Original Article

DIVERSITY OF REPRODUCTIVE ECOLOGICAL GROUPS IN SEMIDECIDUOUS SEASONAL FORESTS

DIVERSIDADE DE GRUPOS ECOLÓGICOS REPRODUTIVOS EM FLORESTAS ESTACIONAIS SEMIDECIDUAIS

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ABSTRACT: Ecosystem degradation leads to loss of interactions between animals and plants, and changes in frequency of pollination systems, dispersal modes and sexual systems of plants. The objective of the present work was to compare the reproductive ecological groups of tree species among semideciduous seasonal forests remnants in the Triangulo Mineiro, Brazil, and to understand the organization of those plant communities. We analyzed the reproductive biology of 243 tree species found in 10 fragments, which showed different levels of disturbance. The occurrence and relative density of the species were used to estimate the importance of each reproductive feature. The study was based on a compilation of data present in specialized works and community surveys conducted in the region. We aggregated the species of these communities in ecological groups according to their reproductive characteristics. The frequency of species in each reproductive ecological group was, to a certain extent, similar between remnants. The pollination by small insects (small bees, wasps and flies) represented 42%, dispersal by birds 35%, and hermaphrodite sexual system 54% of the species. Clearer differences among fragments were found on the relative densities of each reproductive ecological group. Relatively specialized bat and moth pollination, as well as wind dispersal were common in the most disturbed fragment. But generalist reproductive characteristics predominated in the studied fragments.

KEYWORDS: Pollination system. Dispersal system. Sexual system. Forest fragments.

INTRODUCTION

The Cerrado Biome has a high diversity of plant physiognomies intensively explored by man for livestock, agriculture, and sugar cane cultivation (KLINK; MACHADO, 2005), and has been reduced to a fraction of the original vegetation. These disturbances contributed to changes in the natural processes of communities, because the composition and abundance of species are affected by degradation (NUNES et al., 2003). The semideciduous seasonal forest (*sensu* IBGE 2012), also referred as dry semideciduous forests (RIBEIRO; WALTER, 2008), is one of the Cerrado phytophysiognomies, which trees elements loose between 20 and 50% of their leaves during the dry season (RIBEIRO; WALTER, 2008). Many of these formations are characterized by a large floristic diversity, including species of the Amazon, Atlantic Forest and Cerrado flora (OLIVEIRA-FILHO; FONTES, 2000).

The plant diversity identified in the remnants of seasonal forests suggests an intricate network of interactions with animals. Hence, the process of pollination as well as the dispersal of fruits and seeds are fundamentally dependent on biotic vectors, especially birds and mammals (TALORA; MORELLATO, 2000). Over 90% of the world Angiosperms are pollinated by animals (BUCHMANN; NABHAN, 1996), so pollination is essential for the maintenance of biodiversity in forest ecosystems in general (VAMOSI et al., 2006) and in these forests in particular (OLIVEIRA; PAULA, 2001).

With the degradation and forest fragmentation, many of the animal-plant interactions may disappear, since many species of animals cannot find enough resources to feed or reproduce efficiently in fragments (FRANCHESCHINELLI et al., 2003). Fragmentation processes of Atlantic forest areas in Northeastern Brazil have prompted a shift in the frequency of certain pollination systems and reproductive features, leading to a simplification of the reproductive process and breakdown of the interdependence between animals and plants (GIRÃO et al., 2007). With the change of plant-pollinator interactions, the species reproductive success is affected, disturbing the processes of seed dispersal and germination, reducing the size of populations and often promoting local extinctions (HARRIS; JOHNSON, 2004).

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Considering that each forest fragment has a history of disturbance and occupation by different plant species (LOPES, 2010), we expected to find variation in the occurrence of pollination systems, fruit and seed dispersal modes, and sexual systems between fragments. The basic idea is that well preserved forests tend to have species with more specialized reproductive features and which depend more broadly on animal pollinators and dispersers. Furthermore, the conservation status and the possibility of recovery of these areas are dependent on biotic interactions and reproductive requirements of the plant species in these communities. Therefore, the objective of the present work was to compare the reproductive ecological groups of tree species among fragments of semideciduous seasonal forests of Triangulo Mineiro, Brazil, and to understand the organization of plant communities, using those reproductive characteristics.

MATERIAL AND METHODS

We here compiled and supplemented information on the reproductive biology and ecology of tree species found in ten fragments of semideciduous seasonal forests (*sensu* IBGE 2012) of the Triangulo Mineiro region, in Central Brazil (Table 1). These ten forests were studied in phytosociological surveys conducted by Lopes (2010). The relative density data in each area for each species, obtained from that study, were used to estimate similarities and/or differences in the pollination systems, dispersal and sexual system. The species information about the flowering phenology and fruiting was also compiled from herbarium data and specific literature, when available. Data on sexual system, pollination and reproduction systems were obtained from literature or other community studies conducted in the region (OLIVEIRA; GIBBS, 2000; PINHEIRO; RIBEIRO, 2001).

Table 1. Information of the ten fragments of semideciduous seasonal forest (*sensu* IBGE 2012) in Triangulo Mineiro region used in the data collection analyzed in this work, Minas Gerais, Brazil. According to the study of Lopes (2010). MASL – Meters above sea level.

Fragment	City	Watersheed	Area(ha)	Latitude(S)	Longitude(W)	Altitude (MASL)	Tree density (ind.ha^{-1})
Água Fria	Araguari	Rio Paranaíba	200	18°29'50"	48°23'03"	680	839
Ipiaçu	Ipiaçu	Rio Paranaíba	40	18°43'39"	49°56'22"	530	837
Monte Carmelo	Monte Carmelo	Rio Paranaíba	119	18°44'59"	47°30'56"	910	798
Uberaba	Uberaba	Rio Grande	70	19°40'35"	48°02'12"	790	805
Cruzeiro	Uberlândia	Rio Paranaíba	17,5	18°40'26"	48°24'32"	600	1233
Glória	Uberlândia	Rio Paranaíba	30	18°57'03"	48°12'22"	880	976
Irara	Uberlândia	Rio Paranaíba	22,3	19°08'39"	48°08'46"	930	945
Panga	Uberlândia	Rio Paranaíba	16	19°10'04"	48°23'41"	800	1292
Pereira	Uberlândia	Rio Paranaíba	35	18°51'35"	48°03'51"	890	1144
São José	Uberlândia	Rio Paranaíba	20	18°29'50"	48°13'53"	890	1063

Data were compiled and organized into a spreadsheet of Excel 2007, following some of the categories and parameters used in previous studies (PAULA; OLIVEIRA, 2001; GIRÃO et al., 2007). The categories used for pollination systems were: SMI - small insects (small bees, flies and wasps); LGB - large bees; WIN - wind; VSI - very small insects; BUT - butterflies; BAT - bats; MOT - moths; BTL - beetles; NID - not identified. For fruit and seed dispersal modes, the categories were: ORN

- birds; MAM - non-flying mammals; CHI - bats; ANE - wind, AUT - autochory; NID – not identified. And for the sexual systems the categories were: DIO: dioecious; MON: monoecious; HER: hermaphrodite; NID – not identified. Each of these categories for pollination system, dispersal system and sexual system were considered reproductive ecological groups. The species richness and relative density of the species in each of the studied areas and reproductive ecological group were calculated. The relative density was calculated based on the density of each species divided by the total tree density in each area (Table 1). The sum of the relative densities of species within each reproductive ecological group was used as an estimator of the relative importance of each group. Since there were species that could not be classified into a reproductive group, the relative density used in the analyses was the percentage of the effectively classified species, excluding the non-classified plants (NID –not identified).

