Original Article

IMPACTS OF DISTURBANCE INTENSITY IN FUNCTIONAL TRAITS PATTERNS IN UNDERSTORIES OF SEASONAL FORESTS

IMPACTOS DA INTENSIDADE DE PERTURBAÇÃO NOS PADRÕES DOS TRAÇOS FUNCIONAIS EM SUB-BOSQUES DE FLORESTAS ESTACIONAIS

Jamir Afonso do PRADO JÚNIOR[1]; Vagner Santiago do VALE[1]; Sérgio de Faria LOPES[2]; Carolina de Silvério ARANTES[1]; Ana Paula de OLIVEIRA[1]; Ivan SCHIAVINI[3]

1. Post Graduation in Ecology and Conservations of Natural Resources, Biology Institute, Uberlandia Federal University, Uberlandia, MG, Brazil. jamirpradojunior@gmail.com; 2. Adjunct Professor, Biology Department, Paraiba State University, Brazil.
3. Associated Professor, Biology Institute, Uberlandia Federal University, Uberlandia, MG, Brazil.

ABSTRACT: Environmental disturbances alter the functional structure of forests, mainly in the understory, the layer which is most sensitive to disturbance. This study evaluated the patterns of leaf phenology and seed dispersal syndrome of tree species in ten understories of seasonal semideciduous forests under different stages of disturbance, and tested the hypothesis that an increase in disturbance intensity directly affects the representativeness of these two functional traits in the understory. The classifications of leaf phenology and seed dispersal syndrome were based on the literature and were compared between the understory and upper strata in each area, among ten understories and among understories under different intensities of disturbance. Comparisons of leaf phenology and dispersal syndrome showed a very low proportion of deciduous and anemochoric species in the understory compared to the upper strata. In comparisons of these traits among understories, there was a significant increase in the proportion of deciduous species in more disturbed stadiums, but not in the proportion of anemochoric species. The results showed that even with very distinct floristic diversity it was possible to establish functional patterns related to leaf phenology and dispersal syndrome in the understories of seasonal semideciduous forests. It is suggested that analysis of these traits can help as a parameter for the classification of successional stages of seasonal semideciduous forests in a global comparison.

KEYWORDS: Conservation. Seed dispersal syndrome. Ecological filters. Environmental perturbation. Leaf phenology. Stratification.

INTRODUCTION

Functional plant ecology assumes that the distribution of plant organisms is not random, and therefore, that there is a link between functional differences of species and their distribution in contrasting habitats (DUARTE, 2007). Classification of plant species based on their functional traits allows us to understand their interactions within ecosystems (CORNELISSEN et al., 2003).

Many functional plant traits are directly affected by microclimatic vertical gradient resulting from stratification in tropical forests (POORTER et al., 2006). Starting from understory to canopy, the gradient of abiotic conditions include increased availability of light, temperature and wind exposure, and a decrease in humidity and CO_2 concentration (FATHI-MOGHADAM, 2007). Thus, differences are expected between strata, not only in the floristic patterns, but also regarding the ecophysiological processes related to the functional traits of species (POORTER et al., 2006).

Leaf phenology, a trait that represents the period of the year when the tree canopy is photosynthetically active (CORNELISSEN et al., 2003), is often associated with the functional disposition of species in the stratum of the community (KISANUKI, 2008; ISHII; ASANO, 2010). In very shady areas, evergreen species predominate, while in environments with high insolation, the development of species with lower leaf longevity is favored (UEMURA, 1994). Functional reproductive traits, such as dispersal syndrome, may also reflect the adaptive capacity of species to environmental heterogeneity associated with stratification (HOWE; SMALLWOOD, 1982). The occurrence of anemochoric species, for example, is commonly attached to open environments with greater exposure to wind, and in forest communities, its occurrence is virtually restricted to the canopy (HOWE; SMALLWOOD, 1982).

