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ABUNDANCE OF TREES USED AS FOOD BY PRIMATES IN FRAGMENTS OF ATLANTIC FOREST

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Abstract. Forest fragmentation favours the propagation of some arboreal primate species that can alter the floristic composition of a community. This process may be associated with the loss of seed dispersants. In this work we propose to identify if the presence of frugivorous primates of medium and large size (*Sapajus flavius* and *Alouatta belzebul*) can influence forest diversity and structure. Further, we ask if the size of the fragment affects the availability of resources for these primates. Three fragments were studied in the Atlantic Forest of the State of Paraíba, Brazil, located in the municipalities of Sapé, Mamanguape, Rio Tinto, and Mataraca. In each area 25 plots of 50 x 4 m were delimited, randomly distributed along trails and transects. All trees with chest-high circumferences (CAP) above 12 cm found within the plots were marked with ribbons, and numbered continuously. A total of 114 plant species were documented in the Pacatuba Forest, 79 in the Asplan Forest, and 97 in the "Guaribas" (Sema III) Biological Reserve (REBIO) Forest. According to the Chao and Jacknife estimators, the REBIO Guaribas Forest can present more species than recorded in the present

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investigation. Species *Tapirira guianensis, Protium giganteum* and *Protium heptaphyllum* are the most abundant in the Asplan, Pacatuba and Sema III Forests, respectively. In the REBIO Guaribas Forest, the Shannon diversity index was (H') = 3.75, the Alpha-Fisher index was = 26.57 and the Simpson index (1-D) was = 0.90. Pacatuba was the forest fragment with the highest index of diversity (H') = 375, Alpha-Fischer = 33.74 and Simpson (1-D) = 0.95. Pacatuba and REBIO Guaribas Forsts possess greater *Beta* diversity. The results suggest that local and historical factors possibly increase *Beta* diversity, contributing to the increase in resources used as food by primates. Therefore, the presence of primates of medium and large size in the Pacatuba Forest may affect the diversity of resources, contributing to the dispersion of large fruits and seeds. The presence of primates of medium and large size can thus contribute to the preservation of floristic diversity in forest fragments.

Key words: Forest fragmentation; Availability of resources; Diversity.

ABUNDÂNCIA DE ÁRVORES USADAS COMO RECURSO POR PRIMATAS EM FRAGMENTOS DE MATA ATLÂNTICA

Resumo. A fragmentação florestal favorece a propagação de algumas espécies arborícolas, que podem alterar a composição florística da comunidade, podendo estar associados à perda de dispersores de sementes. Neste trabalho, foi verificado se a presença de primatas frugívoros de médio e grande porte (*Sapajus flavius* e *Alouatta belzebul*) podem influir na diversidade e estrutura florestal; bem como se o tamanho do fragmento afeta a disponibilidade de recursos para estes primatas. Foram estudados três fragmentos na Mata Atlântica do Estado da Paraíba, localizadas nos municípios de Sapé, Mamanguape, Rio Tinto e Mataraca. Em cada área, foram delimitados 25 “plots”, medindo 50 x 4 m, localizados ao longo de trilhas e transectos, distribuídos de forma aleatória. Todas as árvores encontradas dentro dos “plots”, com circunferência à altura do peito (CAP) ≥ 12 cm, foram marcadas com fitas, e numeradas de forma contínua. Foram registradas 114 espécies vegetais na mata de Pacatuba, 79 na mata da Asplan, e 97 na mata da Reserva Biológica (REBIO) “Guaribas” (Sema III). De acordo com os estimadores $Chao_1$ e $Jacknife_1$, a mata REBIO Guaribas pode apresentar mais espécies em relação ao que foi registrado na presente pesquisa. As espécies *Tapirira guianensis*, *Protium giganteum* e *Protium heptaphyllum* são as mais abundantes na mata da Asplan, Pacatuba e Sema III, respectivamente. Na mata REBIO Guaribas, o índice de diversidade de Shannon (H’) foi 3.2, Alpha-Fisher = 26.57 e Simpson (1-D) = 0.90. Pacatuba foi o fragmento de mata com maior índice de diversidade (H’) = 3.75, Alpha-Fisher = 33.74 e Simpson (1-D) = 0.95. Pacatuba e REBIO Guaribas possuem maior diversidade *Beta*. Os resultados sugerem que possivelmente fatores locais e históricos aumentam a diversidade *Beta*, podendo contribuir para o aumento dos recursos usados como alimento pelos primatas. Além disso, a presença de primatas de médio e grande porte na mata Pacatuba pode afetar a diversidade de recursos, ao contribuir com a dispersão de frutos e sementes de tamanho

grande. A presença de primatas de médio e grande porte pode contribuir para a conservação e manutenção da diversidade florística em fragmentos.

Palavras-chave: Fragmentação florestal; Disponibilidade de recursos; Diversidade.

ABUNDANCIA DE ÁRBOLES USADOS COMO RECURSO POR PRIMATES EN FRAGMENTOS DE FLORESTA ATLÁNTICA

Resumen. La fragmentación forestal favorece la propagación de algunas especies arborícolas que pueden alterar la composición florística de la comunidad, pudiendo estar asociado a la pérdida de dispersores de semillas. En este trabajo fue verificado si la presencia de primates frugívoros de mediano y grande porte (*Sapajus flavius* y *Alouatta belzebul*) pueden influir en la diversidad y estructura forestal; como también, si el tamaño del fragmento afecta la disponibilidad de recursos para estos primates. Fueron estudiados tres fragmentos en la Floresta Atlántica del estado de Paraíba-Brasil, localizados en los municipios de Sapé, Mamanguape, Rio Tinto y Mataraca. En cada área, fueron delimitados 25 "plots" midiendo 50 x 4 m, localizados a lo largo de senderos y transectos, distribuidos de forma aleatoria. Todos los árboles encontrados dentro de los "plots", con circunferencia a la altura del pecho (CAP) $\geq$ 12 cm, fueron marcadas con cintas, y numeradas de forma continua. Fueron registradas 114 especies vegetales en la floresta de Asplan y 97 en la Reserva Biológica (REBIO) "Guaribas" (Sema III). De acuerdo con los estimadores $Chao_1$ y $Jacknife_1$, la floresta REBIO Guaribas puede presentar más especies en relación a lo que fue registrado en la presente investigación. Las especies *Tapirira guianensis*, *Protium giganteum* y *Protium heptaphyllum* son las más abundantes en la floresta de Asplan, Pacatuba y Sema III, respectivamente. En la floresta REBIO Guaribas, el índice de diversidad de Shannon (H') = 3.75, Alpha-Fisher = 26.57 y Simpson (1-D) = 0.90. Pacatuba fue el fragmento de floresta con mayor índice de diversidad (H') = 375, Alpha-Fisher = 33.74 y Simpson (1-D) = 0.95. Pacatuba y REBIO Guaribas poseen mayor diversidad *Beta*. Los resultados sugieren que posiblemente factores locales e históricos aumentan la diversidad *Beta*, pudiendo contribuir para el aumento de los recursos usados como alimento por los primates. Además de eso, la presencia de primates de mediano y grande porte en la floresta Pacatuba, puede afectar la diversidad de recursos, al contribuir con la dispersión de frutos y semillas de gran tamaño. La presencia de primates de mediano y grande porte puede contribuir para la conservación y mantenimiento de la diversidad florística en fragmentos.

Palabras clave: Fragmentación forestal; Disponibilidad de recursos; Diversidad.

