Seed inflow to a forest patch promoted by understory frugivorous birds

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Abstract: We studied the contribution of understory frugivorous birds to the seed inflow into a late successional Atlantic forest patch in southeastern Brazil. Five sampling units were established in the study site, each composed of a line of six mist nets and two adjacent plots containing six seed traps. Immigrant seed species were more frequent in seed traps during the rainy season, when fruit production was higher. On the other hand, the frequency of occurrence of immigrant seed species found in fecal samples of the understory frugivores was higher during the dry season. Although understory frugivorous birds were not responsible for the temporal pattern of the seed rain, they can play an important role in bringing edge plant species that will eventually colonize forest gaps, contributing to forest patch dynamics.
Keywords: Atlantic forest, frugivory, immigrant seeds, seed dispersal.

Resumo: Estudamos a contribuição de aves frugívoras de subosque para a entrada de sementes em uma mancha de Floresta Atlântica secundária em estado avançado de regeneração no sudeste do Brasil. Foram estabelecidas cinco unidades amostrais, cada uma composta por uma linha de seis redes de neblina e duas parcelas adjacentes contendo seis coletores de sementes. Espécies de sementes imigrantes foram encontradas mais frequentemente nos coletores durante a estação chuvosa, quando houve maior produção de frutos. Por outro lado, a frequência de ocorrência de espécies imigrantes nas amostras fecais de aves de subosque foi maior durante a estação seca. Embora aves frugívoras de subosque não tenham sido determinantes para o padrão temporal da chuva de sementes, podem desempenhar um papel importante ao trazerem espécies de plantas de borda que poderão colonizar clareiras, contribuindo assim para a dinâmica de manchas florestais.
Palavras-chave: Floresta Atlântica, frugivoria, sementes imigrantes, dispersão de sementes.

Introduction

Natural regeneration in tropical forests is greatly dependent upon a frequent seed rain, as most plants have seeds with rapid germination and low longevity (Garwood 1983, Vazquez-Yanes & Orozco-Segovia 1993). Therefore, in these forests seed bank may play a minor role in natural regeneration (Ng 1983), what puts seed rain in the spotlights. Seed rain is composed by local or immigrant seeds in different proportions (Martinez-Ramos & Soto-Castro 1993), depending on plant phenology (Rathcke & Lacey 1985) and seed dispersal. Its patterns are importantly influenced by seed dispersal, which may favor germination and establishment, either by making seeds arrive at specific "safe sites" or by allowing the seeds to avoid competition or predation under the parent plant (Green 1983, Howe & Miriti 2000).

Understand a seed rain pattern generated by vertebrate seed dispersers allows us to comprehend regeneration and organization of plant communities (McDonnell & Stiles 1983, Loiselle et al. 1996, Hubbell et al. 1999). For seed rain generated by birds, it has been shown that it may depend on local plant diversity, structural characteristics of the habitat, local availability of resources (McClanahan & Wolfe 1987, Levey 1990, Oldeman 1990), and behavior of the disperser species (Krijger et al. 1997, Jordano & Godoy 2002).

Vertebrate seed dispersal gained another perspective in the context of forest fragmentation. Like in other tropical areas, most of the Brazilian Atlantic forest is reduced to small fragments of secondary forests (Ribeiro et al. 2009), vulnerable to indirect biological edge effects, such as plant invasion from the matrix through seed dispersal by animals (Murcia 1995). Thus, there is an urgent need to gather information on how forest fragments are influenced by their surroundings (Janzen 1983, Chimera & Drake 2010), with implications for the conservation of natural preserves (Janzen 1986).

