campylocentrum robustum* Cogn., *Catasetum fimbriatum* (Morren.) Lindl., *Lophiaris pumila* (Lindl.) Braem, *Polystachya estrellensis* Rchb.f. and *Rodriguezia decora* (Lem.) Rchb.f. The terrestrial species were *Oeceoclades maculata* Lindl. and *Sacoila lanceolata* (Aubl.) Garay (Tab. 1-2).

Table 1. Epiphytic species recorded in the quantitative survey in a fragment of remnant Semi-deciduous Seasonal Forest from *Nova Santa Cruz* farm, Araras, São Paulo State, Brazil. NS (number of strata with epiphytic species), AFs (absolute frequency on strata) and RFe (relative frequency on strata), NAi (absolute frequency over phorophytic individuals) and NRi (Relative frequency over phorophytic individuals), SAi (absolute frequency over phorophytic species), and SRi (relative frequency over phorophytic species), and EIV (epiphytic importance value).

Species	NS	AFe	RFe	NAi	NRi	Sai	Sri	EIV	N°. HRBC
Fragment edge									
Baptistonia cornigera	41	52.56	37.27	36.68	36.68	72.73	40.00	38.34	45350
Campylocentrum robustum	35	44.87	31.82	33.34	33.34	45.45	25.00	29.17	45348
Lophiaris pumila	31	39.75	28.18	25.00	25.00	36.36	20.00	22.50	45354
Catasetum fimbriatum	1	1.28	0.91	1.66	1.66	9.09	5.00	3.33	45344
Polystachya estrellensis	1	1.28	0.91	1.66	1.66	9.09	5.00	3.33	45346
Rodriguezia decora	1	1.28	0.91	1.66	1.66	9.09	5.00	3.33	45345
Total	110	-	100.00	-	100.00	-	100.00	100.00	
Within the fragment									
Baptistonia cornigerum	16	29.09	35.56	28.12	28.12	54.55	37.50	32.81	
Lophiaris pumila	14	25.45	31.11	34.38	34.38	36.36	25.00	29.69	
Campylocentrum robustum	12	21.82	26.67	28.12	28.12	36.36	25.00	26.56	
Polystachya estrellensis	2	3.63	4.44	6.25	6.25	9.09	6.25	6.25	
Acianthera pubescens	1	1.82	2.22	3.13	3.13	9.09	6.25	4.69	45341
Total	45	-	100.00	-	100.00	-	100.00	100.00	

Table 2. Terrestrial species recorded in the quantitative survey in a fragment of remnant Semi-deciduous Seasonal Forest from *Nova Santa Cruz* farm, Araras, São Paulo State, Brazil. AD (absolute density), RD (Relative density), AF (absolute frequency), RF (relative frequency) and IVI (importance value index).

Species	AD	RD (%)	AF	RF (%)	IVI (%)	N°. HRBC
Fragment edge						
Oeceoclades maculata	109	99.10	80	94.12	96.61	45347
Sacoila lanceolata	01	0.90	5	5.88	3.39	45342
Total	110	100	85	100	100	
Within the fragment						
Oeceoclades maculata	81	100	80	100	100	
Total	81	100	80	100	100	

The Jaccard similarity coefficient was calculated using data from the present study, along with data from other published studies carried out in semi-deciduous seasonal forests from the south and southeast of Brazil. Although low, it is valid for the comparison among this and other studies (Tab. 3).

Table 3. Comparison between the work involving the Orchidaceae family in areas of Semi-deciduous Seasonal Forest in south and southeast regions of Brazil organized in the north-south orientation. Place = city or region where the work has been done; FU = state acronym to which belongs the place; Area = approximate area of the studied place; Met = applied methodology (1 = slightly qualitative; 2 = quali-quantitative study); Gen = number of genera found; Spe = number of species found; JSI = Jaccard's Similarity Index (n/i= no information).

Place (References)	FU	Area (ha)	Met	Gen	Spp	JSI(%)
Barroso (Menini Neto *et al.* 2004)	MG	n/i	1	25	44	10.81
Central Region (Ferreira *et al.* 2010)	SP	450,000	1	46	73	8.00
Araras (present study)	SP	97	2	9	9	-
São Paulo (Dislich & Mantovani 1998)	SP	10	1	6	6	16.67
Iperó (Bataghin *et al.* 2010)	SP	5,179.9	2	2	2	11.11
Maringá (Dettke *et al.* 2008)	PR	47.3	2	3	3	10.00
West Region (Cervi & Borgo 2007)	PR	170,000	1	19	21	11.11
Novo Hamburgo (Brustulin & Schmitt 2008)	RS	51.3	1	7	7	7.14
Guaíba (Buzatto *et al.* 2007)	RS	40	1	35	50	5.45

Among these areas, the one studied by Dislich & Mantovani (1998) in the city of São Paulo, São Paulo State, has shown the greater similarity with our site. The resulting dendrogram formed two main clades; one including the four larger and more pristine areas; the other including the four smaller and more impacted ones. The first group splits into two smaller clades formed by the two areas from the south of Brazil (Guaíba/RS and West PR) versus the two southeast ones (Central SP and Barroso/MG). The second group is formed by two smaller clades grouping the two southern areas (N. Hamb./RS and Maringá/PR) versus the two southeast ones (S. Paulo/SP and Araras/SP). The Iperó/SP area stands apart from all other forest patches (Fig. 2).