Evaluation of the distribution patterns of functional traits for each stratum of vegetation can assist in understanding the responses of forest

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communities to environmental changes related to disturbances. The understory especially, is the stratum most sensitive to environmental perturbations (MULKEY; PEARCY, 1992). In very disturbed areas, irradiance that reaches the ground can represent more than 30% of the total that reaches the canopy and the air temperature can increase by 4-10°C (FETCHER et al., 1985; POORTER et al., 2006). These altered conditions subject the understory species to a greater water stress (MULKEY; PEARCY, 1992) and wind exposure (CASSIANI et al., 2008), which may favor the development of deciduous and anemochoric species in the understories of disturbed communities, contradicting patterns typically observed.

Thus, the objective of this study was to investigate how the disturbance regime influences the patterns of leaf phenology and dispersal syndrome in ten understories of seasonal semideciduous forests under different intensities of disturbance from the following assumptions: (a) although deciduous and/or anemochoric species have great importance in seasonal semideciduous forests, the proportion of these species in the understory is low, which functionally characterizes this stratum as evergreen and non anemochoric; (b) the more intense the disturbance regime of the area, the greater will be the proportion of deciduous and anemochoric species in understory.

MATERIAL AND METHODS

Research sites and stratification

This study departed from previous phytosociological tree community studies (DBH ≥ 5 cm) in ten sites of seasonal semideciduous forests in Central Brazil, totaling a sample of 10 ha (Table 1) (LOPES et al., 2012). Lopes (2010) classified the sites according to disturbance intensity (Table 2) from an impact matrix, which considered structural parameters such as abundance of pioneer species, canopy height, presence of large gaps or internal trails and selective logging, among others.

The areas under lower disturbance intensity have forests in advanced succession stages, presenting lower edge effects and the absence of cattle and selective logging (LOPES, 2010). The areas under intermediary disturbance, as well as the lower impact areas, present a high canopy and a low number of pioneer species, but the areas strongly disturbed under the matrix, have internal trails and livestock which increase the trampling and grazing in the area, also increasing its degradation (LOPES, 2010). Areas under higher disturbance intensity (except PAN) are, under the matrix, strongly disturbed presenting a large edge effect. At present the lowers canopies have many internal trails and the presence of cattle and selective logging (LOPES, 2010). The PAN, despite being a Conservation Unit, is in the initial stage of succession, with many gaps, a low canopy and the presence of many internal trails (LOPES, 2010). More details on the sampling methodology and the impact matrix description of the ten sites can be found in Lopes (2010).

Species sampled at the ten sites used in this study were classified according to their position in the community strata: canopy, intermediary stratum (under-canopy) and understory species (LOPES, 2010), using a nonparametric methodology based on quartiles and medians of species heights (VALE et al., 2009). As the focus of this study was the understory, upper strata (canopy and intermediary stratum) were combined into a single category.

Since this paper aimed to study the tree community, with DBH ≥ 5 cm standardized for seasonal semidecidual forests (FELFILI et al., 2011), herbaceous and shrubby species that were present in the understory "*lato sensu*" were not included in the sample. Thus, tested hypotheses are just applicable to the tree community in the understory (Appendix 1).

Functional traits

For the leaf phenology trait, species were classified as evergreen or deciduous. The deciduousness of a species should be considered when the leaf loss exceeds 80% of the total estimated volume of foliage for the individual (CORNELISSEN et al., 2003). Therefore, even if a species loses some leaves during the dry season, it will continue to be considered evergreen (CORNELISSEN et al., 2003). As for dispersal syndrome, species were classified into anemochoric (dispersion by wind), zoochoric (dispersion by animals) or autochoric (dispersion by gravity and / or explosion) according to morphological criteria fruit (VAN DER PIJL, 1982). To test our hypotheses, the zoochoric and autochoric species were combined into a single category (non anemochoric).

Data analysis

As the number of individuals varies within the same site (whether between plots or among strata) and between areas, we chose to relativize the absolute values of density and use percentages or numbers of deciduous/anemochorous individuals in this analysis. Comparative analyses of the proportion of functional traits between understory and upper strata were performed in each site through the nonparametric Wilcoxon test. When the comparison involved the same stratum in the ten sites, we used the nonparametric Kruskal-Wallis test. To test whether disturbance intensity affects patterns of leaf phenology and dispersal syndrome in the understory, those under the same disturbance intensity category were grouped and then the nonparametric Kruskal-Wallis test was performed. These analyses were calculated using the program SYSTAT 10.2 (WILKINSON, 2002).