INTRODUCTION

The rate of destruction of tropical forests is presently alarming (PUIG, 2008). Tha Atlantic Forest in particular has been drastically reduced and fragmented due to excessive exploration, deforestation and fires, being presently restricted to less than 7% of its original area

(CHIARELLO, 1994; DALPONTE, LIMA, 1999). The destruction of tropical forests and their deforestation reduce forested areas, transforming them into fragments known as patches or islands. Such a process of reduction and isolation of the natural vegetation affects the structure and functioning of plant communities, resulting in loss of biological biodiversity, death of trees in bordering areas, among other changes (CERQUEIRA et al., 2003). Fragmentation causes isolation among the surviving forested áreas. According to Laurance and Vasconcelos (2009), the distance between two forest fragments or the distance existing between a fragment and a continuous area of forest may affect the displacement of animals and of plant propagules. Deforestated areas measuring from 15 to 100 m in width may act as barriers for the displacements of several species, including arboreal mammals (GILBERT; SETZ, 2001; LAURANCE; VASCONCELOS, 2009).

In Northeastern Brazil, Bonvicino (1989) observed that some species of trees provided more than one food item. For example, the species *Guapira* sp furnishes leaves, flowers and fruits as food items. In that research, 47 species of plants were used as food by the guariba-monkeys. Thirty-six percent of these plants were consumed by *Callithrix jacchus* (the White-tuft Marmoset) and 12,7% were consumed by some species of bats. Camargo et al. (2008) observed a reduction in the consumption of fruits during the dry season and an increase in the consumption of the other food items such as leaves and flowers, due to the reduction of the availability of fruit during the periods of lower precipitation. Tabarelli et al. (2010) reinforced that the borders resulting from fragmentation stimulate the proliferation of pioneer species and a constant reduction in the abundance of species with lower growth rates. This occurrs because most of these species have large seeds and their dispersal agents, the frugivorous animals, are unable to become established in their original habitat and thus search for other more favourable areas. This breaks existing links previously existing with the plants that depend on animals for dispersal. The pioneer species, which do not necessarily depend on animals for dispersal, tend to dominate, because their seeds are small and may be transported by physical agents such as water and wind. They gradually replace species which are late to arrive. This affects the whole community in the long run. Even strongly resilient forests, when fragmented, reduce their availability of resources, demanding many years to recover and to furnish the same resources which were available previously (GUREVITCH; SCHEINER; FOX, 2009).

Primates are important agents for the regeneration of fragmented forests, because they are effective dispersants of large seeds (IZAR, 2008; MOURA; McCONKEY, 2007). Thus, forest fragments that possess large primates are possibly more diverse in trees used as food

resources. This hypothesis is based on three premises: i) The size of the primate affects the species composition of plants in the forest, because when a primate chooses between fruit of small seeds or of large seeds belonging to different species, it is in fact selecting the species which it will disperse; ii) The size of the primate affects the composition and distribution of species because the selected fruit are ingested and dispersed during their daily locomotion; iii) The size of the primate affects the composition, the distribution of species, and consequently the forest structure. Depending on the type of seed dispersed, the fragment will have emergent species or species tolerant of shade. In this paper we evaluate if (1) the size of a forest fragment indeed affects the availability of resources for non-human primates in the Atlantic Forest in the State of Paraíba and if (2) the presence of frugivorous primates of median and large size (*Sapajus flavius* and *Alouatta belzebul*) influence the diversity and structure of the forest.

MATERIAL AND METHODS

Study area

Three forest fragments were studied, two located in the northern coast of the State of Paraíba, and the third located about 50 km inland (Fig. 1). The forest of Pacatuba Farm is a Private Reserve of the Natural Heritage (RPPN) with 266.53 ha, located in the Municipality of Sapé. The forst of ASPLAN (Sugar Cane Planters Association of Paraíba), with 96.5 ha, is a Legal Reserve located between the Municipalities of Mamanguape and Mataraca. The Biological Reserve (REBIO) "Guaribas" SEMA III (327.0 ha), also known as "Mata do Maracujá", is located in the Municipality of Rio Tinto. The three areas share an *AS*-type climate, that is, a humid tropical climate, with rains in the fall-winter (KÖPPEN, 1948). The rainy season begins during the month of March, at the beginning of Fall, and continues until July, just after the onset of Winter. Between 2008 and 2011, the maximum rainfall in Asplan and Sema III occurred in the month of April, with 279.6 mm and 282.5 mm, respectively. Lowest precipitation occured in November, with 18.9 mm and 11.0 mm, respectively. In Pacatuba, maximum precipitation (236.2 mm) occurred in the month of July and minimum rainfall, 7.4 mm, occurred in October (Fig. 2).

In each area 25 plots measuring 50 x 4 meters were delimited. These plots were located along trails and transects within the forest fragments (Fig. 3). Some of these trails measured up to 2 km long. Along the longest trails, points were established by draws to determine the beginning of each vegetation plot. The side in which a plot was positioned was selected at ramdom with the through of a coin. Plots were rectangular, a shape that may

contain more species than a square or circular plot of the same size (GUREVITCH; SCHEINER; FOX, 2009), and may thus better sample the vegetation. These plots were delimited by string. All trees located within each plot, with a circumference at the height of the chest (CAP) ≥ 12 cm were marked with a ribbon and numbered consecutively. Later, the values of CAP were transformed into diameters at chest height (DAP), using the formula DAP = CAP / π, where (π = 3.14). The height of all marked trees were estimated visually using a scaled stick of 6 meters. Each study area that contained at least 5% of the total number of individuals was considered abundant.

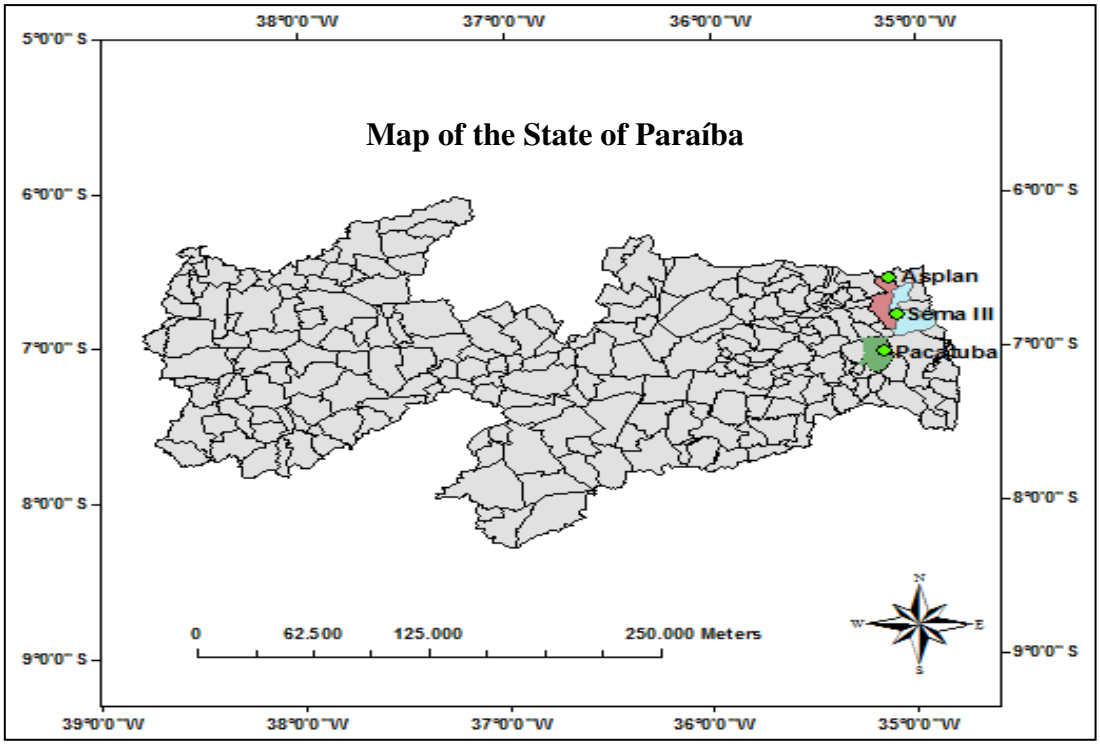


Figure 1. Location of study areas, in the State of Paraíba, Northeastern Brazil. **Source**: National Water Agency.