We compared the similarity between areas based on the reproductive features with a hierarchical cluster analysis, the similarity index Morisita-Horn, based on the group average (UPGMA = unweighted Pair-Groups Method using Arithmetic Averages) (SNEATH; SOKAL, 1973) using the FITOPAC 1.6 (SHEPHERD, 2004).

RESULTS

Species general analysis – Some 243 tree species were found in semideciduous seasonal forest fragments, of which only three were not identified (see a complete list in Appendix 1). The species were distributed in 163 genera and 58 families. We found information on pollination system for 76.5% of the species (186 spp.) Out of the total of species, some 103 (42%) were pollinated by small insects, such as bees, wasps and flies, 22 (9%) by large bees, and 18 (7%) by moths (Figure 1A). As for dispersal mode, 78% of species (189 spp.) were classified. We observed a high percentage of zoochory as a whole (46%), and 33% were bird dispersed (81 spp). Wind dispersal accounted for 25% of the species (60 spp.) (Figure 1B). Sexual system was defined for 79.2% of species (190 spp.), of which the hermafroditism represented 54% (130 spp.), dioecy 15% (37 spp.), and monoecy 9% (23 spp.) (Figure 1C).

Species and relative density – Number of species with each pollination systems showed little variation among the analyzed areas. Some 40% of the trees were predominantly pollinated by small insects (bees, wasps and flies small) (Figure 2A). Yet when considering the sum of the relative density for each pollination system, the results were more contrasting, with pollination by small insects showing large variations among the ten areas (Figure 2B). For example, this pollination system accounted for about 27% of individuals in São José area while in Água Fria it represented 69% of individuals (Figure 2B). In Ipiaçu fragment, pollination by moths and bats seemed to be more important, representing respectively 22% and 25% of the relative density and differing from other areas where between 2% to 14% were pollinated by moths and 1% to 4% pollinated by bats (Figure 2B). Panga, Monte Carmelo and Água Fria were the only fragments with species pollinated by non-flying mammals, although with very low densities (0.1%, 0.3% and 0.6% respectively). Pollination involving very small insects (VSI) had reduced values, when considering the number of plant species with this system (Figure 2B). However, when the relative density of these species was analyzed, we observed much higher importance for this type of pollination system in most areas, except Ipiaçu. Such differences in relative density of species in the areas of São José and Ipiaçu explain the separation of these two areas in the similarity analysis based on pollination systems (Figure 2C).

Dispersal modes – The analysis about the ecological groups demonstrated the occurrence of many zoochorous species, and more specifically many ornithochorous species in semideciduous seasonal forests (Figure 3A). Bird dispersal showed no marked differences in the frequency of species among the ten fragments. But Ipiaçu was the fragment with the lowest representation of this dispersal system with 23% (Figure 3A). However, when analyzing species relative density, we observed that ornithochory showed greater importance in the natural processes of some fragments such as Água Fria, Irara, Monte Carmelo, Glória and Pereira reaching values of 74%, 61%, 54 %, 48% and 47%, respectively (Figure 3B). Panga, Cruzeiro and São José showed respectively 32%, 29% and 37% of individuals dispersed by non-flying mammals (Figure 3B). In the Ipiaçu fragment, the most representative dispersal modes were anemochory and autochory, with values between 37% and 23% of individuals, respectively. The Uberaba fragment also stood out by presenting approximately 36% of individuals with autochory (Figure 3B). These differences in the relative density of autochorous species in Ipiaçu and Uberaba areas explain the separation of these two areas in the similarity analysis (Figure 3C).

Sexual systems – The sexual systems analysis showed low values of dioecy and monoecy when compared with the frequency of hermaphroditism (Figure 4A). However, considering the relative density of individuals, the importance of dioecy increased in six of the areas, indicating the importance of this process in such environments (Figure 4B). Fragments such as Irara, Glória, Monte Carmelo and Pereira showed highest relative density of dioecious individuals and dispersal by animals, when compared to other areas (Figure 4B). The similarity analysis for the sexual system using the relative density of individuals (Figure 4C), highlighted the Irara fragment with the highest relative density of monoecious and dioecious species.

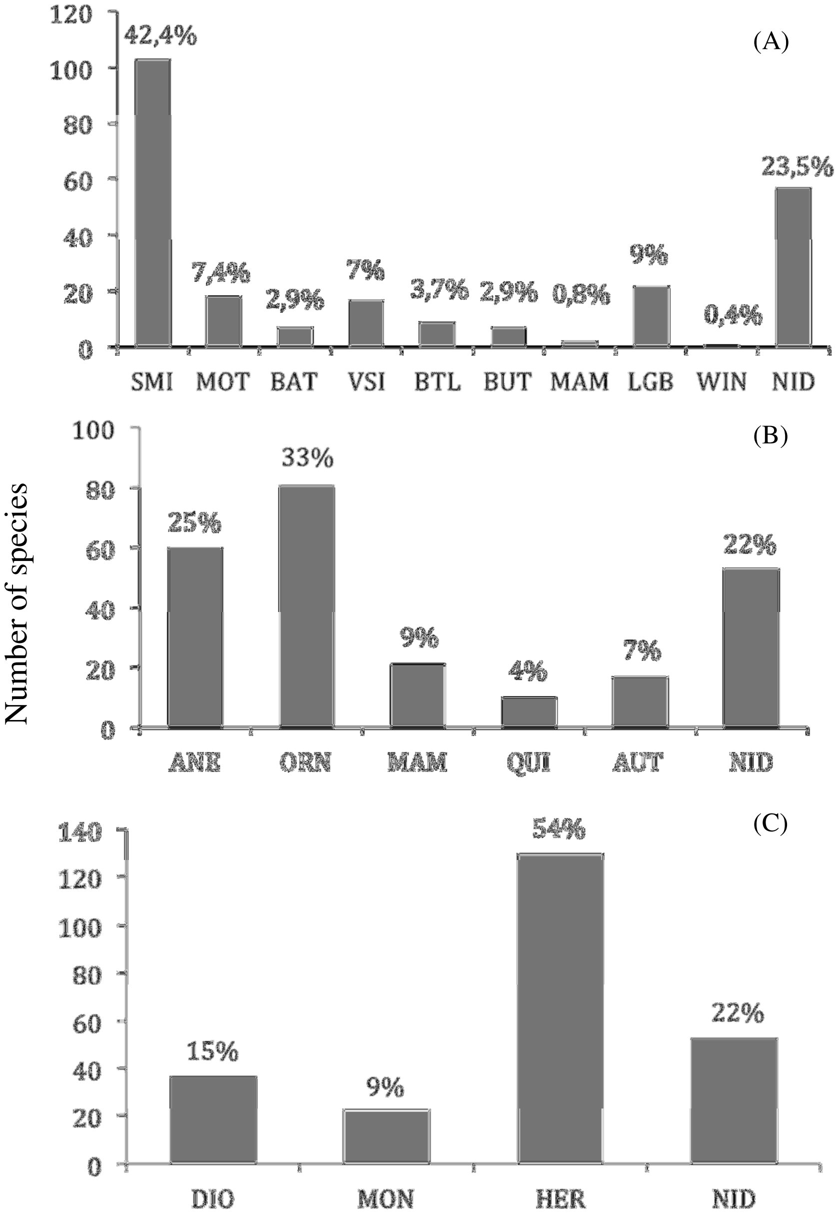

Figure 1. Number of species found in each ecological reproductive groups found in ten fragments of semideciduous forests of Triangulo Mineiro, Minas Gerais, Brazil. (A) Pollination systems: SMI – small insects (small bees, flies and wasps); MOT – moths; BAT – bats; VSI – very small insects; BTL – beetles; BUT – butterflies; MAM – non-flying mammals; LGB – large bees; WIN – wind; NID – not identified. (B) - Dispersal systems: ANE – wind; ORN – birds; MAM – non-flying birds; CHI – bats; AUT – autochory; NID – not identified. (C) - Sexual systems: DIO – dioecious; MON – monoecious; HER – hermaphrodite; NID – not identified.