Table 1. Location, floristic and structural parameters of tree community (DBH ≥ 5 cm) in ten sites of seasonal semideciduous forests in Central Brazil. S = number of species, NI = number of individuals; BA = basal area (m^2), H '= Shannon's diversity index, J' = evenness index. Codes correspond to areas of original nomenclature used by Lopes (2010). Structural parameters are equivalent to absolute values per hectare (adapted from Lopes et al. (2012).

Site	Code	Latitude (S)	Longitude (O)	Extension (ha)	S	NI	BA	H'	J'
1	AGU	18º 29' 50"	48º 23' 03"	200	78	839	25,5	3,44	0,79
2	IPI	18º 43' 39"	49º 56' 22"	40	50	837	15,1	2,92	0,75
3	MON	18° 45' 02"	47º 30' 35"	120	98	798	26,4	3,97	0,87
4	UBE	19º 40' 35"	48º 02' 12"	70	90	805	45,8	3,33	0,73
5	CRU	18º 40' 26"	48º 24' 32"	18	79	1233	23,5	3,37	0,77
6	GLO	18º 56' 23"	48º 12' 39"	30	86	976	26,2	3,71	0,83
7	IRA	19º 08' 39"	48° 08' 46"	22	76	945	27,0	3,47	0,81
8	PAN	19º 10' 04"	48° 23' 41"	16	98	1292	21,7	3,78	0,82
9	PER	18º 55' 40"	48º 03' 51"	35	103	1144	26,8	3,87	0,84
10	SÃO	18° 51' 35"	48º 13' 53"	20	88	1063	34,7	3,53	0,79

Table 2. Classification and description of ten sites of seasonal semideciduous forests according to disturbance intensity (adapted from Lopes (2010)).

Sites	Disturbance intensity	Description
AGU, UBE	Low	Low number of pioneer species, many individuals with high basal area, high canopy, large fragments without internal trails or logging
GLO, IRA, PER, SÃO	Medium	Low number of pioneer species, few individuals with high basal area, high canopy, small fragments, presence of internal trails with surrounding disturbed matrix
CRU, IPI, MON, PAN	High	High number of pioneer species, few individuals with high basal area, low canopy, presence of internal trails with surrounding disturbed matrix

RESULTS

The percentage of deciduous individuals in the understory was lower than in the upper strata in all areas (Wilcoxon test, $p < 0.05$) (Table 3). In the understory, the percentage of deciduous individuals ranged from 0 to 28.4%, much lower than in the upper strata which ranged from 24.5 to 90.2%. For the percentage of deciduous individuals in the upper strata, there were significant differences between areas (Kruskal-Wallis test, H = 145.57, $p < 0.05$), whereas no significant differences were found in the understories (Kruskal-Wallis test, H = 121.08, $p < 0.05$), except for in two areas that had a high index of disturbance, IPI and PAN (Table 3).

The same pattern was found for anemochory, where the percentage of anemochorous individuals in the understory was lower compared to the upper strata (Wilcoxon test, p <0.05). In the understory, the percentage of anemochorous individuals ranged from 0 to 3.0%, and in the upper strata from 14.6 to 47.5% (Table 3). The percentage of anemochory in the upper strata showed significant differences between areas (Kruskal-Wallis test, H = 107.34, p <0.05), but not in the understory (Kruskal-Wallis , H = 10.26, p <0.05), which confirms the low representation of these functional traits in the understory.

Table 3. Comparison of the percentage of deciduous individuals and anemochorous individuals between the understory and the upper strata, using the Wilcoxon test, and among the same stratum in different sites, using the Kruskal-Wallis test (p <0.05). The letters beside percentages indicate the result of the median test with the same stratum among different sites (p <0.05). df = degrees of freedom of the Wilcoxon test, Z = critical value of the Wilcoxon test, p = probability of the Wilcoxon test.