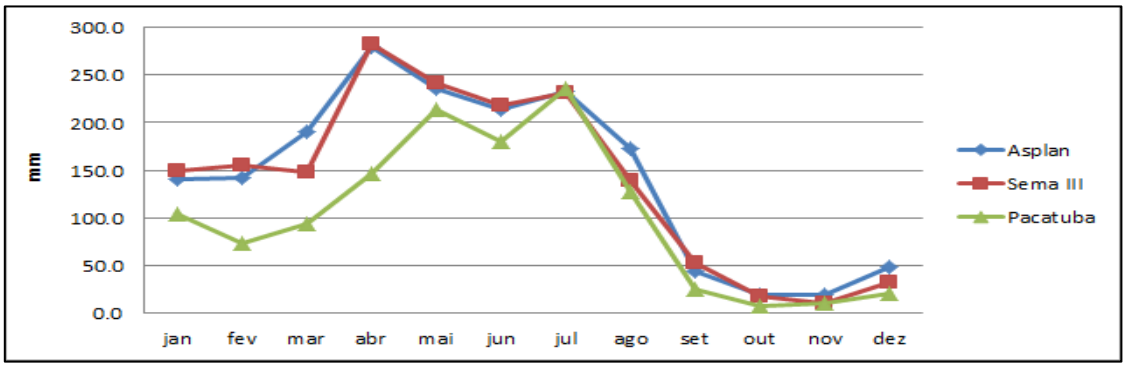


Figure 2. Pluviometric mean of the study areas (2008-2011). **Source**: AESA/PB (Agência Executiva de Gestão das Águas do Estado da Paraíba).

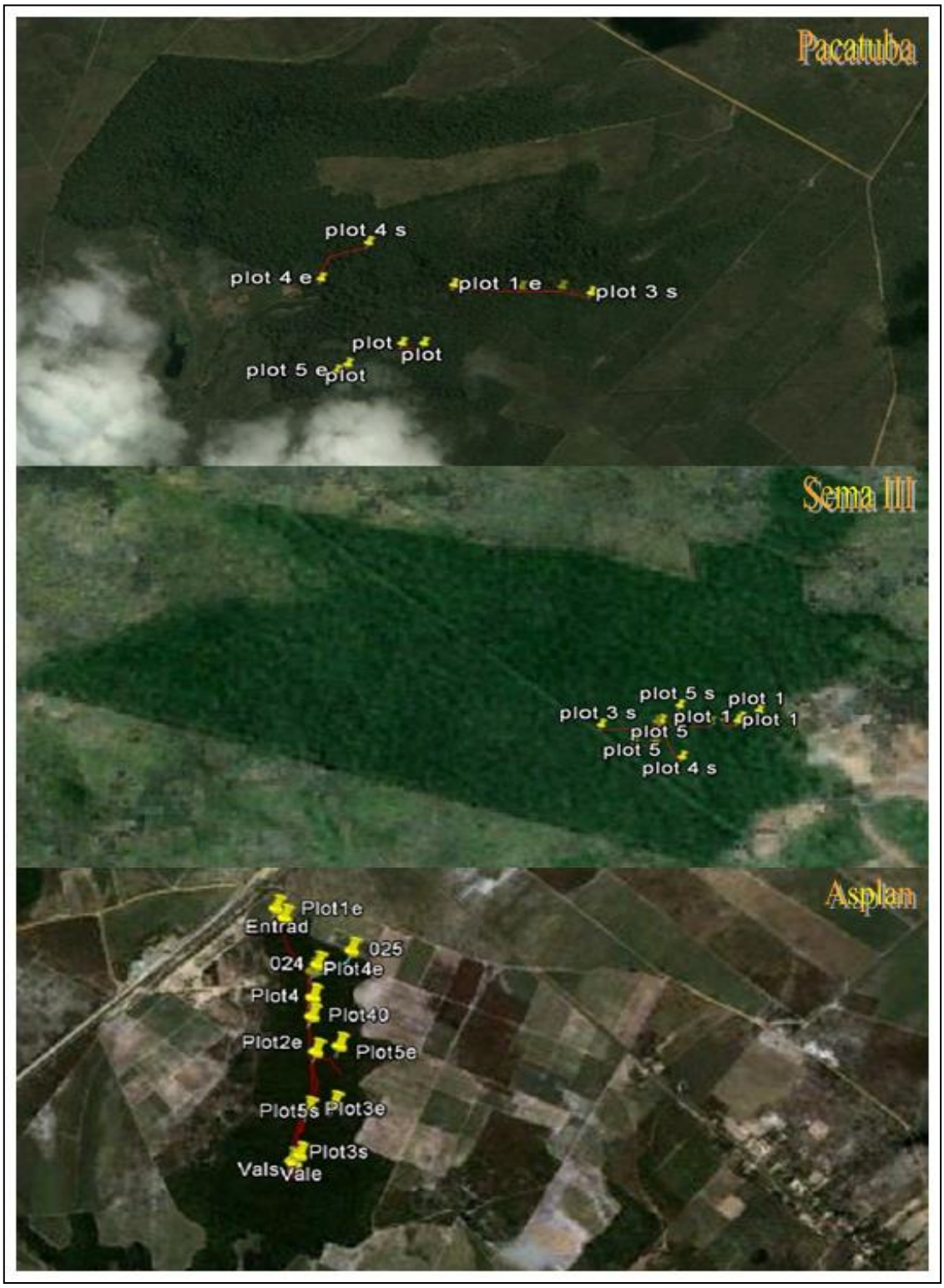


Figure. 3. Distribution of plots in the study areas. **Source**: Google Earth (2018).

The REBIO Guaribas (SEMA III) Forest is located about one km away from an urban area. Altitudes vary from 20 to 134 m above sea level (GOOGLE EARTH, 2018), having a

brook flowing through it. The Pacatuba Farm Forest has altitudes that vary from 75 m to 150 m, being drained by several permanent streams (DE SOUZA, 2005). In the localities with more water available the forest is larger and the vegetations is denser. At higher altitudes the soil varies from sand to clay, with a vegetation of the Savanna type, trees being of small to median size. The ASPLAN Forest is unike in not having water streams. Its relief is not very steep, altitudes varying from 96 to 136 m (GOOGLE EARTH, 2018). All three fragments are surrounded by sugar-cane plantations or pastures. The REBIO Guaribas Forest is further surrounded by an urban area.