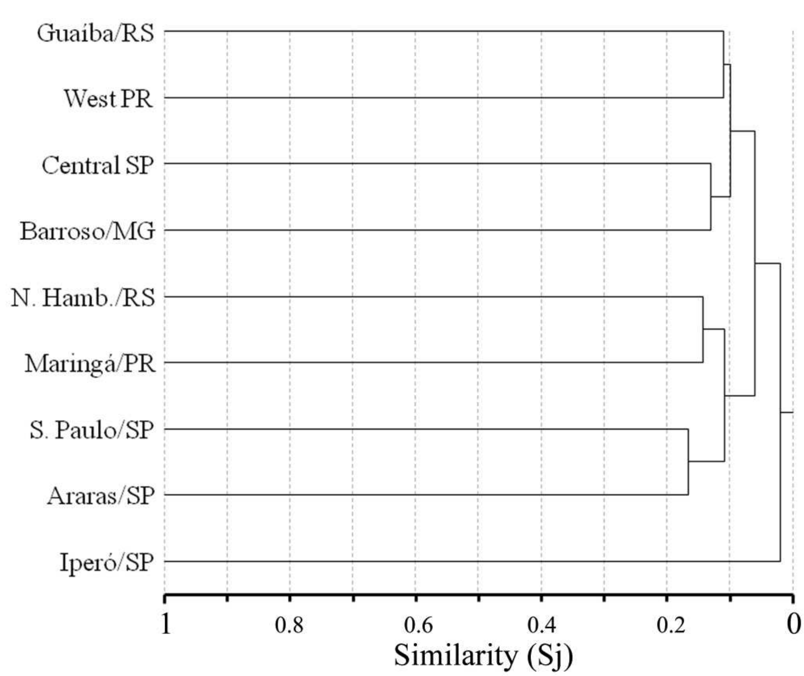

Fig. 2. Dendrogram showing the results of the cluster analysis based on coefficients obtained using the Jaccard index of similarity between the diversity of orchids of Semi-deciduous Seasonal Forest remnants from the south and southeast of Brazil. Guaiba/RS (Buzatto et al., 2007), West PR (Cervi; Borgo, 2007), Central SP (Ferreira et al., 2010), Barroso (Menini-Neto et al., 2004a), N. Hamb./RS (Brustulin and Schmitt, 2008), Maringa/PR (Dettke et al., 2008), S. Paulo/SP (Dislich; Mantovani, 1998), Araras/SP (present study), Ipero/SP (Bataghin et al., 2010).

In the 20 parcels of the edge, 110 epiphytic individuals were observed, distributed into six species, in which two species are exclusive. Just one epiphytic orchid, of a total of five epiphytic species recorded within the 20 fragment parcels, is exclusive, for a total of 45 individuals. The number of terrestrial individuals on the edge was 110, represented by the species *O. maculata* and *S. lanceolata*. Within the fragment, 81 individuals were recorded, represented only by *O. maculata*, the most abundant of the study. The epiphytes *B. cornigera, L. pumila,* and *C. robustum* had the highest EIV, both on the edge as well as within the forest. The terrestrial *O. maculata* presented the highest IVI, both on the edge as well as within the forest (Tab. 1-2).

The quantitative study referring to the relative frequency of epiphytic species within the intervals of sampled heights showed that the species *B. cornigera*, *C. robustum,* and *L. pumila* had the highest frequencies. Among all other epiphyte species recorded, the frequencies summed up to a value lower than 4% (Tab. 1). The analysis of the specificity by phorophyte showed that the species *B. cornigera* presented absolute and relative frequencies higher on the edge of the fragment than when compared to the interior of the fragment. The frequencies recorded for *C. robustum* were higher for the parcels of the edge than for parcels of the interior of the fragment, except for SRi, which was similar for both areas. *L. pumila* was observed at the lowest strata on the natural substrates, as revealed by the values of NAi, NRi, SAi and Sri, with the higher value of AFe found on the edge of the fragment (Tab. 1).

For both the edge and the interior, the stratum preferentially occupied by epiphytes was 2-4 meters. However, while for the edge the stratum of 4-6 meters was densely occupied, the occupation of this stratum was sparse for the parcels of the interior, with these epiphytic orchids secondarily preferring 0-2 meters. Also, while the stratum of 6-8 meters was occupied in the edge, no individual was observed occupying this stratum in the interior of the fragment (Fig. 3).