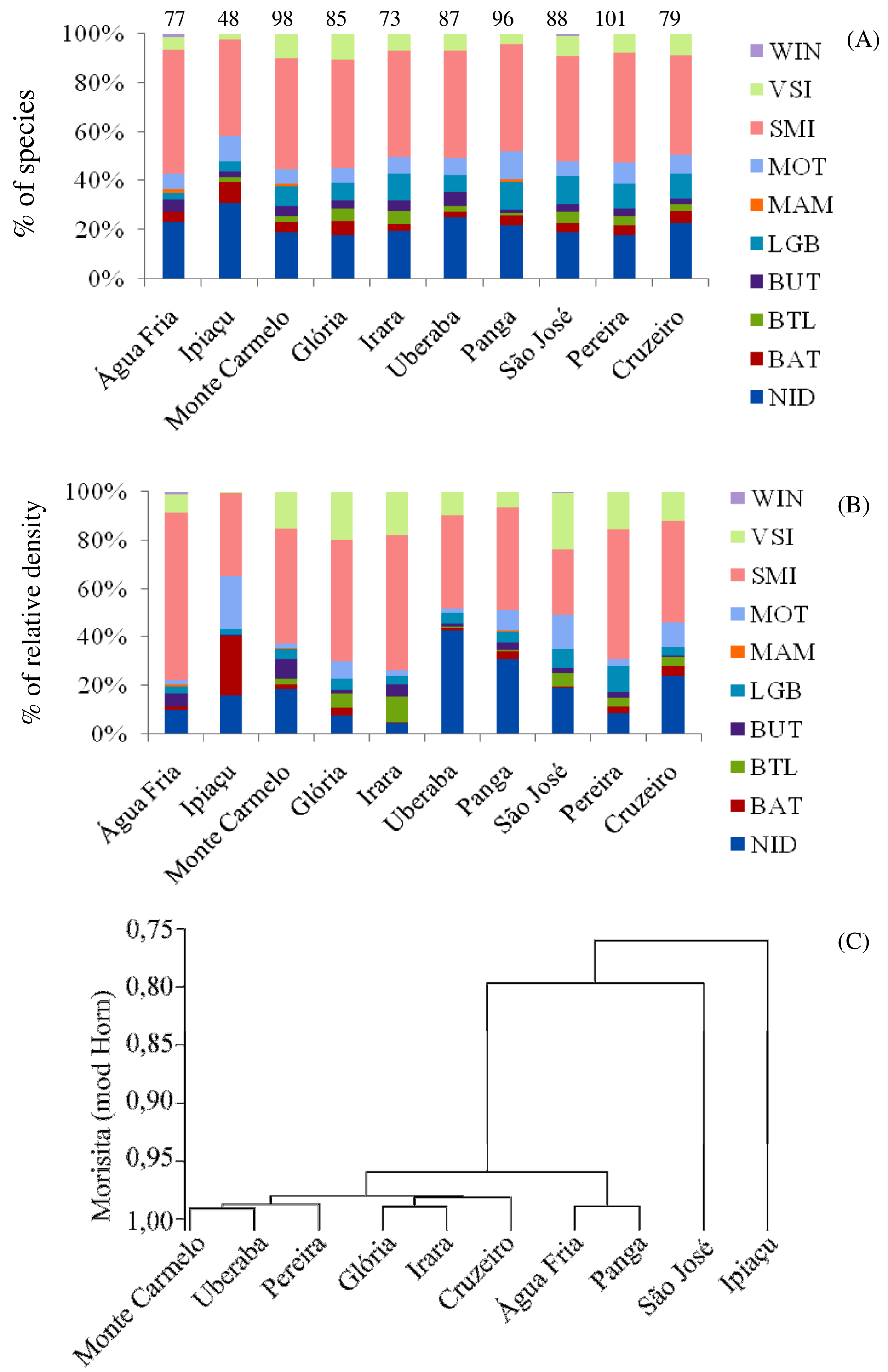

Figure 2. Pollination system in ten fragments of semideciduous seasonal forests of Triangulo Mineiro, Minas Gerais, Brazil. (A) Percentage of the number of species in each pollination system. Number of species analyzed in each area on the top of the column, (B) Percentage of the relative density represented by the sum of the species density in each pollination system; and (C) Cluster of similarity based on the relative density of the pollination systems using the UPGMA method. WIN – wind; VSI – very small insects; SMI – small insects (small bees, flies and wasps); MOT – moths; MAM – non-flying mammals; LGB – large bees; BUT – butterflies; BTL – beetles; BAT – bats; NID – not identified.