Some plant species were identified *in situ.* For the identification of the remaining species, samples of the vegetative structures (leaves) and, when possible, of the reproductive structures (flowers and fruits) were obtained. Exicatae were prepared from the collected samples and compared to those deposited in the Herbarium Lauro Pires Xavier (JPB) of the Federal University of Paraíba (UFPB/Campus I), in order to confirm identifications. The new exicatae were deposited in this herbarium.

Data analyses

The data were inserted into electronic spredsheets for preliminary analyses. They were later analysed in different programs. The statistic program "Past" (version 3.13) was used to evaluate the alfa diversity of the communities. Indices of Shannon-Wiener (H'), Simpson (1-D) and Alpha-Fisher were used.

Two non-parametric estimators were used ($Chao_1$ and $Jaccknife_1$), calculated with the program "Estimates" (version 7.52).

Beta diversity, corresponding to the dissimilarity between species of two or more communities (BARROS, 2007), represents the dissimilarity between species of two or more communities. Beta diversity was estimated for the three studied areas. As lowest similarities indicate highest dissimilarities; the *Beta* diversity ndicates few shared species.

The "Jaccard" similarity index was used in the three study areas. The advantage of this index is that it is not influenced by the more abundant species. Furthermore, areas with a history of environmental perturbations are more susceptible to the appearance of pioneer species, and the abundance of these species would also be able to influence the similarity.

RESULTS AND DISCUSSION

A total of 1339 trees were recorded in the Asplan Forest, belonging to 79 species. In the Pacatuba Forest we recorded 956 trees, while in REBIO Guaribas (Sema III) Forest

(alternatively named the Psiion-Fruit Forest), a total of 996 individuals belonging to 97 species were recorded. The Asplan Forest has the highest abundance of trees with a height of uto to 10 m; trees with Heights up to 50 m were only found in Pacatuba Farm Forest. At REBIO Guaribas Forst, the maximum height of the trees reached 35 m (Fig. 4A). Regarding tee diameter, Pacatuba Forest differs from the remaining ones for having trees with a large diameter, such as of an individual of *Parkia pendula* that has 171.02 cm; in REBIO Guaribas and Asplan, the largest diameters did not overreach 82.74 cm (Fig. 4B). REBIO Guaribas further presented the largest number of trees with up to 15 cm in diameter. The mean diameter in Pacatuba is higher than for the remaining areas (Tab. 1).

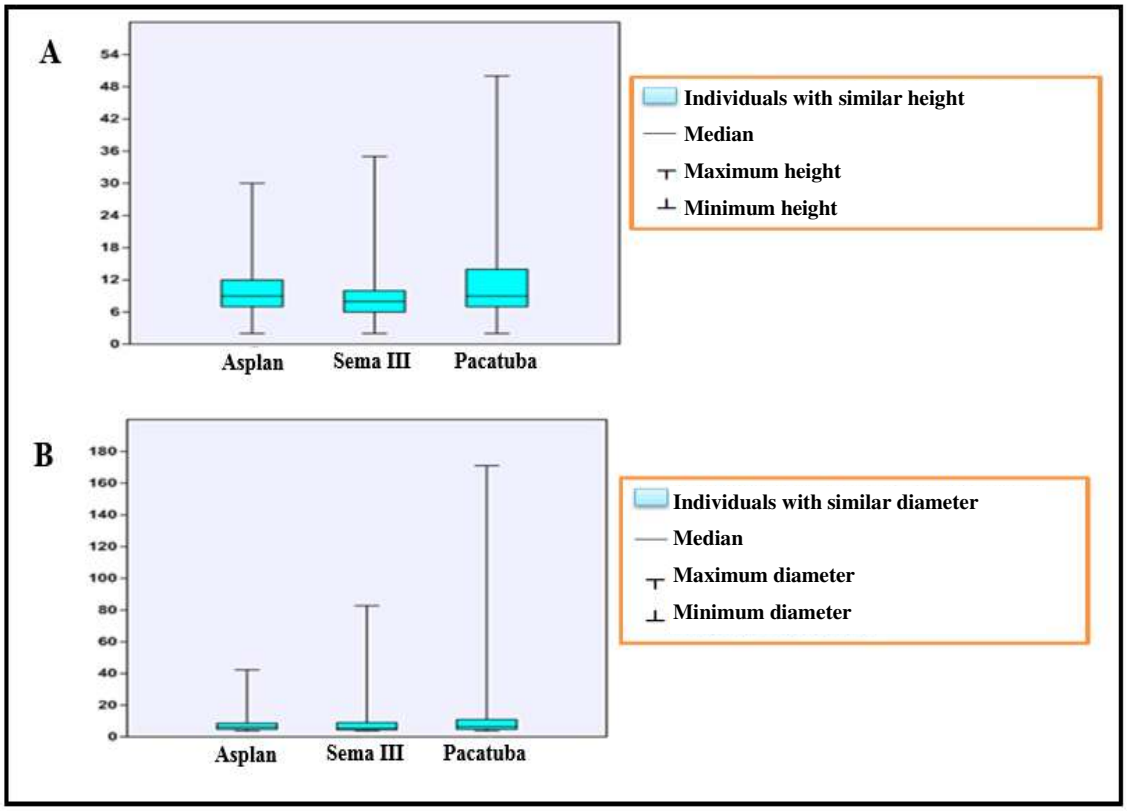


Figure 4. "Box-Plot" graphs of the measurements of trees (in meters) in the three studied areas. **A**. Differences in height; **B**. Variations in diameter.

Table 1. Differences in means and standard deviation of height and diameter of trees in the studied forests.

Study area	Height (m)		Diameter (cm)	
	Mean	**Standard Deviation**	**Mean**	**Standard Deviation**
Asplan	9.91	± 4.05	7.97	± 5.25
Pacatuba	10.5	± 5.6	10.34	± 11.8

Sema III	9.63	± 6.6	9.65	± 10.15

All diversity indexes indicate Pacatuba Forest as having the highest diversity, while the Asplan Forest had the lowest diversity (Tab. 2).

Table 2. Variation in diversity indexes in the three studied areas.

Diversity Index	Pacatuba	Asplan	Sema III
Simpson (1-D)	0.95	0.92	0.9
Shannon-Wiener (H')	3.75	3.07	3.2
Alpha-Fisher	33.74	18.36	26.57

Seven species of highest occurrence were indicated for Asplan Forest, four in Pacatuba Forest, and three in REBIO Guaribas Forest (Fig. 5). The most abundant species in Pacatuba Forest was *Protium giganteum*, while the species *Protium heptaphyllum* was most frequent in REBIO Guaribas Forest. In Asplan Forest, *Eschweilera ovata* was the species of highest occurrence.