Sites	Deciduousness					Anemochory				
	Upper strata (%)	**Understories (%)**	**gl**	**Z**	**p**	**Upper strata (%)**	**Understories (%)**	**df**	**Z**	**P**
AGU	28.3 [a]	1.6 [a]	24	4.37	< 0.05	14.6 [a]	0.6 [a]	24	4.08	< 0.05
CRU	66.3 [c,d]	2.8 [a]	24	4.37	< 0.05	47.5 [d]	1.1 [a]	24	4.37	< 0.05
GLO	33.5 [a,b]	2.0 [a]	24	4.37	< 0.05	29.0 [b,c]	0.5 [a]	24	4.37	< 0.05
IPI	90.2 [d]	28.4 [b]	24	4.35	< 0.05	36.9 [c,d]	3.0 [a]	24	4.37	< 0.05
IRA	24.5 [a]	0.0 [a]	24	4.29	< 0.05	18.9 [a,b]	0.0 [a]	24	4.37	< 0.05
MON	27.9 [a]	4.1 [a]	24	4.37	< 0.05	24.4 a,[b,c]	0.5 [a]	24	4.37	< 0.05
PAN	47.0 [b,c]	14.2 [b]	24	4.35	< 0.05	27.0 b,[c]	2.4 [a]	24	4.37	< 0.05
PER	34.8 [a,b]	2.1 [a]	24	4.37	< 0.05	34.8 [c,d]	0.4 [a]	24	4.37	< 0.05
SÃO	31.8 [a,b]	0.4 [a]	24	4.37	< 0.05	33.7 [c,d]	0.8 [a]	24	4.37	< 0.05
UBE	26.9 [a]	0.8 [a]	24	4.35	< 0.05	18.2 [a,b]	2.0 [a]	24	4.29	< 0.05

Despite the low representation of deciduous species in the understory in general, areas with the highest intensity of disturbance had higher percentages of deciduousness in the understory (Figure 1). This trend was confirmed by the Kruskal-Wallis test (H = 49.5, p <0.01) between stages of disturbance, showing that the percentage of deciduous individuals in the understory was significantly higher in the group under high disturbance and similar among areas with the most conserved and intermediate stage. Therefore, the degree of disturbance contributes to an increase in deciduousness in the understory.

For anemochory, the low percentage of anemochorous individuals in the understory was similar among the three categories of disturbance (Figure 1), confirmed by the non-significance of the Kruskal-Wallis test (H = 1.6, p = 0.44). This result demonstrates that the disturbance of forest fragments does not increase the number of anemochorous individuals in the understory, even in the most disturbed fragments.

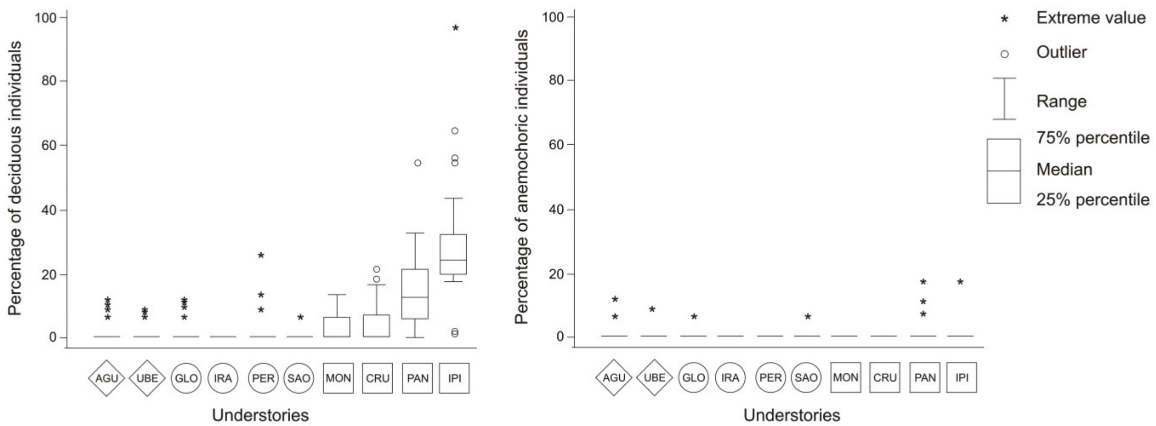

Figure 1. Box plot of the percentage of deciduous and/or anemochorous individuals in ten understories. The legend of the graphs was inserted into the right corner of the figure. The codes of the areas are described in Table 1. The diamonds represent the most conserved sites, circles represent medium disturbance sites and squares represent sites under greater intensity of disturbance.