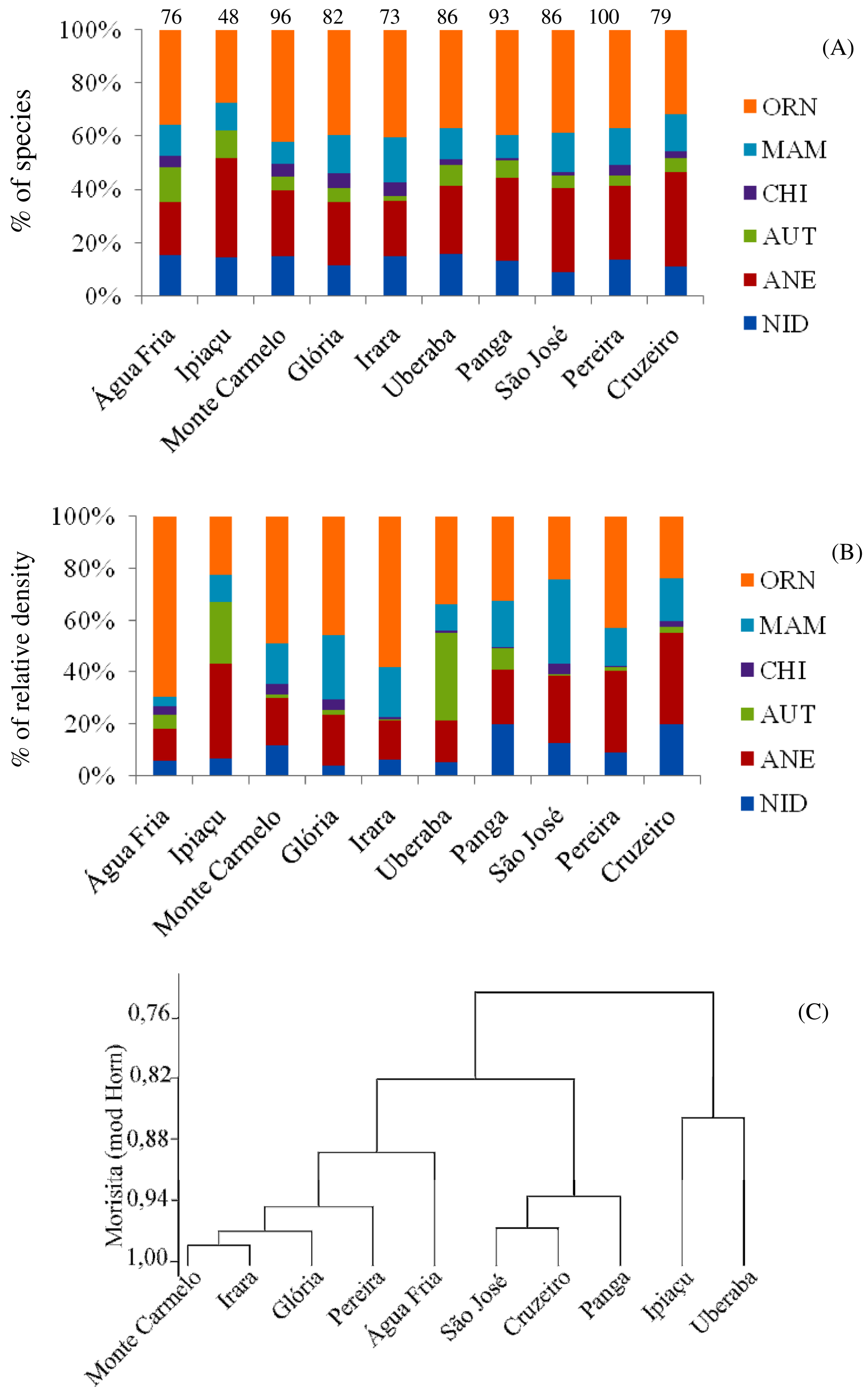

Figure 3. Dispersal system in ten fragments of semideciduous seasonal forests of Triangulo Mineiro, Minas Gerais, Brazil. (A) Percentage of the number of species in each dispersal system. Number of species analyzed in each area on the top of the column, (B) Percentage of the relative density represented by the sum of the species density in each dispersal system; and (C) Cluster of similarity based on the relative density of the dispersal systems using the UPGMA method. ORN – birds; MAM – non-flying birds; CHI – bats; AUT – autochory; ANE – wind; NID – not identified.

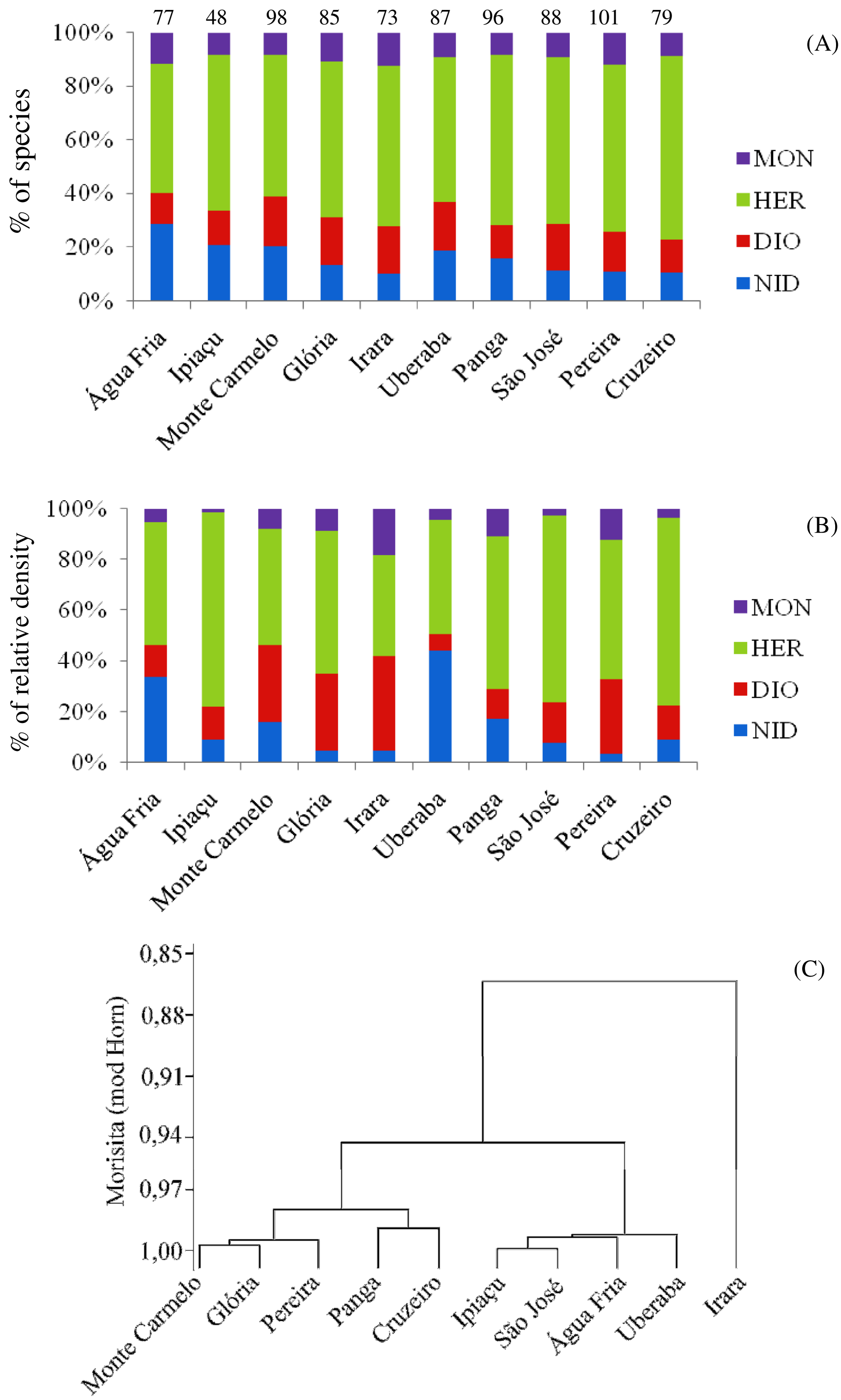

Figure 4. Sexual system in ten fragments of semideciduous forests of Triangulo Mineiro, Minas Gerais, Brazil. (A) Percentage of the number of species in each sexual system. Number of species analyzed in each area on the top of the column, (B) Percentage of the relative density represented by the sum of the species density in each sexual system, and (C) Cluster of similarity based on the relative density of the sexual systems using the UPGMA method. MON – monoecious; HER – hermaphrodite; DIO – dioecious; NID – not identified.

DISCUSSION

The semideciduous seasonal forests studied here showed varied frequencies of pollination systems, despite the relatively high frequency for some systems. In plant communities with high abundance of flowers, the quality and quantity of resources offered varies from species to species, so that pollinators may select some species over others. However there are pollinator species, especially bees, flies and wasps, which can use plant species with different floral traits (GEBER; MOELLER, 2006). Therefore, pollination by these groups can be considered generalist. In the ten studied areas these pollinators were the most important. For gallery forests (*sensu* RIBEIRO; WALTER 2008) in the Cerrado region, this pollination system represents 45% of species (PAULA; OLIVEIRA, 2001), in typical cerrado *s.s.* formations (*sensu* RIBEIRO; WALTER 2008) it represents 44% (OLIVEIRA; GIBBS, 2000), but in a rainforest in Costa Rica it represents only 18% (KRESS; BEACH, 1994). Therefore, the main pollinators for the cerrado *s.s.*, gallery forests and semideciduous seasonal forests in the region are the animals included in this small insects group, different from moist rain forest areas, which have distinct, perhaps more specialized pollinators.

As for the dispersal systems, almost half of the studied species in forest remnants was dispersed by animals (46%), but this value is likely to be even higher due to 22% of non–classified species. For semideciduous forests in the Atlantic forest region, zoochory represented 70% of plant species (CARVALHO et al., 2006), and in the cerrados and semideciduous forests in the region of Mato Grosso zoochory was about 58% (TAKAHASI; FINA, 2004). In the forests of the Cerrado region as a whole, zoochory represents 67%, and in gallery forests up to 71% of the species (OLIVEIRA; PAULA, 2001). Thus, zoochorous dispersal mode is the most common among arboreal plants, and the Cerrado birds stand out as the main seed and fruit dispersers (GOTTSBERGER; SILBERBAUER-GOTTSBERGER, 2006). The ornithochory was present in 33% of species in fragments of semideciduous forests here studied. The dispersal by birds is very common in the region forests, and may include up to 57% (OLIVEIRA; PAULA, 2001) or even 70% of gallery forest species (PINHEIRO; RIBEIRO, 2001). Despite the dominance of zoochory in the studied semideciduous seasonal forest fragments, abiotic seed and fruit dispersal by wind and gravity (anemochory and autochory respectively) represent important process in some of these forests. Especially anemochory is a common dispersal mechanism on seasonal environments, since drought facilitates the carrying of propagules to longer distances.