Literature commonly reports bird-mediated seed dispersal from forest to earlier successional habitats (e.g. Scot Duncan 2006, Herrera & Garcia 2010). However, it scarcely reports the opposite seed flow performed by birds, the influx of edge seeds into the forest. Indeed, it would not be surprising that the same bird species that are able to carry seeds off the forest could also introduce into the forest seeds ingested in the more open nearby habitats, as seem to be the case for several opportunistic edge-dweller forest frugivores (Restrepo et al. 1999). This seed counter-flow would present composition, spatial and temporal variation according to the differences in fruit phenology and habitat preferences by frugivorous birds, with possible consequences for the plant populations at local and regional scales. In this study we addressed the contribution of understory frugivorous birds to the influx of pioneer seed species into an Atlantic forest patch, as well as the composition and temporal patterns of the seed rain promoted by them.

Material and Methods

1. Study area

We collected data in a secondary forest tract of Atlantic forest with approximately 4 ha inside Intervales State Park (PEI), south of São Paulo State, southeastern Brazil (24° 16' 09" S and 48° 24' 56" W, 800 m asl). PEI is a 49,000 ha protected park well connected to three other reserves encompassing a total of 120,000 ha of continuous protected forest, being a mosaic of pristine/old-growth and secondary forests. Regional climate is characterized by rainfall throughout the year with the highest values being reached in the hottest months, from November to March. Annual mean temperature in the study year was

16.7 °C (31 °C max and 1.6 ° min) and the annual rainfall was 1543 mm. Although variation occurs, the vegetation of the park is broadly classified as lower montane rain forest (700-1100 m asl; Oliveira-Filho & Fontes 2000) and plant composition is influenced by the humid forests of Southern Brazil and the mesophilous forests of the interior plateau of São Paulo State (Fundação… 1997). The study area, located 1-2 km from the park administration office, was formerly a plantation and has been regenerating into a secondary forest over the last 50 years. It is surrounded by dirt roads, an arboretum, and another smaller forest tract, but mature forest can be found in a 1 km radius. Forest canopy is about 22 m high, with conspicuous individuals of *Ocotea puberula* (Rich.) Nees (Lauraceae) and the understory is dense with many individuals of *Piper* spp. L. (Piperaceae), *Dichorisandra thyrsiflora* J.C. Mikan (Commelinaceae), *Heliconia farinosa* Raddi (Heliconiaceae) and *Psychotria suterella* Müll. Arg. (Rubiaceae). For a more detailed description of understory structure, see Gomes & Silva (2002).

2. Sampling units

We established five sampling units (SUs), each one containing a line of six mist nets (12×2.5 m; 36 mm mesh) and two plots of 10×25 m adjacent to the nets (totaling 10 plots or 2,500 m²). Between April 1999 and March 2000, we captured birds monthly, for five days per month, one day at each SU, 6 hour per day (2160 net-hours). We marked all captured frugivorous birds with numbered aluminum bands provided by Cemave/Ibama (Ministry of Environment, Brazil). We considered legitimate frugivores those species that ingest seeds and void them intact (according to Snow 1981 and Sick 1997). We kept those birds in cloth bags for 30 to 60 minutes following capture, and then released them. After that, we inspected the bags for the presence of seeds, which we collected and preserved dry. We assumed that seeds found in bird feces would potentially be deposited on the adjacent plots if birds had not been captured. To sample seed rain we set six seed traps (1 m²; 20 cm high; 1 mm² mesh) inside each plot, totaling 60 traps in the whole study area, from which we collected seeds and ripe fruits caught. Although secondary dispersers (ants) could remove some seeds from the traps, or they could even rot in the traps between samplings, we noticed that the species collected in traps represented the true fruit availability for frugivores in the study area. We considered here only those seeds identified at least on the family level.

Once a month we counted (directly) or estimated (counting a branch or a part and extrapolating to the whole crown, when counting was not precise) ripe and unripe fruits inside the plots from all ornithochorous (sensu van der Pijl 1982) or zoochorous plants potentially consumed by birds (Ladrum 1986 apud Pizo 2002, Levey 1988, VSMG pers. obs.), considering not only plants totally inside the plots, as well as plants with their base and/or crown projected over the plots. We calculated the Fruit Abundance Index proposed by Levey (1988) to minimize large crop effects and we used it as a measure of ripe fruit abundance. Levey considered the following indexes for each interval of fruit abundance: (1) 1 to 10; (2) 11 to 25; (3) 26 to 50; (4) 51 to 100; (5) 101 to 200; (6) 201 to 500; (7) 501 to 1,000, (8) 1,001 to 10,000. We checked those species that did not produce fruits during the study period for their dispersal syndrome in Lorenzi (1998, 2000) or at the *herbarium* of the Universidade Estadual de Campinas (Herbário UEC).