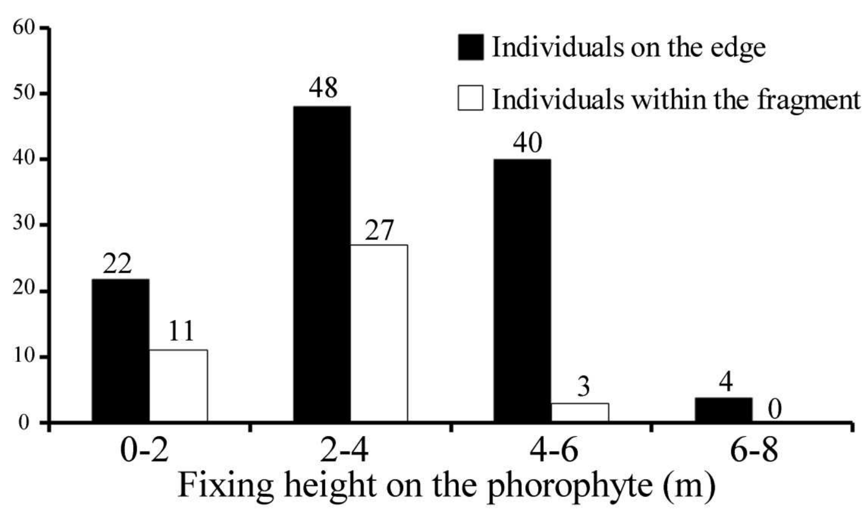

Fig. 3. Number of sampled epiphytic individuals by height interval on the strata in a fragment of remnant Semi-deciduous Seasonal Forest from *Nova Santa Cruz* farm, Araras, Sao Paulo State, Brazil.

DISCUSSION

The elongated shape of the fragment studied presents a longer perimeter due to the presence of irregularities in its outline (Fig. 1). Smaller forest fragments have higher edge/area ratios and thus are more prone to edge effects, once the area and the perimeter of the fragment determine the degree of the edge effect over the forest formation and the influence of the external factors over its biodiversity (Zuidema *et al.* 1996). The ecological processes are influenced by the size of the forest remnant and induced by the formation of the edge (Collinge 1996), and such shifts can compromise the restructuration and sustainability of those forests (Kapos 1989, Bierregaard *et al.* 1992).

The edge effect causes alterations in abiotic factors and leads to microclimatic shifts, such as: increase of winds, humidity and temperature variation, and increases in the vertical penetration of light, i.e. more solar radiation (Davies-Colley *et al.* 2000, Redding *et al.* 2003). Parker (1995) suggests that, among the microclimatic factors, an increase in light intensity implies higher temperatures and lower humidity, which corroborates well with the averages and correlations obtained. In fact, light intensity and temperature correlated negatively with the humidity, since when we proceeded to the internal areas of the fragment, the former two decreased, and the humidity, on the other hand, increased.

Consequently, the edge effect changes the direct biological factors too, leading to shifts in the distribution and abundance of species, for example the increase in density of individuals due to greater primary productivity caused by higher levels of solar radiation (MacDougall & Kellman 1992, Didhan & Lawton 1999). In the present study, such facts could be observed by the correlation found between the abiotic factors and the abundance of orchids, which differed between the areas of the fragment. On the edge, the abiotic factors directly influence the distribution of orchids and, among these factors, light is the most influent (Bataghin *et al.* 2008), affecting other abiotic factors directly (Parker 1995). In the interior of the forest fragment such influences were not observed, showing that the edge effect affects the distribution of these plants (Bataghin *et al.* 2012).

The evolution of land occupation in tropical regions has led to a fragmented forest landscape (Viana *et al.* 1997). In the south and southeast of Brazil, this picture is even more worrying, considering that the edaphic conditions favor mechanized agriculture, which appears as one of the main factors that contribute to the accentuation of this fragmentation (Viana *et al.* 1992). The populations of arboreous species are affected by the process of fragmentation and its consequent changes toward the structure of vegetation of forest remnants (Nascimento & Viana 1999). This directly influences the diversity of epiphytes, which, according to Kersten & Silva (2001), depend on the availability of substrata and on the microclimatic conditions present in the habitat.

The process of forest fragmentation, besides generating considerable microclimatic differences between forest patches isolates, restricts the distribution of species once it begins to reduce processes like seed dispersal and colonization of new areas. Furthermore, characteristics of orchids, like restricted geographical distribution (Pridgeon *et al.* 2009), aggregated spatial distribution (Rasmussen 2002), and high sensitivity to microclimatic factors (Benzing 1990), causes only those most abundant and/or most tolerant to survive, increasing the differences between distant forest patches, as well as differences in conservation status. Conversely, this increases the similarity between the near forest patches and among those with similar conservation statuses. However, even those have many exclusive species, which causes what similarity between them to be relatively low (Fig. 2). The diversity of orchids of the Atlantic Forest is globally high, though with most of the species occurring in one or few areas (Barros 1990, Dressler 2005, Souza & Lorenzi 2005, Campos 2008).

The diversity of Orchidaceae recorded in the studied area is, more or less, intermediate when compared to other surveys in fragments of similar vegetation (Tab. 3). The works of Novo Hamburgo/SP (Brustulin & Schimitt 2008), Maringá/PR (Dettke *et al.* 2008), S. Paulo/SP (Dislich & Mantovani 1998) and Iperó/SP (Bataghin *et al.* 2010), all in areas characterized as impacted by their authors, showed less diversity than what was observed in this study, having also suffered from anthropization. This observation shows that the edge also positively influences the flora of Orchidaceae, since that the area here studied had its orchid population increased on the edge, such an increase being correlated to abiotic alterations, especially the increase of luminosity (Bataghin *et al.* 2008). However, when considering the interior and the fragment as a whole, the diversity seems to be lower than what was observed in other, better conserved areas.