In the ten forest fragments the hermaphroditism was the predominant sexual system (54%) followed by dioecy (15%) and monoecy (9.5%). In a rainforest in Costa Rica, 65.5% of the species are hermaphrodites, 23.1% and 11.4% are respectively monoecious and dioecious (BAWA et al., 1985b). For the cerrado savanna physiognomies (*sensu* RIBEIRO; WALTER 2008) in a reserve of CPAC - Agricultural Research Center, 88% of the species are hermaphrodites, and 7% and 5% are monoecious and dioecious respectively (RIBEIRO et al., 1985). Thus, hermaphroditism was the predominant sexual system in tropical forests, cerrado physiognomies and semideciduous forests.

The ten areas were more similar in terms of the number of species in each of the reproductive ecological groups than in terms of relative density of individuals in each group. This means that the differences between areas are less related to species turnover and more related to the species relative importance, which changes from area to area. The relative density may indicate more quickly the interactions between species and environmental conditions of the forests remnants, including degradation (LOPES, 2010).

Ipiaçu was the most distinct area due to the relative density of species pollinated by bats and moths. This difference may be associated with the historical use of the area, which allowed the establishment of species with specialized pollination agents, but it is somewhat surprising since this is clearly the most degraded fragment.

The Ipiaçu fragment presented occupation by pastureland and annual crops in the surrounding area, and signals of selective logging, forming gaps where vegetation consisted of shrub species and juveniles, with few large individuals (LOPES, 2010). Despite degradation, high relative density values were found for plants pollinated by relatively specialized moths and bats, both in the canopy and understory layers. The species *Hymenaea courbaril* and *Luehea divaricata* pollinated by bats and *Piptadenia gonoacantha* by moths, had the highest relative densities in this disturbed fragment.

Studies conducted in the Atlantic Forest in Pernambuco (GIRÃO et al., 2007) indicated a reduction in specialized pollination systems in small and degraded forest fragments. The idea is that fragmentation and disturbance would select generalist pollination systems as small insect (SMI) and very small insects (VSI). But those systems seems to be the most common and widespread in both semideciduous seasonal forests and gallery forests in the region (OLIVEIRA; PAULA, 2001) and we could not find a clear relationship between disturbance and the frequency of these systems, as described for the Atlantic Forest in Pernambuco (GIRÃO et al., 2007).

According to a study conducted in a floodplain dipterocarp forest in Sarawak, Malaysia, the flowers present in open areas, as forest gaps, have characteristics that attract specialized pollinators (MOMOSE et al., 1998). These forest gaps are formed by a smaller number of species and present low productivity. These characteristics are similar to those observed in Ipiaçu fragment and may help to understand pollination systems found in this area.

As for the dispersal modes, Uberaba and Ipiaçu differed more than other areas in the similarity analysis, presenting the highest relative importance for species dispersed by wind and gravity. Autochory has been associated with pioneering species and arid regions (PIJL, 1969). This dispersal mode is considered, therefore, a limiting process in closed forests, as can be seen in the gallery forest where only 3% of the plants have this type of dispersal (PINHEIRO; RIBEIRO, 2001). Although the Uberaba fragment showed the highest percentage of autochorous species, the vegetation of this area is in an advanced stage of succession, with large individuals (LOPES, 2010). In this fragment, species of *Galipea jasminiflora* and *Micrandra elata* are dispersed by autochory, and present high relative density in the understory and canopy, respectively. Therefore, autochory seems to be important even in better conserved forests in the region.

As for anemochory, some authors consider this type of dispersion associated with open habitats (OLIVEIRA; MOREIRA, 1992), this system tends also to decrease in denser environments, because they prevent the action of wind (PINHEIRO; RIBEIRO, 2001). But in Ipiaçu fragment, anemochory and autochory systems had higher percentages when compared with the zoochory. As the Ipiaçu fragment is the most open area, probably a result of disturbance and gaps, wind dispersed species have better chances to spread their diaspores in this area. However, despite differences in Uberaba and Ipiaçu, dispersal by birds and non-flying mammals predominated in most semideciduous forest studied.

Irara fragment differed by the relatively high abundance of dioecious and monoecious plants, while other areas showed lower values. The dioecy and monoecy can be seen as sexual systems associated with pollination by small insects and dispersal by animals, which can be most directly affected by environmental changes in forests (OLIVEIRA, 1996). On the other hand, dioecy has been associated also with vegetation in isolated islands or where pollination may be somewhat limited (BAWA et al., 1985b).

For the semideciduous seasonal forests of Triangulo Mineiro, we observed that more than 50% of species pollinated by small insects were hermaphrodites, 21% were dioecious and 15% were monoecious. The guild of small insects is very diverse and is commonly considered the most important group of pollinators of dioecious plants (OLIVEIRA, 1996). In the rainforests of Costa Rica, 66% of species pollinated by small insects are dioecious (BAWA et al., 1985a,b). This means that there is a predominance of dioecy in rainforests, probably due to the diversity of pollinators and environmental stability of these forests. This stability allows the maintenance of viable dioecious plant populations pollinated by small insects, and contrasts with seasonal and degraded environments such as semideciduous season forests studied here. However this small insect pollination system, is not well defined in many cases and tends to be subdivided in plants adapted to different groups of pollinators, as small bees, flies, and wasps, which may exhibit specialized and distinct requirements for the pollination process (KRESS; BEACH, 1994).

The predominance of certain systems such as hermaphroditism and small insect pollination may represent an effect of fragmentation and degradation in these areas, influencing the loss of diversity of ecological groups. The predominance of generalist pollinators may also lead to increased frequency of self-compatible hermaphrodites plants (GIRÃO et al., 2007).

CONCLUSION

The study points out to a great diversity of reproductive ecological groups in the semidecidous seasonal forests in the Triangulo Mineiro. We observed a trend of generalist reproductive characteristics, which seem to be associated with the poorly conserved forest fragments studied. This is even clearer when using the relative density of the species, which may indicate that changes in environmental conditions affected species density and relative importance well before they affect species turnover. But some reproductive characteristics associated with more pristine habitats, as e.g. moth and bat pollination, are still present even in the most disturbed remnants.

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RESUMO: A degradação dos ecossistemas gera a perda das interações entre animais e plantas e a mudança na frequência de sistemas de polinização, modos de dispersão e sistema sexual das plantas. O objetivo do estudo foi comparar os grupos ecológicos reprodutivos de árvores entre remanescentes de florestas estacionais semideciduais no Triângulo Mineiro, Brasil, e entender a organização destas comunidades. Foi analisada a biologia reprodutiva de 243 espécies arbóreas encontradas em 10 fragmentos que apresentavam diferentes níveis de perturbação ambiental. A ocorrência e densidade relativa das espécies foi utilizada para estimar a importância de cada característica reprodutiva. O estudo baseou-se na compilação de dados presentes em trabalhos especializados e estudos comunitários realizados na região. As espécies dessas comunidades foram agregadas em grupos ecológicos reprodutivos de acordo com suas características. A frequência das espécies foi, até certo ponto, semelhante entre os fragmentos. A polinização por pequenos insetos (abelhas, moscas e vespas pequenas) representou 42% no total das espécies, a dispersão pelas aves foi de 35% e o sistema sexual que se destacou foi o hermafroditismo com 54%. Diferenças mais evidentes foram encontradas entre as densidades relativas de cada grupo ecológico reprodutivo. Polinização por morcegos e mariposas, relativamente especializadas, bem como dispersão pelo vento foram comuns na área com maior perturbação. No entanto, características reprodutivas consideradas generalistas prevaleceram nos fragmentos.