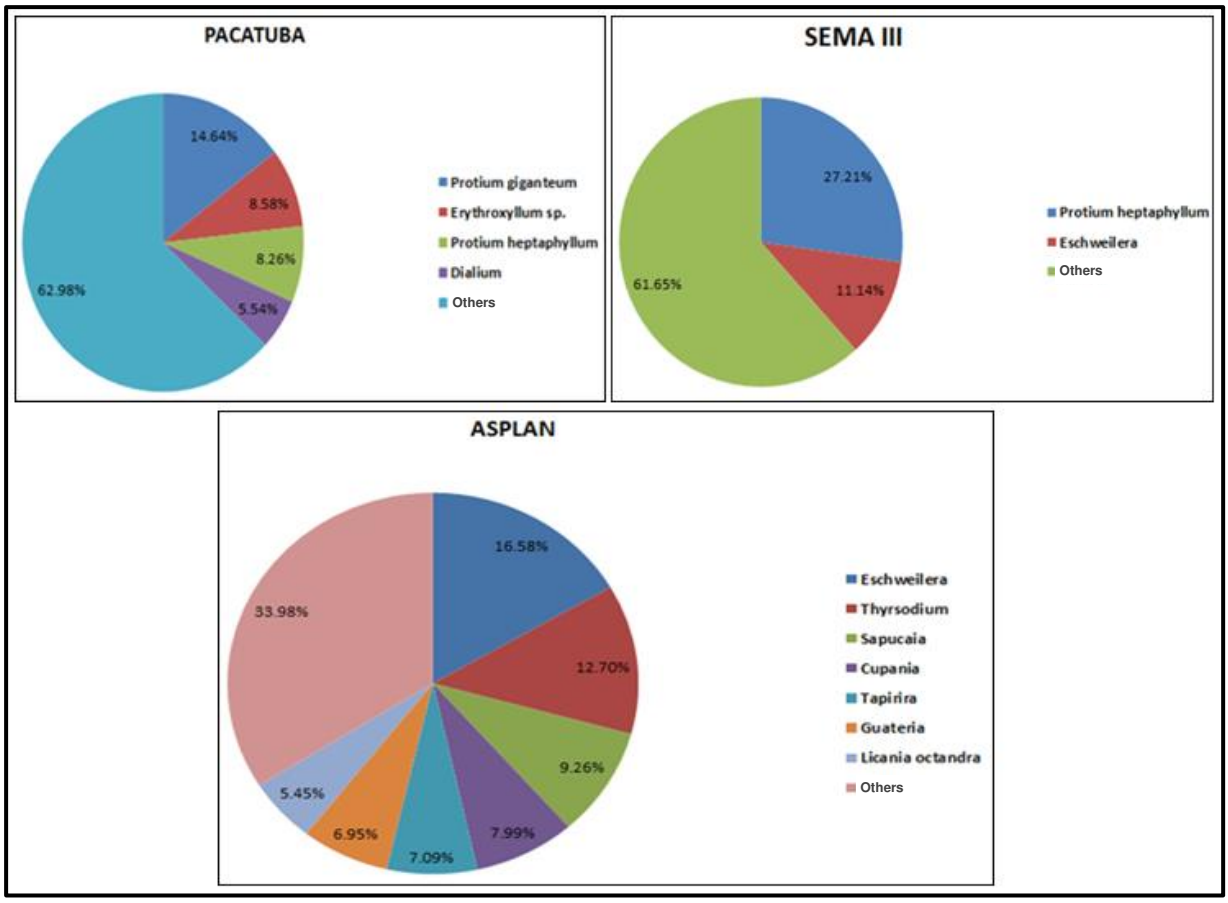


Figure 5. Species with highest abundance in individuals in the sampled areas.

The collector curve, or cumulative species curve, indicates a gradual increase in the number of species for the Asplan Forest, indicating that further species may be found. On the other hand, the REBIO Guaribas Forest and the Pacatuba Forest show a graph line that is close to stabilization, which theoretically indicates that most species have been sampled. The collector curve may not be the best indicator for the total number of species from a given locality, because even after stabilization there is always the possibility that unsampled species will appear. Thus, the use of estimators permits more precision in the evaluation of total species numbers in the studied areas.

Estimates of species richness are very useful, when different communities are compared, or even when comparing the number of species or individuals per sample. Such measurements permit the estimation of the total number of species present in a community on the basis of the sampled data.

According to the estumators $Chao_1$ and $Jacknife_1$, the REBIO Guaribas or Passion-Fruit Forest was possibly subsampled, indicating that a larger sampling effort may possibly increase the number or recorded species (Fig. 6).

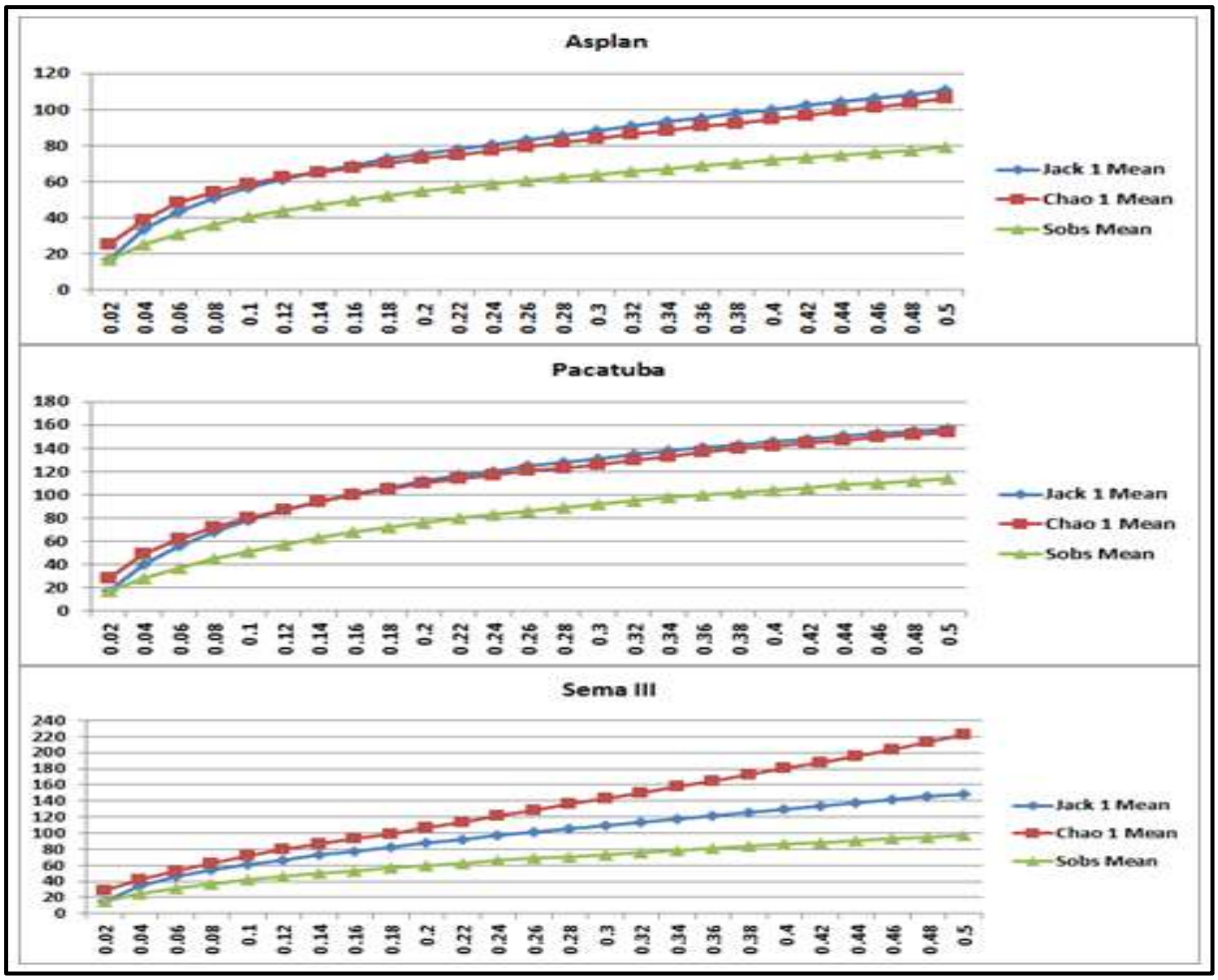


Figure 6. Estimate of the total number of species relative to species effectively sampled.