The larger and best conserved areas (Menini Neto *et al.* 2004, Buzatto *et al.* 2007, Cervi & Borgo 2007, Ferreira *et al.* 2010) have higher orchid diversity due to greater equilibrium in their conditions, which led the similarity among them (Fig. 2). According to Rogalsky & Zanin (2003), the microclimatic differences formed within the forest and among the phorophytes benefit the wealth of epiphytes. However, such differences are minimized when the environments are altered.

The terrestrial species, on the other hand, were influenced by the alteration in the availability of light caused by the edge formation, which contributed to the increase of their abundance in this area (Didhan & Lawton 1999). Within the forest, the alteration of nutrient cycling which, according to D'Antonio &

Vitousek (1992), is caused by the proliferation of invasive species like bamboos and lianas associated to microclimatic shifts—seems to have promoted the reduction in the abundance of these plants.

Oeceoclades maculata stood out as the most abundant species in the area, certainly resulting from its highly developed mechanism of selfing, and from its fruits with anemochoric seeds which are easily dispersed (Gonzalez-Diaz & Ackerman 1988, Pedroso-de-Moraes *et al.* 2010). Such species possesses an enormous capacity for colonization of habitats, especially anthropized ones (Cohen & Ackerman 2009, Dubbern *et al.* 2013, Quenzer & Pedroso-de-Moraes 2014, Souza-Leal & Pedroso-de-Moraes 2014).

Sacoila lanceolata is frequently found as a ruderal species, especially in ecotones of *Cerrado* and *Campos*, as a colonizer of anthropogenically disturbed environments, serving as biomonitor of natural conditions (Menini Neto *et al.* 2004, Orzell & Bridges 2006, Rocha & Waechter 2006). It is not found in glades with great edaphic variations, especially when regarding humidity, being restricted to the track edges and patches of forest with low intra and interspecific competition and high availability of light (Brown 2008). Furthermore, the fact that *S. lanceolata* is a deciduous species, devoid of pseudobulbs, and highly demanding in terms of soil moisture (Garay 1980) corroborates with the location of the species in the present study due to it appearing only on the edge of the fragment (Tab. 2), in a region characterized by greater availability of light and great humidity due to the presence of an watercourse parallel to the parcel where the species was found.

According to Lovejoy *et al.* (1986) and Murcia (1995), the increase of incident light on the edge area increments the biodiversity, providing, in this study, a greater number of orchids. In fluvial forests, the constant humidity allows species that usually inhabit shadowed environments to cope with greater light intensity (Fischer & Araújo 1995). Likewise in the present study, the increase in light intensity on the edge, although reducing the humidity, enabled the epiphytes to colonize and be abundant, once the humidity was maintained in bearable rates due to the presence of the watercourse (Fig. 1). This abiotic configuration allied to specific characteristics led the species *B. cornigera, C. robustum,* and *L. pumila* to stand out amongst the epiphytes found.

Campylocentrum robustum is the largest species within the genus (Pabst & Dungs 1977, Menini Neto *et al.* 2004) and *B. cornigera* presents pseudobulbs that allow it to store water (Braga 1987). These characteristics, according to Pabst & Dungs (1977) and Braga (1987), facilitates survival in environments characterized by intense solar radiation, high temperatures, and reduced humidity, like the edge of the studied area.

Lophiaris pumila, on the other hand, has high adaptability to different phorophytes and environmental conditions. It can be found vegetating from branches at the top of trees, being directly exposed to solar rays, to the base of the trunk where the humidity is higher and the light more diffuse (Schuster *et al.* 2010). Thereby, when under direct incidence of solar radiation, its length is reduced and the leaves are vinously pigmented and become more fleshy, whereas under low-light intensity conditions it presents longer and thinner leaves and of greenish coloration (Perleberg *et al.* 2008). In the present study, longer and greenish leaves occurred in the lowest strata of the phorophytes, which was less occupied by the two other outstanding species, and proved to be adequate for the development of *L. pumila* due to its lack of pseudobulbs.

Factors like light intensity, humidity, availability, and conditions of substrate, influence the abundance and the diversity of epiphytes throughout the different height strata of phorophytes (Benzing 1990). The strata of 2-4 m and 4-6 m presented intermediate conditions of light intensity and humidity, and are characterized by a higher availability and quality of substrate (bifurcations, horizontal branches and accumulation of organic matter) for the fixation of epiphytes (ter Steege & Cornelissen 1989). Rogalsky & Zanin (2003), suggesting that species classified as holoepiphytes, as in the present study, show preference to the intermediate branches, once, according to Benzing (1990), these species present a greater variety of adaptations to the epiphytic habit, like the form of growth, support capacity, and ways of obtaining water, light and nutrients. Succulent vegetative organs (pseudobulbs, leaves, and roots) and presence of velamen are examples of morphoanatomic structures developed by these plants to provide better adaptability to life on phorophytes.