PALAVRAS-CHAVE: Sistema de polinização. Sistema de dispersão. Sistema sexual. Fragmentos florestais.

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Appendix 1 – Woody species observed in semideciduous forests remnants of the Triangulo Mineiro region and their reproductive ecological groups. The categories used for pollination systems were: SMI - small insects (small bees, flies and wasps); LGB - large bees; WIN - wind; VSI - very small insects; BUT - butterflies; BAT - bats; MOT - moths; BTL - beetles; NID - not identified. For the sexual systems the categories were: DIO: dioecious; MON: monoecious; HER: hermaphrodite; NID – not identified. And for fruit and seed dispersal systems, the categories were: ORN - birds; MAM - non-flying mammals; CHI - bats; ANE - wind, AUT - autochory; NID – not identified. *Allien species spontaneous in the region.

Families	Species	Pollination systems	Sexual systems	Dispersal systems
Anacardiaceae	*Astronium fraxinifolium Schott*	NID	DIO	ANE
Anacardiaceae	*Astronium nelson-rosae D.A. Santin*	SMI	DIO	ANE
Anacardiaceae	*Myracrodruon urundeuva Allemão*	SMI	DIO	ANE
Anacardiaceae	*Lithrea molleoides (Vell.) Engl.*	SMI	DIO	ORN
Anacardiaceae	*Tapirira guianensis Aubl.*	SMI	DIO	ORN
Anacardiaceae	*Tapirira obtusa (Benth.) J.F. Mitch*	SMI	DIO	ORN
Annonaceae	*Annona cacans Warm.*	BTL	HER	MAM
Annonaceae	*Annona montana Macfad.*	NID	NID	NID
Annonaceae	*Cardiopetallum calophyllum Schlecht.*	BTL	HER	ORN
Annonaceae	*Duguetia lanceolata St. Hil.*	BTL	HER	MAM
Annonaceae	*Guatteria australis A. St.-Hil.*	BTL	NID	NID
Annonaceae	*Porcelia macrocarpa (Warm.) R.E.Fr.*	BTL	NID	NID
Annonaceae	*Rollinia sylvatica (A.St.-Hill.) Mart.*	BTL	MON	ORN
Annonaceae	*Unonopsis lindmanii R.E.Fr.*	SMI	HER	ORN
Annonaceae	*Xylopia aromatica (Lam.) Mart.*	VSI	HER	ORN
Annonaceae	*Xylopia brasiliensis Spreng.*	BTL	MON	ORN
Annonaceae	*Xylopia sericea St. Hil.*	BTL	HER	ORN
Apocynaceae	*Aspidosperma cuspa (H.B.K.) S.F. Blake*	MOT	HER	ANE
Apocynaceae	*Aspidosperma cylindrocarpum M.Arg.*	MOT	HER	ANE
Apocynaceae	*Aspidosperma discolor A. DC.*	MOT	HER	ANE
Apocynaceae	*Aspidosperma olivaceum M.Arg*	MOT	HER	ANE
Apocynaceae	*Aspidosperma parvifolium A. DC.*	MOT	HER	ANE
Apocynaceae	*Aspidosperma polyneuron Müll. Arg.*	MOT	NID	ANE
Apocynaceae	*Aspidosperma subincanum Mart. ex A. DC.*	MOT	HER	ANE
Aquifoliaceae	*Ilex cerasifolia Reissek*	NID	NID	NID
Araliaceae	*Aralia warmingiana (Marchal) J. Wen*	SMI	HER	ORN
Araliaceae	*Dendropanax cuneatum (DC.) Decne. et Planch*	SMI	DIO	ORN
Araliaceae	*Schefflera morototoni (Aubl.) Maguire et al.*	SMI	HER	MAM
Arecaceae	*Acrocomia aculeata (Jacq.) Lodd.*	BTL	MON	MAM
Asteraceae	*Piptocarpha macropoda Baker*	SMI	HER	ANE
Bignoniaceae	*Handroanthus impetiginosus (Mart. Ex DC.) Mattus*	LGB	HER	ANE
Bignoniaceae	*Jacaranda cuspidifolia Mart. Ex A.DC.*	NID	HER	ANE
Bignoniaceae	*Jacaranda macrantha Cham.*	NID	HER	ANE
Bignoniaceae	*Tabebuia roseo-alba (Ridley) Sandwith*	LGB	HER	ANE
Bignoniaceae	*Tabebuia serratifolia (Vahl) Nicholson*	LGB	HER	ANE
Boraginaceae	*Cordia alliodora Cham.*	MOT	HER	ANE
Boraginaceae	*Cordia sellowiana Cham.*	SMI	HER	MAM
Boraginaceae	*Cordia superba Cham.*	SMI	NID	MAM

Boraginaceae	*Cordia trichotoma*	SMI	NID	ANE
Burseraceae	*Protium heptaphyllum (Aubl.) March.*	SMI	DIO	ORN
Cannabaceae	*Celtis iguanaea (Jacq.) Sargent.*	SMI	NID	ORN
Cannabaceae	*Trema micrantha (L.) Blume*	NID	NID	NID
Cardiopteridaceae	*Citronella paniculata (Mart) R.A.Howard*	NID	NID	NID
Caricaceae	*Jacaratia spinosa (Aubl) A.DC*	MOT	DIO	AUT
Celastraceae	*Cheiloclinium cognatum (Miers.) A.C.Sm.*	VSI	HER	MAM
Celastraceae	*Maytenus floribunda Reiss.*	NID	NID	NID
Celastraceae	*Maytenus robusta Reissek*	NID	NID	NID
Celastraceae	*Maytenus sp.*	NID	NID	NID
Celastraceae	*Salacia elliptica (Mart.ex Schult.) G.Don*	SMI	MON	MAM
Chrysobalanaceae	*Hirtella glandulosa Spreng.*	BUT	HER	ORN
Chrysobalanaceae	*Hirtella gracilipes (HooK f.) Prance*	BUT	HER	ORN
Chrysobalanaceae	*Hirtella racemosa Lam.*	BUT	NID	ORN
Clusiaceae	*Calophyllum brasiliense Cambess*	SMI	DIO	CHI
Clusiaceae	*Garcinia brasiliensis Mart.*	NID	NID	NID
Combretaceae	*Terminalia argentea Mart. & Zucc.*	SMI	HER	ANE
Combretaceae	*Terminalia glabrescens C. Zucc.*	SMI	HER	ANE
Combretaceae	*Terminalia phaeocarpa Eichl.*	SMI	HER	ANE
Cunoniaceae	*Lamanonia ternata Vell.*	SMI	HER	ANE
Ebenaceae	*Diospyros hispida A. DC.*	VSI	DIO	MAM
Elaeocarpaceae	*Sloanea hirsuta (Schott) Planch. ex Benth*	NID	HER	MAM
Erythroxylaceae	*Erythroxylum daphnites Mart.*	SMI	HER	ORN
Erythroxylaceae	*Erythroxylum deciduum St. Hil.*	SMI	HER	ORN
Euphorbiaceae	*Acalypha gracilis (Spreng.) Müll. Arg.*	WIN	NID	AUT
Euphorbiaceae	*Alchornea glandulosa Poepp. & Endl.*	VSI	DIO	ORN
Euphorbiaceae	*Mabea fistulifera Mart.*	BAT	MON	AUT
Euphorbiaceae	*Maprounea guianensis Aubl.*	SMI	MON	ORN
Euphorbiaceae	*Micrandra elata Müll. Arg.*	NID	NID	AUT
Euphorbiaceae	*Pera glabrata (Schott.) Baill.*	SMI	DIO	NID
Euphorbiaceae	*Sapium glandulosum (L.) Morong*	NID	NID	NID
Fabaceae	*Acacia polyphilla DC.*	SMI	HER	ANE
Fabaceae	*Albizia niopoides (Spruce ex. Benth.) Brukat*	MOT	HER	AUT
Fabaceae	*Albizia polycephala (Benth.) Killip*	SMI	MON	AUT
Fabaceae	*Anadenanthera colubrina (Vell) Brenan*	SMI	HER	AUT
Fabaceae	*Andira fraxinifolia Benth.*	SMI	HER	NID
Fabaceae	*Andira ormosioides Benth.*	NID	HER	NID
Fabaceae	*Apuleia leiocarpa (Vog.) Macbr.*	LGB	HER	ANE
Fabaceae	*Bauhinia rufa (Bong.) Steud*	BAT	HER	AUT
Fabaceae	*Bauhinia ungulata L.*	BAT	HER	AUT
Fabaceae	*Calliandra foliolosa Benth*	MOT	HER	AUT
Fabaceae	*Cassia ferruginea Schrad. ex DC.*	LGB	HER	ANE
Fabaceae	*Centrolobium tomentosum Guillem. ex Benth.*	LGB	HER	ANE
Fabaceae	*Copaifera langsdorffii Desf.*	SMI	HER	ORN
Fabaceae	*Dipterix alata Vogel*	SMI	HER	MAM
Fabaceae	*Enterolobium contortisiliquum (Vell.) Morong*	SMI	HER	MAM