DISCUSSION

We observed a pattern of leaf phenology and dispersal syndrome in the understory of the studied areas, where the percentage of deciduous species and anemochoric species was very low. In the upper strata the representativeness of these traits varied greatly among sites. Deciduousness and anemochoric syndrome are closely related to seasonal climate and therefore have great importance in semideciduous forests. Results show that although the representativeness of deciduous and/or anemochoric species varies greatly among semideciduous forests (MURPHY; LUGO, 1986; OLIVEIRA-FILHO; FONTES, 2000; TONIATO; OLIVEIRA-FILHO, 2004), this variation is largely confined to the higher strata, maintaining a pattern of evergreen and non anemochoric species in the understory of these forests. This corroborates our first hypothesis.

The period of leaf senescence and leaf loss of canopy species allows a longer growing season for evergreen species in the understory (UEMURA, 1994). Moreover, the reduction of light intensity and temperature in the understory result in a lower vapor pressure deficit, reducing transpiration and water stress (MULKEY; PEARCY, 1992), and consequently, the deciduousness in the understory. The decrease in expenses related to the photoinhibition of understory species, mainly related to mechanisms mediating the xanthophyll, enable increased investment in structural carbohydrates, which reduce damage against herbivory and prolong the longevity of the leaf (PEARCY, 2007).

Another condition that corroborates the evergreen understory is related to variation between the amount of irradiance that reaches the upper and lower canopy. As this change is greater in the upper strata (KUPPERS et al., 1996), species of these strata accelerate the process of senescence for lower leaves, and self-shadow and reallocate resources to form sheets in the highest portion of the canopy (VALADARES; NIINEMETS, 2007). In the understory, where this difference is much lower, the retention of leaves by species of the understory allow an increase in the canopy of these species and the consequent increase in their photosynthetic rate (POORTER et al., 2006)

The species of the understory develop various responses to maximize photosynthesis at low light intensities (PEARCY, 2007). Besides the increase in leaf area and/or photosynthetic capacity per leaf biomass (REICH et al., 2003), increase in leaf longevity also plays an important role in enhancing the net photosynthesis of these species. Shaded leaves show a low foliar construction cost, since they are less thick and have lower concentrations of photosynthetic enzymes per area (PEARCY, 2007). However, these sheets can take 60 to 150 days to recover the amount of carbon invested in the sheet, while leaves in the sun reach this balance within a few days (SIMS; PEARCY, 1992; PEARCY, 2007).

The flow of seed also has a potential role in the establishment of species in a community

(HARPER, 1977). Anemochoric species present winged diaspora and a greater surface area to increase the fall time of seeds and therefore the distance at which the wind will carry them (HOWE; SMALLWOOD, 1982). The vegetative elements, such as stems and leaves, are an obstruction to the passage of wind inside the forest, which reduces the intensity of air currents in the understory (FATHI-MOGHADAM, 2007; CASSIANI et al., 2008), and the effectiveness of anemochoric in this stratum. Proximity to the parent plant reduces the likelihood of survival for the seeds and for the establishment of new individuals, mainly due to increased predation, pathogen attack and competition among seedlings (JANZEN, 1970).

The height of the individual positively influences the dispersal distance of anemochoric seeds (AUGSPURGER, 1986). Furthermore, anemochory is generally associated with non-tolerant species, shade, and deciduousness (JANZEN, 1988), which increase the ecological filters (CINGOLANI et al., 2007) for establishment of anemochoric species groves in the understory. Of the 57 anemochoric species sampled in ten sites, for example, 48 (84%) were classified as deciduous. Thus, deciduous and/or anemochoric species are not functionally viable in the understory, and therefore their occurrence should be largely confined to the upper strata, which explains our first hypothesis.