The most frequent species in the stratum of 0-2.0 m was *L. pumila*, one of the most abundant of the study. Because it does not possess a pseudobulb for the storage of water, it prefers such strata, since it presents reduced light intensity, temperature, and higher humidity (Parker, 1995), whereas the highest stratum (6.0-8.0 m), in spite of the considerable number of twigs for fixation according to Kersten

& Silva (2001), does not provide optimal fixation conditions for various epiphytic orchids species, whether for mechanical, spatial, or temporal reasons, due to those branches being thinner and younger. Environmental factors, such as high luminosity, high temperature, and intense winds, negatively influence the presence of epiphytes in the higher strata (Rogalsky & Zanin 2003).

The diversity of orchids in the studied area is low, and the abundance of species in the fragment is not spread in an equitable way. The edge has more species and individuals, showing it to be more beneficial for the survival of orchids, especially when associated to the watercourse. This increase in the orchid population in the edge can be related to luminosity. However, the forest fragment studied has fewer orchid species than other, better conserved fragments of Semi-Deciduous Seasonal Forest.

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REFERENCES

Barbosa Rodrigues, J. 1877. Genera et Species Orchidearum Novarum quas Collecit, Descripsit et Iconibus Illustravit. Typographia Nacional, Sebastianópolis, vol. I, p. 1-295.

Barbosa Rodrigues, J. 1882. Genera et Species Orchidearum Novarum quas Collecit, Descripsit et Iconibus Illustravit, Typographia Nacional, Sebastianópolis, vol. II, p. 296-526.

Barros, F. 1990. Diversidade taxonômica e distribuição geográfica das Orchidaceae brasileiras. Acta Botanica Brasilica 4(1):177-187.

Barros, F., Vinhos, F., Rodrigues, V.T., Barberena, F.F.V.A., Fraga, C.N., Pessoa, E.M., Forster, W. & Menini Neto, L. 2015. Orchidaceae. *In* Lista de Espécies da Flora do Brasil. Available at http://reflora.jbrj.gov.br/jabot/floradobrasil/FB11323.Accessed on 11 February, 2015.

Bataghin, F.A., Fiori, A. & Toppa, R.H. 2008 Efeito de borda sobre epífitos vasculares em floresta ombrófila mista, Rio Grande do Sul, Brasil. O Mundo da Saúde 32(3):329-328.

Bataghin, F.A., Barros, F. & Pires, J.S.R. 2010. Distribuição da comunidade de epífitos vasculares em sítios sob diferentes graus de perturbação na Floresta Nacional do Ipanema, São Paulo, Brasil. Brazilian Journal of Botany 33(3):501-512.

Bataghin, F.A., Pires, J.S.R. & Barros, F. 2012. Epifitismo vascular em sítios de borda e interior em Floresta Estacional Semidecidual no Sudeste do Brasil. Hoehnea 39(2):235-245.

Bawa, K.S. 1992. Mating systems, genetic differentiation, and speciation in tropical forest plants. Biotropica 24(2b):250-255.

Benzing D.H. 1990. Vascular epiphytes: General Biology and Related Biota. Cambridge University Press, Cambridge. 354 p.

Bernardi, S. & Budke, J.C. 2010. Estrutura da sinúsia epifítica e efeito de borda em uma área de transição entre Floresta Estacional Semidecídua e Floresta Ombrófila Mista. Floresta 40(1):81-92.

Bierregaard, R.O., Lovejoy, T.E., Kapos, V., Santos, A.A. & Hutchings, R.W. 1992. The biological dynamics of tropical rainforest fragments. Bioscience 42(11):859-866.

Braga, P.I.S. 1987. Orquídeas. Biologia floral. Ciência Hoje 5(28):53-55.

Brown, P.M. 2008. The genus *Sacoila* (Orchidaceae) in the continental United States and a new combination. North American Native Orchid Journal 14(3):121-132.

Brun, F.G K., Longhi, S.J., Brun, E.J., Freitag, A.S. & Schumacher, M.V. 2007. Comportamento fenológico e efeito da poda em algumas espécies empregadas na arborização do bairro Camobi – Santa Maria, RS. Revista da Sociedade Brasileira de Arborização Urbana, 2(1):44-63.

Brustulin, J. & Schmitt, J.L. 2008. Composição florística, distribuição vertical e floração de orquídeas epifíticas em três parques municipais do estado do Rio Grande do Sul, Brasil. Pesquisas Botânicas 59:143-158.

Buzatto, C.R., Freitas, E.M., Silva, A.P.M. & Lima, L.F.P. 2007. Levantamento florístico das Orchidaceae ocorrentes na Fazenda São Maximiano, Município de Guaíba, Rio Grande do Sul. Revista Brasileira de Biociências 5(2-3):19-25.

Campos, F.A.D.B. 2008. Considerações sobre a Família Orquidaceae: taxonomia, antropismo, valor econômico e tecnologia. O mundo da saúde 32(3):383-392.

Cervi, A.C. & Borgo, M. 2007 Epífitos vasculares no Parque Nacional do Iguaçu, Paraná (Brasil). Levantamento Preliminar. Fontqueria 55(51):415-422.

Clements, F.E. 1929. Experimental Methods in Adaptation and Morphogeny. Journal of Ecology 17(2):356-379.