Fabaceae	*Hymenaea courbaril* L. *var. stilbocarpa* (Hayne) Lee & Lang.	BAT	HER	MAM
Fabaceae	*Inga laurina (Sw.) Willd*	MOT	HER	MAM
Fabaceae	*Inga marginata* Willd.	SMI	MON	CHI
Fabaceae	*Inga sessilis (Vell.)Mart.*	BAT	HER	CHI
Fabaceae	*Inga vera Willd.*	SMI	MON	ORN
Fabaceae	*Lonchocarpus cultratus (Vell.)Az.-Tozzi & H.C.Lima*	SMI	HER	AUT
Fabaceae	*Machaerium acutifolium Vog.*	SMI	HER	ANE
Fabaceae	*Machaerium brasiliense Vogel*	NID	HER	ANE
Fabaceae	*Machaerium hirtum (Vell.) Stellfeld*	SMI	HER	ANE
Fabaceae	*Machaerium nictitans (Vell.) Benth.*	SMI	HER	ANE
Fabaceae	*Machaerium opacum Vogel*	NID	HER	NID
Fabaceae	*Machaerium stipitatum Vog.*	SMI	MON	ANE
Fabaceae	*Machaerium villosum Vog.*	SMI	HER	ANE
Fabaceae	*Myroxylon peruiferum L.F.*	SMI	MON	ANE
Fabaceae	*Ormosia arborea (Vell.) Harms*	SMI	MON	AUT
Fabaceae	*Peltophorum dubium (Spreng.) Taub.*	SMI	HER	ANE
Fabaceae	*Piptadenia gonoacantha (Mart.) Macbride*	MOT	HER	AUT
Fabaceae	*Platyciamus regnellii Benth.*	LGB	HER	ANE
Fabaceae	*Platypodium elegans Vog.*	LGB	HER	ANE
Fabaceae	*Pterodon emarginatus Vogel*	NID	HER	NID
Fabaceae	*Sclerolobium paniculatum Vog. var rubiginosum (Tul.) Benth.*	SMI	HER	ANE
Fabaceae	*Sweetia fruticosa Spreng.*	SMI	HER	ANE
Fabaceae	*Vatairea macrocarpa (Benth.)Ducke*	NID	HER	NID
Fabaceae	*Zollernia ilicifolia(Brongn.)Vogel*	NID	HER	AUT
Lacistemataceae	*Lacistema aggregatum (Berg.) Rusby*	NID	HER	ORN
Lamiaceae	*Aegiphila sellowiana Cham.*	SMI	DIO	ORN
Lamiaceae	*Vitex polygama Cham.*	LGB	HER	ORN
Lauraceae	*Ocotea corymbosa (Meissn.) Mez.*	SMI	DIO	ORN
Lauraceae	*Cryptocaria aschersoniana Mez.*	SMI	HER	MAM
Lauraceae	*Endlicheria paniculata (Spreng.) Macbride*	SMI	HER	ORN
Lauraceae	*Nectandra cissiflora Nees.*	SMI	HER	ORN
Lauraceae	*Nectandra megapotamica (Spreng.) Mez*	VSI	MON	ORN
Lauraceae	*Nectandra membranacea ssp cuspidata Ness Rower*	SMI	MON	ORN
Lauraceae	*Ocotea minarum (Nees.) Mez.*	SMI	NID	ORN
Lauraceae	*Ocotea pulchella (Ness.) Mez.*	SMI	DIO	ORN
Lauraceae	*Ocotea spixiana (Nees) Mez.*	SMI	DIO	ORN
Lecythidaceae	*Cariniana estrellensis (Raddi) O. Kuntze*	LGB	HER	ANE
Lythraceae	*Lafoensia pacari A.ST.-Hil. (syn. L. densiflora Pohl)*	NID	NID	NID
Malpighiaceae	*Byrsonima laxiflora Griseb.*	LGB	HER	ORN
Malvaceae	*Apeiba tibourbou Aubl.*	LGB	HER	ORN
Malvaceae	*Ceiba speciosa (A.St.-Hil) Ravenna*	BUT	HER	ANE
Malvaceae	*Eriotheca candolleana (K. Sch.) A. Robyns*	LGB	HER	ANE
Malvaceae	*Eriotheca gracilipes (K. Sch.) A. Robyns*	LGB	HER	ANE