Differences between strata with respect to dispersal syndrome were also observed in other semideciduous forests, and understory dominated by species typically zoochoric (MORELLATO; LEITÃO-FILHO, 1992; YAMAMOTO et al., 2007). The prevalence of zoochorous syndrome in the understory is related to the increased activity of animal life in the lower strata of the forest (GENTRY; EMMONS, 1987). Unlike wind dispersed species, which commonly bear fruit in the dry season when they would be stronger, many zoochoric species have a sequential fruiting pattern, producing fruit throughout the year (MORELLATO; LEITÃO-FILHO, 1992). This thus demonstrates the importance of the understory in offering resources for local wildlife and, consequently, the balance between the ecological processes of forest formations.

Despite the lower percentage of deciduousness in understories compared to the canopy, there is a significant increase in the percentage of deciduous individuals in most disturbed understories. Thus, even having very distinct species diversity, relative to leaf phenology the more conserved understories are functionally closest to understories with intermediate disturbance rather than those under high intensity of disturbance. In addition, despite the deciduousness in semideciduous forests being closely associated with climatic variations and soil between areas (MURPHY; LUGO, 1986), in the understory, the effect of disturbance has a great influence on deciduousness, confirming our second hypothesis.

The lower canopy and the presence of internal trails or selective logging in the most disturbed sites (LOPES, 2010) increases the discontinuity canopy and changes in lighting conditions and water stress, which alters the microclimate of the forest and exposes the understory to increased susceptibility (FETCHER et al., 1985). The understory is characterized by having the largest forest dynamics among the other strata (WHITMORE, 1978), and just opening glades, whether natural or anthropogenic, allows the entry of new groups of species with different functional characteristics, in this case, deciduous species.

Patterns of leaf phenology and dispersal syndrome in the understory can serve as a parameter in the classification of successional stages of semideciduous forests in a global comparison. Most studies comparing the successional stages of forest communities complete classification of species in so-called "regeneration guilds". However, this classification has been widely questioned regarding subjectivity, since many tropical forest species survive and develop over a relatively broad spectrum of light gradients.

Considering the wide distribution of semideciduous forests worldwide, the high richness of endemic species and the different factors that can affect beta diversity (MURPHY; LUGO, 1986; KALACSKA et al., 2004; MILES et al., 2006) even at small spatial scales, it is difficult to draw comparisons between these forests using only taxonomic classifications. These results reinforce the importance of using the functional traits of species to understand the functioning of semideciduous forests and for establishing ecological standards that exceed the regional comparison.

Remnants of seasonal forest are exposed to constant threats from fragmentation of habitat by global climate change (MILES et al., 2006). Considering the high endemism and phytodiversity of most species, the conservation of these forests should be adopted as a priority (MILES et al., 2006). As regional and even global disturbances directly affect the functional traits of species, evaluation of the distribution patterns of these traits in natural remnants may aid the understanding of ecological processes and vegetation responses to future disturbances.

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RESUMO: Os distúrbios ambientais alteram a estrutura funcional das florestas, principalmente no sub-bosque, estrato mais sensível às perturbações. Este estudo avaliou os padrões de fenologia foliar e síndrome de dispersão das espécies arbóreas em dez sub-bosques de florestas estacionais semideciduais sob diferentes estádios de perturbação, e testou a hipótese de que o aumento na intensidade de perturbação da comunidade afeta diretamente a representatividade destes dois traços funcionais. A classificação de fenologia foliar e síndrome de dispersão foi baseada na literatura, e foram comparadas entre o sub-bosque e os estratos superiores em cada área, entre os sub-bosques como um todo e entre os sub-bosques sob diferentes intensidades de perturbação. As comparações de fenologia foliar e síndrome de dispersão mostraram uma proporção muito baixa de espécies decíduas e anemocóricas no sub-bosque em relação aos estratos superiores. Nas comparações destes traços entre os sub-bosques, observou-se um aumento significativo nas proporções de espécies decíduas nos estádios mais perturbados, mas não nas proporções de espécies anemocóricas. Os resultados obtidos mostraram que, mesmo com diversidades florísticas muito distintas, foi possível estabelecer padrões funcionais relacionados à fenologia foliar e síndrome de dispersão dos sub-bosques e, sugerem que a análise destes traços pode servir como parâmetro na classificação dos estádios sucessionais das florestas estacionais semideciduais em uma perspectiva global de comparação.