Cogniaux, A. 1893-1896. Orchidaceae. *In* Flora brasiliensis (C.F.P. Martius, A.G. Eichler & I. Urban, eds.). Typographia Regia, Munich, p. 1-672.

Cogniaux, A. 1898-1902. Orchidaceae. *In* Flora brasiliensis (C.F.P. Martius, A.G. Eichler & I. Urban, eds.). Typographia Regia, Munich, p. 1-664.

Cogniaux, A. 1904-1906. Orchidaceae. *In* Flora brasiliensis (C.F.P. Martius, A.G. Eichler & I. Urban, eds.). Typographia Regia, Munich, p. 1-604.

Cohen, I.M. & Ackerman, J.D. 2009. *Oeceoclades maculata*, an alien tropical orchid in a Caribbean rainforest. Annals of Botany 104(3):557-563.

Collinge, S.K. 1996. Ecological consequences of habitat fragmentation: implications for landscape architecture and planning. Landscape and Urban Planning 36(1):59-77.

D'Antonio, C.M. & Vitousek, P.M. 1992. Biological invasion by exotic grasses, the grass/fire cycle and change. Annual Review of Ecology and Systematics 23:63-87.

Davies-Colley, R.J., Payne, G.W. & Van Elswijk, M. 2000. Microclimate gradients across a forest edge. New Zealand Journal of Ecology 24(2):111-121.

Dettke, G.A., Orfrini, A.C. & Milaneze-Gutierre, M.A. 2008. Composição florística e distribuição de epífitas vasculares em um remanescente alterado de floresta estacional semidecidual no Paraná, Brasil. Rodriguesia 59(4):859-872.

Didhan, R.K. & Lawton, J.H. 1999. Edge structure determines the magnitude of changes in microclimate and vegetation structure in tropical forest fragments. Biotropica 31(1):17-30.

Dislich, R. & Mantovani, W. 1998. Flora de epífitas vasculares da Reserva da Cidade Universitária "Armando de Salles Oliveira" (São Paulo, Brasil). Boletim de Botânica da Universidade de São Paulo 17: 61-83.

Dressler, R.L. 2005. How many orchid species? Selbyana 26(1,2):155-158.

Dubbern, C.A., Souza-Leal, T. & Pedroso-de-Moraes, C. 2013. Distribuição espacial de *Oeceoclades maculata* Lindl. (Orchidaceae) em fragmento florestal Estacional Semidecidual da fazenda Santa Tereza, Cordeirópolis, SP, Brasil. Natureza On Line 11(1):29-32.

Ferreira, A.W.C., Lima, M.I.S. & Pansarin, E.R. 2010. Orchidaceae na região central de São Paulo, Brasil. Rodriguesia 61(2):243-259.

Fischer, E.A. & Araújo, A.C. 1995. Spatial Organization of a Bromeliad Community in the Atlantic Rain Forest, South-Eastern Brazil. Journal of Tropical Ecology 11(4):559-567.

Forman, R.T.T. & Gordon, M. 1986. Landscape Ecology. Wiley & Sons, New York. 619 p.

Garay, L.A. 1980. A generic revision of the Spiranthinae. Botanical Museum Leaflets 28(4):278-425.

Gentry, A.H. & Dodson, C.H. 1987. Diversity and biogeography of neotropical vascular epiphytes. Annals of the Missouri Botanical Garden 74(2):205-233.

Gonzalez-Díaz, N. & Ackerman, J.D. 1988. Pollination, fruit set, and seed production in the orchid *Oeceoclades maculata*. Lindleyana 3(3):150-155.

Hoehne, F.C. 1940. Orchidaceas. *In* Flora Brasilica (F.C. Hoehne, ed.). Secretaria da Agricultura, Indústria e Comércio de São Paulo, São Paulo, p. 1-254.

Hoehne, F.C. 1942. Orchidaceas. *In* Flora Brasilica (F.C. Hoehne, ed.). Secretaria da Agricultura, Indústria e Comércio de São Paulo, São Paulo, p. 1-218.

Hoehne, F.C. 1945. Orchidaceas. *In* Flora Brasilica (F.C. Hoehne, ed.). Secretaria da Agricultura, Indústria e Comércio de São Paulo, São Paulo, p. 1-389.

Hoehne, F.C. 1949. Iconografia das Orchidaceas do Brasil. Secretaria da Agricultura, Indústria e Comércio de São Paulo, São Paulo. 397 p.

Hoehne, F.C. 1953. Orchidaceas. *In* Flora Brasilica (F.C. Hoehne, ed.). Secretaria da Agricultura, Indústria e Comércio de São Paulo, São Paulo, p. 1-397.

Kapos, V. 1989. Effects of isolation on the water status of forest patches in the Brazilian Amazon. Journal of Tropical Ecology 5:173-185.

Kersten, R.A. & Silva, S.M. 2001. Composição florística do componente epifítico vascular em floresta da planície litorânea na Ilha do Mel, Paraná, Brasil. Revista Brasileira de Botânica 24(2):213-226.

Kress, W.J. 1986. The systematic distribution of vascular epiphytes: an update. Selbyana 9(1):2-22.