Pacatuba Forest has a larger number of species of fruit trees consumed by primates (31 consumed species). REBIO Guaribas (Sema III) Forest has fewest species consumed by primates (19 species). In Asplan Forest, *Tapirira guianensis*, a species common in secondary forests or in forests subject to recovery, stands out (e.g. LORENZI, 2002). This species may also be common in fragmented areas, as the Asplan Forest is being subject to stages of regeneration. Other species that have the fruits consumed by primates are: *Licania* sp., *Guatteria* sp., and *Inga* sp. In Pacatuba Forest, the species with fruits eaten by primates were: *Ocotea* sp., *Brosimum* sp., *Dialium* sp., and *Garcinia* sp. In the REBIO Guaribas Forest the following species were found: *Protium* spp., *Campomanesia* sp., *Eugenia* sp., *Guatteria* sp., *Copaifera* sp., *Ocotea* sp., and *Brosimum* sp. (Fig. 7).

The species *T. guianensis*, *Licania* sp., *Guatteria* sp. and *Inga* sp. were the most abundant in the Asplan Forest. Species such as *Cecropia* sp., *Myrcia* sp. and *Piptadenia* were not found in the plots of the Pacatuba Forest, although they occur in the region, having been found in the Asplan Forest (Fig. 7).

The species that serve as food resources for *C. jacchus* are: *T. guianensis*, *Inga* sp., *Cecropia* sp., *Ocotea* sp., *Talisia* sp., *Byrsonima* sp., *Protium* spp., *Ficus* sp., *Brosimum* sp., *Campomanesia*. sp., *Eugenia* sp., *Sorocea* sp. and *Coccoloba* sp. The remaining species, together with some of the previously cited species, serve as a food source for *A. belzebul* and *S. flavius (*see Appendix I).

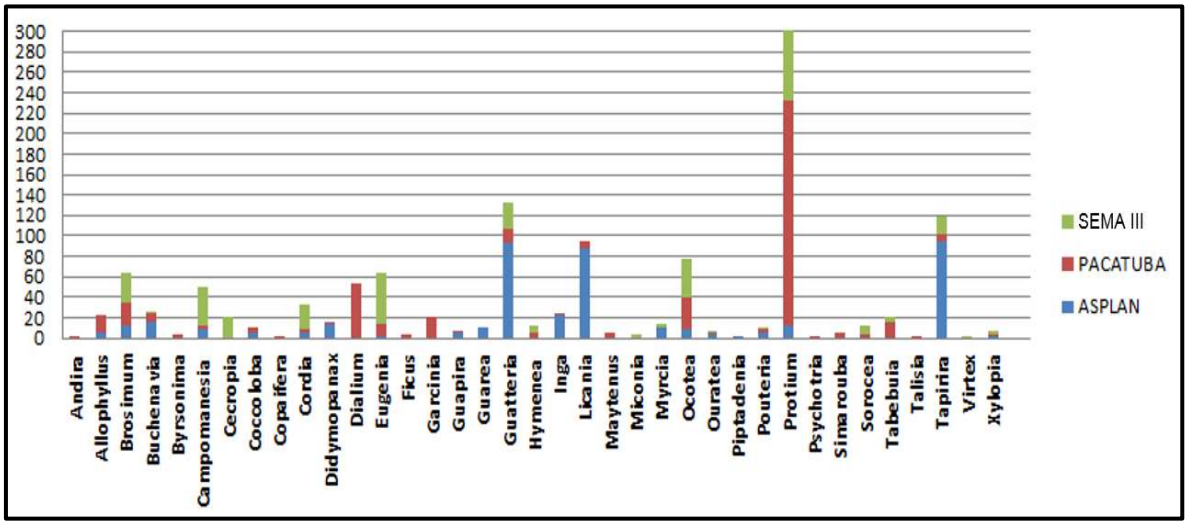


Figure 7. Abundance of trees used as feeding resources by primates in the three studied areas.

In Pacatuba Forest, the species *P. giganteum*, *Dialium guianensis* and *Ocotea* sp. were most representative in the studied plots, while the species *Brosimum* sp., *Ocotea* sp. and *Pouteria* sp. were common in the Asplan and Pacatuba Forests. Species belonging to the genera *Inga* and *Tapirira* occurred only in the Asplan Forest. On the other hand, the species *Garcinia* sp. appeared only in the Pacatuba Forest (Fig. 8). During the collection of data in the Asplan Forest, the primate species *S. flavius* was seen very briefly on three occasions, eating a fruit of *Inga* sp. However, it displayed an agonistic behavior off flight each time it was observed by the researchers.

In the REBIO Guaribas (Sema III) Passion-Fruit Forest, species *Ocotea* sp. and *Brosimum* sp. were quite representative in number of individuals, occurring in over 22% of the plots (n= 25 plots); while in the Pacatuba Forest the species *D. guianensis* occurred in 76% of the plots.

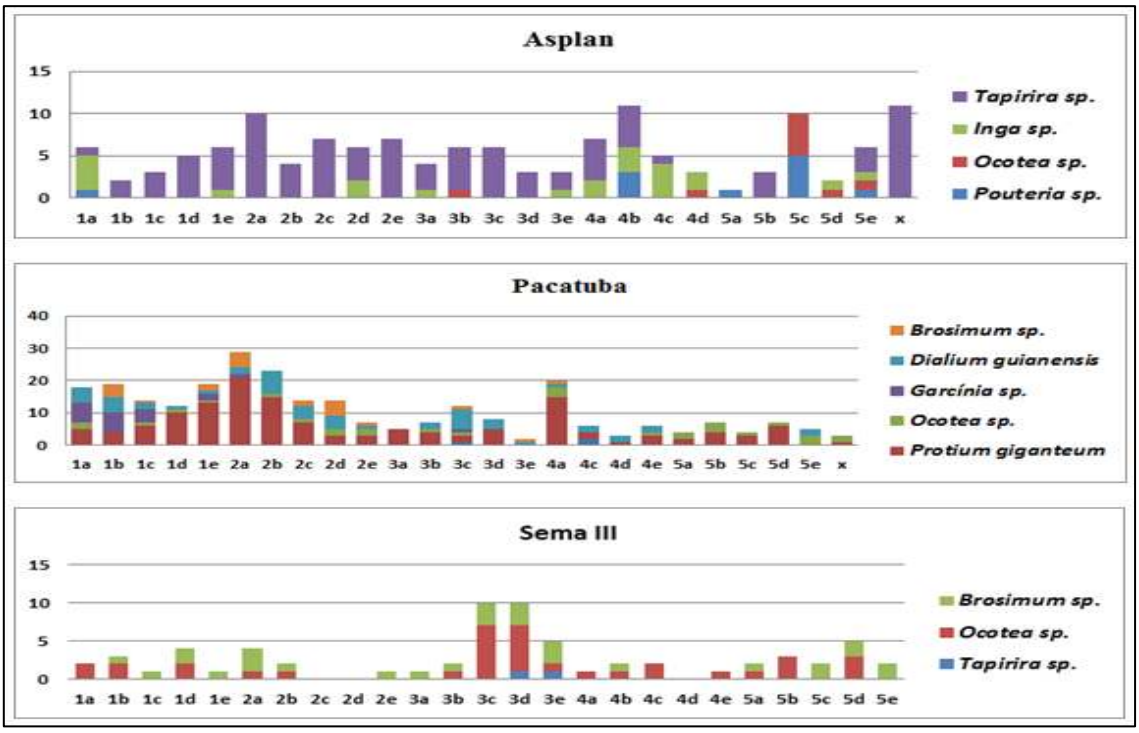


Figure 8. Abundance and distribution of tree species used as food resources (predominantly fruits) by primates in plots in the three areas.