Contrasting to resident seed species, immigrant ones were those neither recorded in any plot, nor in the study area outside the plots during random observations. We conducted those random observations on the main trail and along the mist net trails, totaling approximately 1500 m² sampled every month. In our analyses, pioneer species, presumably capable of colonizing edge or gap habitats are always shown separately from the understory species. To assign the

status of immigrant or resident to a seed we considered only those seeds identified at least on the genus level.

3. Data analysis

In order to verify the temporal pattern of seed immigration, we analyzed fruit production, seed rain, bird capture and fecal samples throughout 12 study months. To determine a possible relationship between ripe fruit production (independent) and presence of immigrant seeds in the traps (dependent) over the 12 months, we used Linear Regression Analyses. First we tested normality with the Kolmogorov-Smirnov test (Sokal & Rohlf 1997), option Lilliefors (SYSTAT 1990). When normality was rejected, we used the square root transformation (Zar 1996), and tested for normality again. Then, we performed linear regression with SYSTAT (1990).

Results

1. General aspects of the seed rain

We recorded 48 fruiting plant species (Appendix) and 52 morphospecies in the seed rain inside the plots, from which we identified 73% (38) at least on the genus level (being eight immigrants). Despite 41 species presented ripe fruits, 11 (27%) were never recorded at the local seed rain, indicating that we were not able to sample the entire seed rain. However, other seeds were recorded at the seed rain with no conspecifics in the same plot (letter S in Appendix), meaning that we were able to detect seed movement. Immigrant seeds represented 21% of the identified seeds and their adults were detected on the margins of the dirt road adjacent to the study area (Table 1). From the four typically pioneer species, three were present in one SU and one (*Rubus urticifolius* Poir.) in three. Immigrant species also represented 36% of seed species found in bird samples (10 species out of 28), from which the melastomes were represented by five species. Most of those immigrant species, both in bird samples and seed rain, typically inhabit forest edges and gaps (Table 1).

2. Temporal pattern of seed immigration

Immigrant seed species were more abundant in the seed rain (number of seed traps, square root transformed) when abundance of fruits was the highest (total fruit abundance) ($R^2 = 0.42$; $P = 0.02$; n = 12 mo; Figure 1), although there was no relationship between fruit production and presence of local species in the seed rain (number of seed traps) ($R^2 = 0.20$; $P = 0.15$; n = 12 mo; Figure 1).

On the other hand, understory birds brought immigrant seeds to the study area during 10 months of the year, mainly from May to September, a period of low fruit availability. Ruby-crowned Tanager *Tachyphonus coronatus* (Vieillot, 1822) and Black-goggled Tanager *Lanio melanops* (Vieillot, 1818) (Passeriformes, Thraupidae) seemed to account for the main influx of those seeds (Table 2), mainly *L. melanops*, from which we captured unbanded individuals with immigrant seeds in May and in August 1999.

Discussion

Understory birds brought seeds into the area during the season of low fruit availability, when seeds of melastome species predominated in fecal samples. In tropical forests, many melastome species produce fruit year-round (Snow 1965, Poulin et al. 1999) and they are heavily consumed by birds, especially small passerine species (Stiles & Rosselli 1993, Poulin et al. 1999, Silva et al. 2002). Levey (1988) reported that during a decline of fruits in primary forest, frugivorous birds tend to move to a secondary one, where fruit abundance may sometimes surpass that of the former habitat. Among the understory species, *Lanio melanops* and, in a lesser degree *Tachyphonus coronatus*, seem to be the main carriers of immigrant seeds to the study area. During periods of shortage of fruits (present study) and insects (light traps in PEI, P. C. Bispo unpublished data), *L. melanops* takes part in multi-specific associations (Rodrigues et al. 1994, Machado 1999). Also, both species usually extend their movements into open areas (W. R. Silva unpublished data).