PALAVRAS-CHAVE: Conservação. Estratificação. Fenologia foliar. Filtros ecológicos. Perturbação ambiental. Síndrome de dispersão.

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Appendix 1. Understory species list sampled in ten sites of seasonal semideciduous forest of southeastern Brazil, with its respective botany families, site occurrence, seed dispersal syndrome and leaf phenology. SDS = seed dispersal syndrome, LF = leaf phenology. Ane = anemochocy, Aut = autochory, Zoo = zoochory. * The numbers of occurrence represents the sites in Table 1. The densities of species in each site can be founded in Lopes et al., (2012).

Species	Family	Occurrence*	LF	SDS
Acalypha gracilis (Spreng.) Müll.Arg.	Euphorbiaceae	1,10	Evg	Aut
Allophylus edulis (A.St.-Hil., Cambess. & A.Juss.) Radlk.	Sapindaceae	1	Evg	Zoo
Allophylus racemosus Sw.	Sapindaceae	1,8,10	Evg	Zoo
Aloysia virgata (Ruiz & Pav.) A.Juss.	Verbenaceae	1,2	Dec	Ane
Annona montana Macfad.	Annonaceae	2	Dec	Zoo
Ardisia ambigua Mez	Myrsinaceae	1,3,4	Evg	Zoo
Bauhinia rufa (Bong.) Steud.	Fabaceae	2,5,6,9	Evg	Aut
Bauhinia ungulata L.	Fabaceae	2,3,6,8,10	Evg	Aut
Byrsonima laxiflora Griseb.	Malpiguiaceae	3,5,7,9	Evg	Zoo
Calyptranthes widgreniana O.Berg	Myrtaceae	1,4	Evg	Zoo
Campomanesia guazumifolia (Cambess.) O.Berg	Myrtaceae	5	Dec	Zoo
Campomanesia velutina (Cambess.) O.Berg	Myrtaceae	2,3,4,5,6,8,9	Dec	Zoo
Celtis iguanaea (Jacq.) Sarg.	Cannabaceae	1,2,3,5,6,9	Dec	Zoo
Centrolobium tomentosum Guillem. ex Benth.	Fabaceae	4	Dec	Ane
Cheiloclinium cognatum (Miers.) A.C.Sm.	Celastraceae	1,3,4,5,6,7,8,9,10	Evg	Zoo
Chionanthus trichotomus (Vell.) P.S.Green	Oleaceae	8	Evg	Zoo
Chomelia pohliana Müll.Arg.	Rubiaceae	1,3,4,10	Evg	Zoo
Chrysophyllum gonocarpum (Mart. & Eichler) Engl.	Sapotaceae	1,3,4,9	Evg	Zoo
Cordiera sessilis (Vell.) Kuntze	Rubiaceae	1,2,3,5,6,7,8,9,10	Evg	Zoo
Coussarea hydrangeifolia (Benth.) Müll.Arg.	Rubiaceae	3,4,5,7,8,9	Evg	Zoo
Coutarea hexandra (Jacq.) K.Schum.	Rubiaceae	2,3,4,5,8,9,10	Evg	Ane
Endlicheria paniculata (Spreng.) J.F.Macbr.	Lauraceae	8	Evg	Zoo
Erythroxylum daphnites Mart.	Erythroxylaceae	5	Evg	Zoo
Erythroxylum deciduum A.St.-Hil.	Erythroxylaceae	8	Evg	Zoo
Eugenia involucrata DC.	Myrtaceae	1,3,4,8	Evg	Zoo
Eugenia ligustrina (Sw.) Willd.	Myrtaceae	4,8,9	Evg	Zoo
Eugenia subterminalis DC.	Myrtaceae	1,4	Evg	Zoo
Faramea hyacinthina Mart.	Rubiaceae	6,7,8,9,10	Evg	Zoo
Galipea jasminiflora (A.St.-Hil.) Engl.	Rutaceae	4	Evg	Aut
Gomidesia lindeniana O.Berg	Myrtaceae	7	Evg	Zoo
Guapira opposita (Vell.) Reitz	Nyctaginaceae	9	Evg	Zoo
Guapira venosa (Choisy) Lundell	Nyctaginaceae	1,2,4,8	Evg	Zoo
Hirtella gracilipes (Hook.f.) Prance	Chrysobalanaceae	3,4,7,9,10	Evg	Zoo
Ilex cerasifolia Reissek	Aquifoliaceae	3	Dec	Zoo
Inga marginata Willd.	Fabaceae	1	Evg	Zoo
Lacistema aggregatum (P.J.Bergius) Rusby	Lacistemataceae	3,7	Evg	Zoo
Magonia pubescens A.St.-Hil.	Sapindaceae	2	Dec	Aut
Maytenus floribunda Reissek	Celastraceae	3,4,5,6,8,10	Evg	Zoo
Maytenus robusta Reissek	Celastraceae	3	Evg	Zoo
Mollinedia widgrenii A.DC.	Monimiaceae	4,9,10	Evg	Zoo