Beta Diversity

In the Asplan Forest, the mean similarity between plots is much larger. Consequently, *Beta* diversity is smaller. On the other hand, Pacatuba Forest has least similarity among areas, and consequently presents a higher *Beta* diversity (Fig. 9).

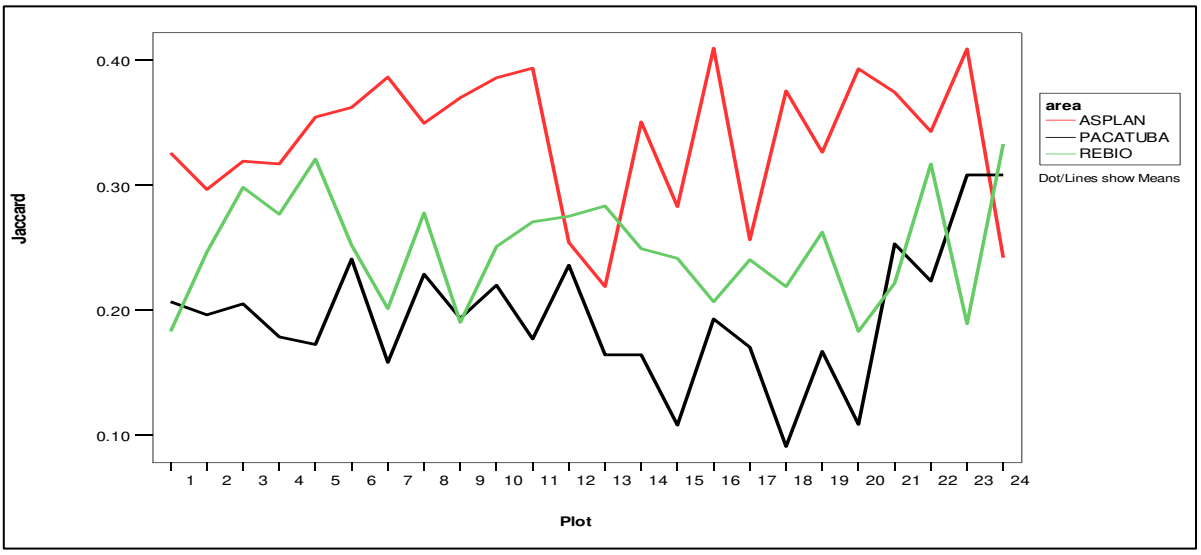


Figure 9. Mean similarity among plots in the studied areas.

Pacatuba is the forest with the largest number of plant species, that serve as food resources for the primates and also represents the forest with the highest quantity of large seeds and fruits (see Appendices I and II; Fig. 10). Pacatuba and REBIO Guaribas (Sema III) have the largest *Beta* diversity, while Asplan Forest has the highest similarity, and consequently the smallest *Beta* diversity. The larger *Beta* diversity in Pacatuba Forest is possibly due to the heterogeneity of the environment.

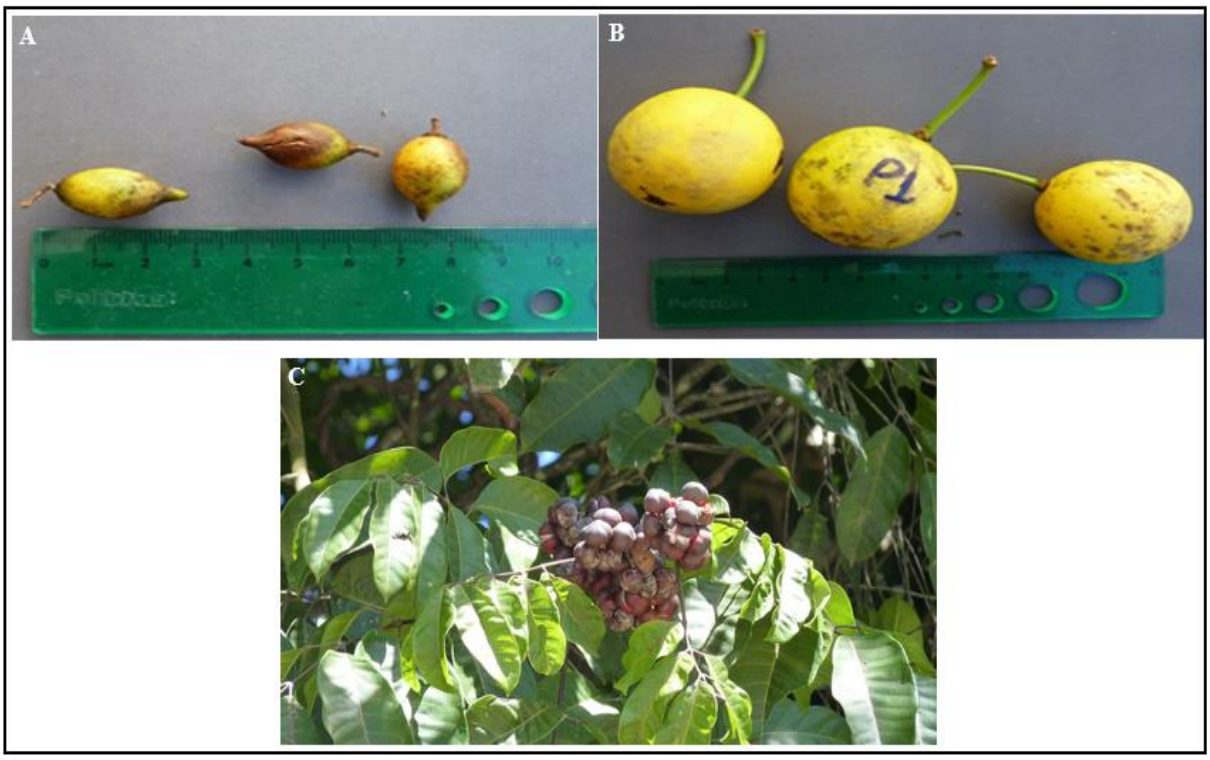


Figure 10. Some fruit consumed by primates in the present research. **A**. *Pouteria* sp.; **B**. *Garcinia* sp.; **C**. *Protium giganteum*. **Photos**: Antônio Moura, 2013.

The differences in the structure and diversity among the three studied areas may be explained in the light of the history of each area. According to inhabitants surrounding the Asplan Forest, about 30 years ago, when this area was not yet a legal reserve, several environmental perturbations were provoked with the selective exploration of trees for the construction of taipa houses, and by deforestation and burning of sectors of the forest for the production of charcoal. The deforestated areas were further used to cultivate corn and beans. A similar situation afflicted the REBIO Guaribas (Sema III) Forest, before it became a Biological Reserve, but deforestation was less pronounced here. The Pacatuba Forest, due to its greater distance from urban areas, and due to its belonging to the Japungu Sugar-Plant, presents a better state of preservation.