Those two Thraupidae species and other understory birds played an important role to the arrival of immigrant melastomes, which,

Table 1. Origin (SR = seed rain, BF = bird feces) and typical habitat[a] (E = Forest edge or gap; I = Forest interior) of the immigrant seed species to the study area, in Intervales State Park.

Tabela 1. Origem (SR = chuva de sementes, BF = fezes de aves) e habitat típico[a] (E = borda ou clareira; I = interior) das espécies de sementes imigrantes na área de estudo, no Parque Estadual Intervales.

Family	Species	Origin	Habitat	Frequency[b]
Aquifoliaceae	*Ilex brevicuspis* Reissek	SR	E	1
Euphorbiaceae	*Sapium glandulosum* (L.) Morong	SR	E/I	2
	Tetrorchidium rubrivenium Poepp.	SR	E/I	4
Melastomataceae	*Leandra australis* (Cham.) Cogn.	BF	E	5
	Leandra cf. *pilonensis* Wurdack	BF	I	5
	Leandra cf. *sabiaensis* Brade	BF	E	1
	Miconia cabucu Hoehne	BF	I	2
	Miconia pusilliflora (DC.) Naudin	BF/SR	I	2
Phyllanthaceae	*Hieronyma alchorneoides* Allemão	SR	E/I	3
Rhamnaceae	*Rhamnus sphaerosperma* Sw.	SR	E	1
Rosaceae	*Rubus brasiliensis* Mart.	BF	E	1
	Rubus rosifolius Sm.	BF	E	3
	Rubus urticifolius Poir.	BF/SR	E	3
Rubiaceae	*Coccocypselum hasslerianum* Chodat	BF	I	1
	Galium hypocarpium (L.) Endl. ex Griseb.	BF	E	1
Solanaceae	*Solanum americanum* Mill.	SR	E	1

[a]According to Lorenzi (1998, 2000) and the authors' personal observations. [b]Number of Sampling Unities with seeds.

[a]De acordo com Lorenzi (1998, 2000) e observações dos autores. [b]Número de unidades amostrais com sementes.
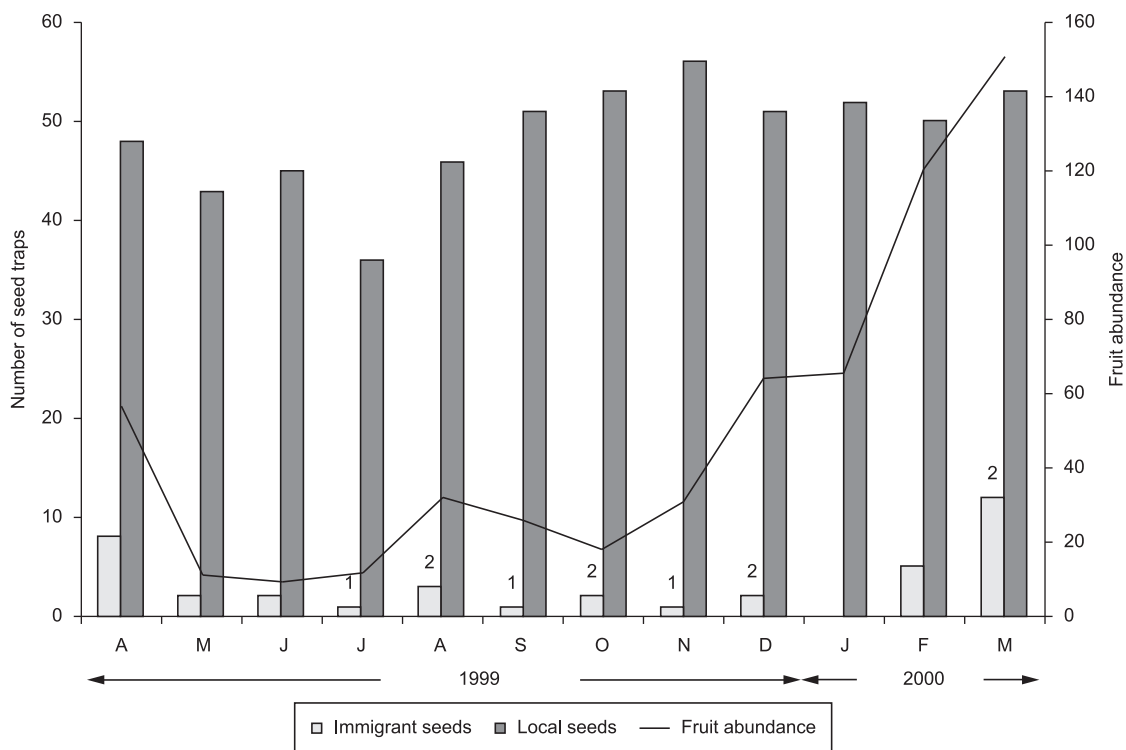
Gomes, V.S.M. et al.