Myrcia splendens (Sw.) DC.	Myrtaceae	2,3,4,5,7,8	Evg	Zoo
Myrciaria glanduliflora (Kiaersk.) Mattos & D.Legrand	Myrtaceae	5,6,7,9	Evg	Zoo
Myrciaria tenella (DC.) O.Berg	Myrtaceae	9	Evg	Zoo
Peltophorum dubium (Spreng.) Taub.	Fabaceae	6,10	Dec	Ane
Phyllanthus acuminatus Vahl	Phyllanthaceae	8	Evg	Aut
Pilocarpus spicatus A.St.-Hil.	Rutaceae	1	Evg	Aut
Piper amalago L.	Piperaceae	1	Evg	Zoo
Piper arboreum Aubl.	Piperaceae	4	Evg	Zoo
Porcelia macrocarpa (Warm.) R.E.Fr.	Annonaceae	4	Evg	Zoo
Prockia crucis P.Browne ex L.	Salicaceae	3,8	Dec	Zoo
Psidium rufum DC.	Myrtaceae	6,7,8,9	Evg	Zoo
Rudgea viburnoides (Cham.) Benth.	Rubiaceae	3,5,7,8,9	Evg	Zoo
Salacia elliptica (Mart. ex Schult.) G.Don	Celastraceae	1	Evg	Zoo
Siparuna guianensis Aubl.	Siparunaceae	3,5,6,7,8,9,10	Evg	Zoo
Sorocea bonplandii (Baill.) W.C.Burger et al.	Moraceae	4,6,9,10	Evg	Zoo
Symplocos pubescens Klotzsch ex Benth.	Symplocaceae	8	Evg	Zoo
Syzygium jambos (L.) Astun.	Myrtaceae	9	Evg	Zoo
Tocoyena formosa (Cham. & Schltdl.) K.Schum.	Rubiaceae	8	Evg	Zoo
Trema micrantha (L.) Blume	Cannabaceae	2,3	Evg	Zoo
Trichilia catigua A. Juss.	Meliaceae	1,2,3,4,5,6,9,10	Evg	Zoo
Trichilia claussenii C.DC.	Meliaceae	1,4	Evg	Zoo
Trichilia elegans A.Juss.	Meliaceae	1,2,3,4,6,8,10	Evg	Zoo
Trichilia pallida Sw.	Meliaceae	1,3,4,5,6,8,10	Evg	Zoo
Vochysia tucanorum Mart.	Vochysiacaeae	8	Evg	Ane
Xylosma prockia (Turcz.) Turcz.	Salicaceae	3	Dec	Zoo