De Souza (2005) recorded 56 species consumed by primates in the Pacatuba Forest, while we found 31 fruit trees consumed by primates in this same area. Our results are similar to the 34 fruit trees recorded by Bonvicino (1989). The larger number indicated in De Souza (2005) is due to the inclusion of liana plants and arboreal trees, whose leaves and sprouts are also consumed by primates, and to the inclusion of exotic fruit trees, such as *Mangifera indica*. Tabarelli et al. (2010) state that the forest fragmentation leads to profound changes in the structure of the forest, affecting the morphology and phenology of the plant species. Fragmentation favours the appearance of species with small seeds and fruits, whose proliferation is more efficient. This results in the increase of species with small seeds or with seeds disopersed by wind. In the long run, species with delayed growth and with larger fruits and seeds become replaced by the smaller-seed pioneer species. These results indicate that large primates such as the guariba monkeys (*A. belzebul*) in the Pacatuba Forest contribute to the dispersal of the larger seeds (> 10.0 mm), such as the plant species *P. giganteum* (11.8 mm) and *Buchenavia grandis* (12.0 mm) (SOUSA, 2013). Perhaps the presence of these animals are in part responsible for the greater diversity found in Pacatuba Forest, for the presence of large-seed species, and for the more homogeneous distribution of these species within the sampled plots. Frugiverous animals disperse seeds of several species, exerting a key role in the regeneration of forested areas. Primates may spit, regurgitate, defecate or simply carry fruits away from the mother-plant, enhancing the probability of survival and germination of seeds (GALETTI; ALVES-COSTA; CAZETTA, 2003; SOUSA, 2013).

In the Asplan Forest we found the primates *S. flavius* and *C. jacchus*. In the Pacatuba Forest, we found *A. belzebul* and *C. jacchus.* In the REBIO Guaribas Forest only a single species was found (*C. jacchus*). It is probable that the difference in body size among these primates determines the potential for ingestion of seeds of different sizes (IZAR, 2008; LUCAS; CORLETT, 1998; UNGAR, 1995), thus affecting the structure of the forests. For example, *D. guianensis* occurs only in the Pacatuba Forest and apparently represents the only seed dispersant within this forested area.

The REBIO Guaribas (Sema III) Passion-Fruit Forest does not have primates of medium or large size, such as *S. flavius* and *A. belzebul*, and has the smallest number of plant species consumed by primates. It is also possible that the proximity of this area to urban settlements has negatively affected the diversity of species, as a result of its history of perturbation. Furthermore, the low declivity of this area does not favour the formation of microhabitats, resulting in an environment of low heterogeneity. The Asplan Forest had three plant species in addition to those found in the REBIO Guaribas Forest. Perhaps the presence

of the primate *S. flavius* is reponsible for the permanence of these species, through the dispersion of its seeds. One example of this is the genus *Inga*, consumed and apparently dispersed by *S. flavius,* which was found relatively frequently in the Asplan Forest, while in the REBIO Guaribas (Sema III) Forest, not a single individual of the genus *Inga* was found.

The pioneer plant species *T. guianensis* is dominant in the Asplan Forest. This species ie relatively common in fragmented areas, indicating that this forested area is in a stage of regeneration. In the Pacatuba Forest, the species *D. guianensis* presents a large number of individuals, while in the Asplan and REBIO Guaribas Forests, in which there are no guariba monkeys, the seeds have a mean size of 9 mm, which is close to the mean of large-seed species (10 mm). This correlates strongly with the presence of the primate *A. belzebul*, apparently the main dispersant of this plant, accounting for its abundance. On the other hand, the species *P. heptaphyllum* is more abundant in the REBIO Guaribas Forest, due to the great annual production of viable seeds by this species, which are dispersed by birds of several species, that appreciate the soft tissue surrounding these seeds (GUARIM NETO, 1991; LIMA, 2012).

In the three studied areas the primates (*C. jacchus*, *A. belzebul* and *S. flavius*), apparently influenced the distribution of species in all or most plots. Of the species consumed by primates, *T. guianensis*, *P. giganteum* and *P. heptaphyllum* are the most common species in Asplan, Pacatuba and Sema III Forests, respectively. The environmental relief of the Pacatuba Forest may also have influenced the higher diversity, due to the presence of more microhabitats in the region. Environments with a constant supply of water guarantee the presence of species that strive in more humid habitats. The occurrence of rare or uncommon species, such as *Hamelia patens*, *Rauia resinosa*, and *Sarcaulus brasiliensis* in the Pacatuba Forest (DIONÍSIO, 2002) is a consequence of the availability of humid environments. Furthermore, in these environments with a larger water availability the forest becomes higher and the vegetation becomes more dense. Although the REBIO Passion-Fruit Forest also has a stream, the primate *A. belzebul* does not occur there. This primate species is responsible for the dispersion of large-seed plants. Its absence may result, in the long run, in the disappearance of large-seed species, and in the reduction of the oversall plant diversity in the area.

CONCLUSIONS

Pacatuba is the forest area with the highest availability of food resoruces for primates. It is also the forest with most species of large seeds and fruits. The Pacatuba and REBIO Guaribas

(Sema III) Forests present the largest *Beta* diversity. The history of anthropic perturbations may explain the pattern of species richness observed between these two areas. The presence of large-body seed dispersants may have had an important influence on the diversity of tree species observed in the Pacatuba Forest.

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APPENDIX I

List of arboreal genera the fruit of which are consumed by the primates *Callithrix jacchus* (j), *Sapajus flavius* (f) and *Alouatta belzebul* (b)

Species	**Asplan**	**Pacatuba**	**Sema III**	**Fruits**
Andira		X		b
Allophyllus	X	X		b
Brosimum	X	X	X	j f b
Buchenavia	X	X	X	b
Byrsonima		X		j b
Campomanesia	X	X	X	j b
Cecropia	X		X	b
Coccoloba	X	X		j b
Copaifera		X		f
Cordia	X	X	X	b
Didymopanax	X	X		b
Eugenia	X	X	X	j b
Dialium		X		b
Ficus		X		j f b
Garcinia		X		b
Guapira	X	X		j f b
Guarea	X			f b
Guatteria	X	X	X	b
Hymenea		X	X	f
Inga	X	X	X	j f b
Licania	X	X	X	f b
Maytenus		X	X	b
Miconia			X	f b
Myrcia	X		X	b

Ocotea	X	X	X	j b
Ouratea	X	X	X	b
Piptadenia	X		X	b
Pouteria	X	X	X	b
Protium	X	X	X	j b
Psychotria		X	X	b
Simarouba		X	X	b
Sorocea		X	X	j f b
Tabebuia		X	X	b
Talesia		X	X	j b
Tapirira	X	X	X	j f b
Virtex			X	b
Xylopia	X	X	X	b

APPENDIX II

List of arboreal genera with medium- and large-sized seeds (* seeds with median size ≥ 5mm and ≤ 10mm, ** large seeds > 10mm)

Asplan	**Pacatuba**	**Sema III**
Buchenavia **	*Buchenavia* **	*Buchenavia* **
Campomanesia *	*Byrsonima* *	*Campomanesia* *
Eugenia *	*Campomanesia* *	*Eugenia* *
Inga **	*Copaifera* **	*Hymenea* **
Protium **	*Dialium* *	*Protium* **
	Eugenia *	
	Hymenea **	
	Inga **	
	Maytenus *	
	Protium **	