Figure 1. Total number of seed traps with immigrant or local seed species (n = 60 in each month, being 5 Sampling Unities × 12 traps) and total abundance of ripe fruits (2,500 m² sampled during 12 months) at the study area, in Intervales State Park. Above the light grey bars are numbers of traps with pioneer species.

Figura 1. Número total de coletores de sementes com espécies de sementes imigrantes ou locais (n = 60 em cada mês, sendo 5 unidades amostrais × 12 coletores) e abundância total de frutos maduros (2.500 m² amostrados por 12 meses) na área de estudo, no Parque Estadual Intervales. Acima das barras cinzas claras estão os números de coletores com espécies pioneiras.

Table 2. Occurrence of site immigrant pioneer seed species in bird fecal samples (taxonomy following CBRO (Comitê… 2011)) at the study area, in Intervales State Park.

Tabela 2. Ocorrência de espécies de sementes imigrantes pioneiras (de borda ou clareira) nas amostras fecais das aves (taxonomia segundo CBRO (Comitê… 2011)) na área de estudo, no Parque Estadual Intervales.

Family	Bird species	N. individuals captured	Total N. fecal samples with seeds	% of samples with immigrant pioneer seed species	N. seed species in fecal samples (pioneer species)
Cardinalidae	*Habia rubica* (Vieillot, 1817)	6	3	0	2(0)
Thraupidae	*Saltator similis* d'Orbigny & Lafresnaye, 1837	2	1	0	2(0)
	Tachyphonus coronatus (Vieillot, 1822)	18	17	18	11(5)
	Lanio melanops (Vieillot, 1818)	20	14	29	8(3)
Turdidae	*Turdus albicollis* Vieillot, 1818	16	12	0	8(0)
	Turdus rufiventris Vieillot, 1818	6	1	100	2(1)
Pipridae	*Chiroxiphia caudata* (Shaw & Nodder, 1793)	18	22	5	11(2)
	Neopelma chrysolophum Pinto, 1944	2	1	0	1(0)
Tityridae	*Schiffornis virescens* (Lafresnaye, 1838)	5	7	0	9(0)
Tyrannidae	*Attila rufus* (Vieillot, 1819)	1	0	0	0
Rynchocyclidae	*Mionectes rufiventris* Cabanis, 1846	5	0	0	0
Vireonidae	*Hylophilus poicilotis* Temminck, 1822	2	0	0	0
	Vireo olivaceus (Linnaeus, 1766)	1	0	0	0
Total: 8	13	102	78	-	-