Laurance, W.F. & Bierregaard R.O. 1997. Tropical forest remnants: ecology management and conservation of fragmented communities. University of Chicago Press, Chicago. 632 p.

Lord, J.M. & Norton, N.A. 1990. Scale and the spatial concept of fragmentation. Conservation Biology 4(2): 197-262.

Lovejoy, T.E., Bierregard, Jr. R.O., Rylands, A.B., Malcolm, J.R., Quintela, C.E., Harper, L.H., Brown, Jr. K.S., Powell, G.V.N., Schubart, H.O.R. & Hay, M.B. 1986. Edge and other effects of isolation on Amazon forest fragments. *In* Conservation biology (M.E. Soulé, ed.). Sinauer Press, Boston, p. 257-285.

MacDougall, A. & Kellman, M. 1992. The understorey light regime and patterns of tree seedlings in tropical riparian forest patches. Journal of Biogeography, 19(6):667-675.

Magini, C. & Chagas, R.L. 2003. Microzoneamento e diagnóstico físico-químico do Ribeirão das Araras, Araras-SP. Geociências 22(2):195-208.

Marchand, P. & Houle, G. 2005. Spatial patterns of plant species richness along a forest edge: What are their determinants? Forest Ecology and Management 223(1-3):113-124.

Martins, I.C.M., Soares, V.P., Silva, E. & Brites, R.S. 2002. Diagnóstico ambiental no contexto da paisagem de fragmentos florestais naturais "ipuca" no municipio de Lagoa da Confusão. Revista Árvore 26(3):299-309.

Matteucci, S.D. & Colma, A. 1982. Metodologia para el estudio de la vegetacion. The General Secretarial of the Organization of American States, Washington. 78 p.

Menini-Neto, L., Assis, L.C.S. & Forzza, R.C. 2004. A família Orchidaceae em um fragmento de Floresta Estacional Semidecidual, no município de Barroso, Minas Gerais, Brasil. Lundiana 4(1):9-27.

Morellato, L.P.C. & Haddad C.F.P. 2000. Introduction: The Brazilian Atlantic Forest. Biotropica 32(4):786-792.

Mori, S.A., Silva, L.A.M., Lisboa, G. & Coradin, L. 1989. Manual de manejo do herbário fanerogâmico. Centro de Pesquisa do Cacau, Ilhéus. 97 p.

Mueller-Dombois, D. & Ellenberg, H. 1974. Aims and methods of vegetation ecology. John Wiley and Sons, New York. 547 p.

Murcia, C. 1995. Edge effects in fragmented forests: implications for conservation. Trends in Ecology and Evolution 10(2):58-62.

Nadkarni, N.M. 1984. Epiphyte Biomass and Nutrient Capital of a Neotropical Elfin Forest. Biotropica 16(4):249-256.

Nascimento, H.E.M. & Viana, V.M. 1999. Estrutura e dinâmica de eco-unidades em um fragmento estacional semidecidual na região de Piracicaba, SP. Scientia Florestalis 55:29-47.

Nascimento, M.C., Soares, V.P., Ribeiro, C.A.A.S. & Silva, E. 2006. Mapeamento de fragmentos de vegetação florestal nativa da Bacia Hidrográfica do Rio Alegre, Espírito Santo, a partir de imagens do satélite Ikonos II. Revista Árvore 30(3):389-398.

Newman, B.J., Ladd, P., Batty, A. & Dixon, K. 2007. Ecology of orchids in urban bushland reserves - can orchids be used as indicators of vegetation condition? Lankesteriana 7(1-2):313-315.

Orzell, S.L. & Bridges, E.L. 2006. Floristic composition of the South-Central Florida dry prairie landscape. Florida Ecosystems 1: 123-133.

Pabst, J.F.G. & Dungs, F. 1975. Orchidaceae Brasilienses. v. 1. Brücke-Verlag Kurt Schmersow, Hildesheim. 408 p.

Pabst, J.F.G. & Dungs, F. 1977. Orchidaceae Brasilienses. v. 2. Brücke-Verlag Kurt Schmersow Hildesheim. 418 p.

Parker, G.G. 1995. Structure and microclimate of forest canopies. *In* Forest canopies (M.D. Lowman & N.M. Nadkarni, eds.). Academic Press, San Diego, p. 73-106.

Pedroso-de-Moraes, C., Domingues, E., Prezzi, L.E., Souza-Leal, T., Zambon, R.I., Brescansin, R.L. & Ramos, P.A.B. 2010. Florística e fitossociologia da família Orchidaceae no Centro de Educação Ambiental "Francisco Mendes", município de Mogi Guaçu, SP, Brasil. Scientia Plena 6(1):012401-1.

Perleberg, T.D., Gomes, J.C.C. & Vargas, D.M. 2008. O gênero *Oncidium* Sw. (Orchidaceae) no sul do Rio Grande do Sul, Brasil. BioScriba 1(2):76-79.

Pridgeon, A.M., Cribb, P.J., Chase, M.W. & Rasmussen, F.N. 2009. Genera Orchidacearum: Volume 5, Epidendroideae (Part two). Oxford University Press, Oxford. 664 p.