however, are not abundant as established plants. It seems that most of the immigrant seed species carried by understory birds are edge species that reach the area but fail to recruit adult individuals in the understory, although they can probably grow in gaps and eventually fruit, providing food for understory frugivores (Blake & Hoppes 1986, Levey 1990). Their influence to forest dynamics may be crucial, once

gap colonization may depend on a constant arrival of seeds (Alvarez-Buylla & Martinez-Ramos 1990). However, natural regeneration has changed the study area into a forest over the last 50 years, gradually favoring the establishment of forest plant species instead of edge ones. Perhaps the role of understory frugivorous species in our study area was more determinant in the beginning of ecological succession. At

further stages, however, their influence on the vegetation structure is diminished, although their movements throughout the area are still dependent on the spatial and temporal configuration of species fruit composition and abundance. The importance of immigrant seeds may depend on the disturbance history of a forest patch and it will be greater in patches with high canopy turnover rates (Martinez-Ramos & Soto-Castro 1993).

The asynchrony in the arrival of immigrant seeds to the study area recorded from bird feces and seed traps was noteworthy. The peak of abundance of immigrant seed species caught on traps occurred when fruit availability in the area reached the highest level. This may be due to a "crop size effect" on the landscape scale, i.e., a patch with high abundance of fruits may attract dispersers (Herrera 1985, Terborgh 1986, Levey 1988, Loiselle & Blake 1991) and may increase the chances of those dispersers bring other seeds to that patch. Since understory avian frugivores solely may not explain this discrepancy, other frugivores might be depositing immigrant seeds in the traps, like *Aburria jacutinga (*Spix, 1825) and *Procnias nudicollis* (Vieillot, 1817), large mid-level and canopy frugivorous species frequently observed in the study area and in nearby areas (Pizo et al. 2002, Silva et al. 2002), as well as many understory bat species (Passos et al. 2003), who are also frequent consumers of some of the zoochorous plants studied (*Piper* spp., *Cestrum* spp., *Ficus* spp. and *Solanum* spp., see Silva (2003)).

We conclude that understory frugivorous birds are important for the maintenance of a constant seed inflow from edge habitats, mainly melastomes, throughout the stages of ecological succession, which may play a critical role on the forest gap dynamics of Atlantic forest patches.

Acknowledgements

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Appendix

Appendix 1. Ornitochorous species found in the sampling units. Classification according to APG II (Angiosperm, 2003) and JBRJ (Jardim... 2010). (E = established[a], F = produced ripe fruits, U = produced only unripe fruits, S = present in the seed rain[b])

Apêndice 1. Espécies Ornitocóricas encontradas nas unidades amostrais. Classificação de acordo com APG II (Angiosperm, 2003) e JBRJ (Jardim... 2010). (E = estabelecido[a], F = produziu frutos maduros, U = produziu somente frutos imaturos, S = presente na chuva de sementes[b])

Family	Species	SU I	SU II	SU III	SU IV	SU V
Acanthaceae	*Mendoncia puberula* Mart.	-	-	-	EF	-
Anacardiaceae	*Schinus terebinthifolius* Raddi	ES	EFS	S	S	S
	Tapirira guianensis Aubl.	-	E	-	-	-
Annonaceae	*Guatteria australis* A.St.-Hil.	EFS	EF	EUS	EFS	EFS
Apocynaceae	*Tabernaemontana catharinensis* A.DC.	-	-	-	ES	EU
Araliaceae	*Oreopanax* sp.	ES	ES	-	S	EFS
Boraginaceae	*Cordia ecalyculata* Vell.	-	-	-	E	E
Cannabaceae	*Celtis iguanaea* (Jacq.) Sarg.	-	-	-	-	EFS
Cardiopteridaceae	*Citronella megaphylla* (Miers)R.A. Howard	E	E	-	E	-
Celastraceae	*Maytenus aquifolia* Mart.	-	E	-	-	-
	Maytenus robusta Reissek	-	-	-	E	-
Commelinaceae	*Dichorisandra thyrsiflora* J.C. Mikan	EF	EUS	EFS	EFS	EFS
	Tradescantia sp.	EF	-	-	-	-
Cucurbitaceae	*Wilbrandia hibiscoides* Silva Manso	E	-	-	-	-
Elaeocarpaceae	*Sloanea monosperma* Vell.	-	E	-	EF	EF
Erythroxylaceae	*Erythroxylum ambiguum* Peyr.	-	E	-	EUS	-
Euphorbiaceae	*Alchornea triplinervia* (Spreng.)Müll. Arg.	-	-	S	ES	S
Lamiaceae	*Aegiphila integrifolia* (Jacq.) Moldenke	E	-	-	-	-
Lauraceae	*Nectandra cuspidata* Nees	EUS	ES	EFS	EUS	ES
	Nectandra mollis (Kunth) Nees				E	
	Ocotea puberula (Rich.) Nees	-	E	EF	EU	EFS
	Unidentified	E	-	-	-	-
Loganiaceae	*Strychnos brasiliensis* Mart.	-	EF	-	-	-
Loranthaceae	*Psittacanthus* sp.	EFS	-	ES	EFS	EFS
Malpighiaceae	*Bunchosia fluminensis* Juss.	-	EF	-	-	-
	Unidentified	EU	-	-	E	-
Melastomataceae	*Leandra dasytricha* (A.Gray)Cogn.	EF	-	-	EF	-
	Miconia tristis Spring	-	-	EFS	EFS	-
Meliaceae	*Cabralea canjerana* (Vell.)Mart.	-	E	E	-	S
	Trichilia pallens C.DC.	EU	EU	-	-	-
Monimiaceae	*Mollinedia floribunda* Tul.	EFS	EFS	ES	EFS	EF
Moraceae	*Ficus* sp. L.	E	-	S	-	E
	Sorocea bonplandii (Baill.)W.C. Burger Lanj. &Wess. Boer	E	-	E	E	-
Heliconiaceae	*Heliconia farinosa* Raddi	-	EF	E	EU	EF
Myrsinaceae	*Ardisia guianensis* (Aubl.)Mez	-	EF	-	-	-
	Myrsine coriacea (Sw.)R.Br.ex Roem.&Schult.	S	EFS	S	S	S
	Myrsine umbellata Mart.	E	-	-	-	-
Myrtaceae	*Calycorectes australis* D. Legrand	EF	-	-	-	-
	Campomanesia guazumifolia (Cambess.)O. Berg	-	-	-	E	-
	Campomanesia neriiflora (O. Berg) Nied.	-	E	-	-	EF
	Campomanesia sp.	S	-	ES	-	S

[a]Plants were considered established when they were trees with DBH > 2 cm or shrubs, herbs and lianas which had produced at least unripe fruits during the study. [b]To seed rain, Commelinaceae seeds were computed here in *Dichorisandra thyrsiflora*; seeds of *Cupania vernalis* or *Matayba juglandifolia* were computed here in *Cupania vernalis*; *Myrsine* sp. was computed here in *Myrsine coriacea*.

[a]As plantas foram consideradas estabelecidas quando eram árvores com DAP > 2 cm ou arbustos, ervas e lianas que produziram pelo menos frutos imaturos durante o estudo. [b]Para a chuva de sementes, as sementes de Commelinaceae foram computadas como *Dichorisandra thyrsiflora*; sementes de *Cupania vernalis* ou *Matayba juglandifolia* foram computadas como *Cupania vernalis*; *Myrsine* sp. foram computadas como *Myrsine coriacea*.

Gomes, V.S.M. et al.

Appendix 1. Continued...