Putz, F.E., Blate, G.M., Redford, K.H., Fimbel, R. & Robinson, J. 2001. Tropical forest management and conservation of biodiversity: an overview. Conservation Biology 15(1):7-20.

Quenzer, F.C.L. & Pedroso-de-Moraes, C. 2014. Distribuição espacial de *Oeceoclades maculata* Lindl. em fragmento florestal estacional semidecidual do "Sítio João XXIII", Pirassununga, SP, Brasil. Natureza on line 12(4):160-163.

Ranta, P., Blom, T., Niemela, J., Joensuu, E. & Siitonen, M. 1998. The fragmented Atlantic rain Forest of Brazil: size, shape and distribution of Forest fragments. Biodiversity and Conservation 7(3):385-403.

Rasmussen, H.N. 2002. Recent developments in the study of orchid mycorrhiza. Plant Soil 244(1-2):149-163.

Redding, T. E., Hope, G.D., Fortin, M.J., Schmidt, M. G. & Bailey, W.G. 2003. Spatial patterns of soil temperature and moisture across subalpine forest-clearcut edges in the southern interior of British Columbia. Canadian Journal of Soil Science 83(1):121-130.

Roberts, A. & Withers, P. 2009. StatistiXL, version 1.8 [online]. Available at http://www.statistixl.com. Accessed on 12 June, 2009.

Rocha, F.S. & Waechter, J.L. 2006. Sinopse das Orchidaceae terrestres ocorrentes no litoral norte do Rio Grande do Sul, Brasil. Acta Botanica Brasilica 20(1):71-86.

Rocha, C.F.D., Cogliatti-Carvalho, L., Nunes-Freitas, A.F. & Rocha-Pessôa, T.C. 2004. Habitat disturbance in Brazilian Coastal sand dune vegetation and present richness and diversity of bromeliad species. Vidália 2(2):52-72.

Rogalski, J.M. & Zanin, E.M. 2003. Composição florística de epífitos vasculares no estreito de Augusto César, floresta estacional decidual do Rio Uruguai, RS, Brasil. Revista Brasileira de Botânica 26(4):551-556.

Scarano, F.R. 2002. Structure, Function and Floristic Relationships of Plant Communities in Stressful Habitats Marginal to the Brazilian Atlantic Rainforest. Annals of Botany, 90: 1-8.

Schuster, H., Pedroso-de-Moraes, C., Souza-Leal, T., Callegari-Correia, E., Prezzi, L.E., Domingues, E. & Canassa, F. 2010. Diversidade de Orchidaceae da fazenda Cantagalo, município de Mogi-Mirim, São Paulo. Revista Brasileira de Biociências 8(3):242-245.

Souza, V.C. & Lorenzi, H. 2005. Botânica Sistemática: Guia ilustrado para a identificação das famílias de Angiospermas brasileiras, baseado no APG II. Instituto Plantarum de Estudos de Plantas, Nova Odessa. 640 p.

Souza-Leal, T. & Pedroso-de-Moraes, C. 2014. Fenologia reprodutiva e distribuição espacial de *Oeceoclades maculata* (Lindl.) Lindl. (Orchidaceae) em Cerrado do município de Mogi Guaçu, São Paulo, Brasil. Iheringia. Série Botânica 69(2):405-416.

Sprunger, S., Cribb, P. & Toscano-de-Brito, A.L.V. 1996. João Barbosa Rodrigues – Iconographie des orchidées du Brésil. v. 1 and 2. The illustrations. Basle, Friedrich Reinhardt Verlag. 540 p.

Tabanez, A.A.J., Viana, V.M. & Dias, A.D.S. 1997. Consequências da fragmentação e do efeito de borda sobre a estrutura, diversidade e sustentabilidade de um fragmento de floresta de planalto de Piracicaba, SP. Revista Brasileira de Biologia 57(1):47-60.

Ter Steege, H. & Cornelissen, J.H.C. 1989. Distribution and Ecology of vascular epiphytes in Lowland Rain Forest of Guyana. Biotropica 21(4):331-339.

Viana, V.M. & Pinheiro, L.A.F.V. 1998. Conservação da biodiversidade em fragmentos florestais. Série técnica IPEF 12(32):25-42.

Viana, V.M., Tabanez, A.A.J. & Martinez, J.L.A. 1992. Restauração e manejo de fragmentos de florestas naturais. Revista do Instituto Florestal 4(2):400-406.

Viana, V.M., Tabanez, A.A.J. & Batista, J.L.F. 1997. Dynamics and restoration of forest fragments in the Brazilian Atlantic Moist Forest. *In* Tropical forest remnants: ecology, management and conservation of fragment communities (W.F. Lawrence & R.O. Bierregard, eds.). University Press, Chicago, p. 351-363.

Waechter, J.L. 1998. Epifitismo vascular em uma floresta de restinga do Brasil subtropical. Ciência e Natura 20(4):43-66.

Williams-Linera, G. 1990. Vegetation structure and environmental conditions of forest edges in Panama. Journal of Ecology 78:356-373.

Zuidema, P.A., Sayer, J.A. & Dijkman, W. 1996. Forest fragmentation and biodiversity: the case for intermediate-sized conservation areas. Environmental Conservation 23(4):290-297.