Family	Species	SU I	SU II	SU III	SU IV	SU V
	Campomanesia xanthocarpa (Mart.) O. Berg	EF	-	-	-	-
	Eugenia cuprea (O.Berg) Nied.	-	EFS	-	-	-
	Eugenia mosenii (Kausel) Sobral	E	E	-	E	-
	Eugenia verticillata (Vell.) Angely	S	EUS	EFS	S	S
	Eugenia sp.	EU	-	-	E	E
	Marlierea eugeniopsoides (Kausel&D.Legrand)D. Legrand	EF	-	-	-	-
	Marlierea sp.	ES	-	-	-	-
	Myrcia splendens (Sw.) DC.	E	EF	E	EU	EF
	Unidentified	-	-	E	-	-
Nyctaginaceae	*Guapira opposita* (Vell.) Reitz	EF	E	EF	E	E
Picramniaceae	*Picramnia ramiflora* Planch.	EF	-	-	-	-
Piperaceae	*Piper aduncum* L.	EU	EF	EF	EF	EF
	Piper corintoanum Yunck.	EUS	EU	EUS	EFS	EUS
	Piper hoehnei Yunck.	EF	E	EU	EU	-
Rosaceae	*Prunus myrtifolia* (L.) Urb.	E	-	-	-	-
Rubiaceae	*Psychotria longipes* Müll.Arg.	-	-	-	EF	-
	Psychotria sp.	EU	-	S	S	-
	Psychotria suterella Müll.Arg.	EF	EFS	EFS	EFS	EFS
	Rudgea jasminoides (Cham.) Müll.Arg.	EU	EF	ES	EFS	-
Rutaceae	*Zanthoxylum fagara* (L.) Sarg.	E	-	E	E	-
Salicaceae	*Banara parviflora* (A.Gray)Benth.	-	E	E	-	-
	Casearia decandra Jacq.	EFS	E	E	EFS	E
	Casearia sylvestris Sw.	EFS	ES	EUS	EFS	ES
Sapindaceae	*Allophylus edulis* (A.St.-Hil., A.Juss. & Cambess.) Radlk.	EFS	EFS	EFS	EFS	EFS
	Cupania vernalis Cambess.	ES	S	S	ES	ES
	Matayba juglandifolia (Cambess.) Radlk.	-	EU	-	-	-
	Paullinia uloptera Radlk.	E	-	-	-	-
Sapotaceae	*Chrysophyllum* cf. *marginatum* (Hook.&Arn.)Radlk.	-	E	-	-	-
Smilacaceae	*Smilax elastica* Griseb.	-	EF	-	-	-
Solanaceae	*Cestrum axillare* Vell.	EF	-	-	EU	EF
	Solanum cf. *argenteum* Dunal	-	-	E	-	-
	Solanum sanctae-catharinae Dunal	-	-	-	S	EFS
	Unidentified	-	E	-	-	-
Symplocaceae	*Symplocos estrellensis* Casar.	S	-	-	EFS	S
Urticaceae	*Urera baccifera* (L.) Gaudich. ex Wedd.	-	-	-	EU	EU
Violaceae	*Hybanthus atropurpureus* (A.St.-Hil.) Taub.	-	E	-	-	-
Total E 40	**78**	**41**	**39**	**26**	**39**	**28**
Total F+U	**48**	**25**	**20**	**13**	**25**	**19**
Total S	**30**	**16**	**15**	**25**	**28**	**23**

[a]Plants were considered established when they were trees with DBH > 2 cm or shrubs, herbs and lianas which had produced at least unripe fruits during the study. [b]To seed rain, Commelinaceae seeds were computed here in *Dichorisandra thyrsiflora*; seeds of *Cupania vernalis* or *Matayba juglandifolia* were computed here in *Cupania vernalis*; *Myrsine* sp. was computed here in *Myrsine coriacea.*

[a]As plantas foram consideradas estabelecidas quando eram árvores com DAP > 2 cm ou arbustos, ervas e lianas que produziram pelo menos frutos imaturos durante o estudo. [b]Para a chuva de sementes, as sementes de Commelinaceae foram computadas como *Dichorisandra thyrsiflora*; sementes de *Cupania vernalis* ou *Matayba juglandifolia* foram computadas como *Cupania vernalis*; *Myrsine* sp. foram computadas como *Myrsine coriacea.*