Malvaceae	*Eriotheca pubescens (Mart. & Zucc) Schott&Endl.*	LGB	HER	ANE
Malvaceae	*Guazuma ulmifolia Lam.*	SMI	HER	ORN
Malvaceae	*Luehea divaricata Mart.*	LGB	HER	ANE
Malvaceae	*Luehea grandiflora Mart. & Zucc.*	BAT	HER	ANE
Malvaceae	*Luehea paniculata Mart.*	LGB	HER	ANE
Malvaceae	*Pseudobombax longiflorum (Mart. & Zucc) A. Robyns*	BAT	HER	ANE
Malvaceae	*Pseudobombax tomentosum (Mart.& Zucc) A.Robyns*	MAM	HER	ANE
Malvaceae	*Quararibea turbinata (Sw.) Poir.*	MAM	NID	CHI
Melastomataceae	*Miconia cuspidata Naud.*	SMI	HER	ORN
Melastomataceae	*Miconia latecrenata (DC.) Naudim*	SMI	NID	ORN
Melastomataceae	*Miconia minutiflora (Bonpl.) DC.*	NID	NID	NID
Meliaceae	*Guarea guidonia (L.) Sleumer*	BUT	DIO	ORN
Meliaceae	*Cabralea canjerana (Vell) Mart.*	SMI	DIO	ORN
Meliaceae	*Cedrella fissilis Vell.*	MOT	HER	ANE
Meliaceae	*Guarea kunthiana A. Juss.*	BUT	DIO	ORN
Meliaceae	*Trichilia catigua A. Juss*	SMI	NID	ORN
Meliaceae	*Trichilia claussenii C. DC.*	SMI	NID	ORN
Meliaceae	*Trichilia elegans A. Juss.*	SMI	NID	ORN
Meliaceae	*Trichilia pallida Sw.*	SMI	NID	ORN
Monimiaceae	*Mollinedia widgrenii A. DC.*	NID	NID	NID
Moraceae	*Sorocea bomplandii (Baill.) W. Burg.*	NID	DIO	ORN
Moraceae	*Ficus clusiifolia Schott*	VSI	NID	NID
Moraceae	*Ficus guaranitica Chodat*	VSI	NID	CHI
Moraceae	*Ficus obtusiuscula (Miq.) Miq*	VSI	NID	NID
Moraceae	*Ficus pertusa L.F.*	VSI	NID	CHI
Moraceae	*Ficus trigona L.F.*	SMI	NID	NID
Moraceae	*Ficus sp1*	VSI	NID	NID
Moraceae	*Ficus sp2*	VSI	NID	NID
Moraceae	*Maclura tinctoria D. Don. Ex Stend.*	VSI	MON	CHI
Moraceae	*Pseudolmedia laevigata Troc.*	SMI	DIO	ORN
Myristicaceae	*Virola sebifera Aubl.*	VSI	DIO	ORN
Myrsinaceae	*Ardisia ambigua Mez*	SMI	NID	ORN
Myrsinaceae	*Myrsine coriacea R.Br.*	SMI	DIO	ORN
Myrsinaceae	*Myrsine leuconeura Mart.*	NID	NID	NID
Myrsinaceae	*Myrsine umbellata Mart.*	SMI	DIO	ORN
Myrtaceae	*Psidium sartorianum (Berg.) Nied.*	NID	HER	NID
Myrtaceae	*Calyptranthes clusiifolia O.Berg.*	NID	NID	NID
Myrtaceae	*Calyptranthes widgreniana Berg.*	SMI	HER	ORN
Myrtaceae	*Campomanesia guazumifolia (Cambess.)O.Berg.*	SMI	HER	ORN
Myrtaceae	*Campomanesia velutina Berg.*	SMI	HER	ORN
Myrtaceae	*Eugenia florida DC.*	SMI	HER	ORN
Myrtaceae	*Eugenia involucrata DC.*	SMI	HER	ORN
Myrtaceae	*Eugenia ligustrina (Sw.) Willd.*	NID	HER	ORN
Myrtaceae	*Eugenia subterminalis DC.*	NID	HER	NID
Myrtaceae	*Gomidesia lindeniana Berg.*	SMI	HER	ORN

Myrtaceae	*Myrcia splendens (Sw.)DC.*	SMI	HER	ORN
Myrtaceae	*Myrcia tomentosa (Aubl.) DC.*	SMI	HER	ORN
Myrtaceae	*Myrciaria glanduliflora (Kiaersk.) Mattos & D.Legrand*	NID	NID	NID
Myrtaceae	*Myrciaria tenella (DC.) Berg.*	SMI	HER	ORN
Myrtaceae	*Psidium longipetiolatum D.Legrand*	NID	HER	NID
Myrtaceae	*Psidium rufum DC.*	NID	HER	NID
Myrtaceae	*Siphoneugena densiflora Berg.*	SMI	HER	ORN
Myrtaceae	*Syzygium jambos (L.) Aston.**	NID	NID	NID
Myrtaceae	*Myrtaceae 1*	NID	NID	NID
Myrtaceae	*Myrtaceae 2*	NID	NID	NID
Nyctaginaceae	*Guapira opposita (Vell.)Reitz*	SMI	DIO	NID
Nyctaginaceae	*Guapira venosa (Choisy)Lundell*	SMI	DIO	ORN
Nyctaginaceae	*Neea hermaphrodita Sp. Moore*	VSI	DIO	ORN
Ochnaceae	*Ouratea castaneifolia DC. Engl.*	LGB	HER	ORN
Olacaceae	*Heisteria ovata Benth.*	NID	HER	CHI
Oleaceae	*Chionanthus trichotomus (Vell.) P.S.Green*	NID	HER	CHI
Opiliaceae	*Agonandra brasiliensis Miers.*	NID	DIO	MAM
Phyllanthaceae	*Margaritaria nobilis L.F.*	NID	DIO	AUT
Phyllanthaceae	*Phyllanthus acuminatus Vahl.*	NID	NID	NID
Piperaceae	*Piper amalago L.*	SMI	MON	NID
Piperaceae	*Piper arboreum Aubl.*	SMI	MON	CHI
Polygonaceae	*Coccoloba mollis Cass.*	NID	HER	ORN
Proteaceae	*Roupala brasiliensis Klotz.*	MOT	HER	ANE
Rhamnaceae	*Rhamnidium elaeocarpum Reiss.*	SMI	HER	ORN
Rubiaceae	*Amaioua guianensis Aubl.*	MOT	DIO	MAM
Rubiaceae	*Chomelia pohliana M.Arg.*	NID	HER	ORN
Rubiaceae	*Cordiera sessilis (Vell.) Kuntze*	SMI	DIO	MAM
Rubiaceae	*Coussarea hydrangeaefolia (Benth.) B. & H.*	MOT	HER	ORN
Rubiaceae	*Coutarea hexandra (Jacq.) K. Schum.*	NID	HER	ANE
Rubiaceae	*Faramea hyacinthina Mart.*	SMI	HER	ORN
Rubiaceae	*Genipa americana L.*	SMI	HER	NID
Rubiaceae	*Guettarda viburnioides Cham. & Schl.*	SMI	HER	ORN
Rubiaceae	*Ixora brevifolia Benth.*	NID	HER	NID
Rubiaceae	*Machaonia brasiliensis (Hoffmanss. Ex Humb.)Cham.&Schltdl.*	NID	HER	NID
Rubiaceae	*Rudgea viburnioides (Cham.) Benth.*	NID	HER	ORN
Rubiaceae	*Simira sampaioana (Standl.)Steyerm.*	SMI	HER	ANE
Rubiaceae	*Tocoyena formosa (Cham.& Schltdl.) K.Schum.*	MOT	HER	NID
Rutaceae	*Galipea jasminiflora (A.St.-Hill)Engl.*	NID	NID	AUT
Rutaceae	*Metrodorea nigra A. St.-Hill.*	NID	NID	NID
Rutaceae	*Metrodorea stipularis Mart.*	SMI	HER	ORN
Rutaceae	*Pilocarpus spicatus A.St.-Hil.*	NID	NID	NID
Rutaceae	*Zanthoxylum riedelianum Engl.*	SMI	DIO	ORN
Salicaceae	*Casearia gossypiosperma Briquet.*	SMI	HER	ANE
Salicaceae	*Casearia grandiflora Camb.*	SMI	HER	ORN
Salicaceae	*Casearia rupestris Eichl.*	NID	HER	ORN

Salicaceae	*Casearia sylvestris Sw.*	SMI	HER	ORN
Salicaceae	*Prockia crucis P.Browne ex L.*	NID	NID	NID
Salicaceae	*Xylosma cf. prockia (Turcz.) Turcz.*	NID	NID	NID
Sapindaceae	*Allophyllus edulis (A.St.-Hil., Cambess.& A.Juss.) Radlk.*	SMI	MON	AUT
Sapindaceae	*Allophyllus racemosus Sw*	SMI	NID	ORN
Sapindaceae	*Cupania vernalis Camb.*	BUT	MON	ORN
Sapindaceae	*Dilodendron bipinatum Radlk.*	SMI	NID	NID
Sapindaceae	*Magonia pubescens A. St.-Hil.*	NID	NID	ANE
Sapindaceae	*Matayba elaegnoides Radlk.*	SMI	MON	ORN
Sapindaceae	*Matayba guianensis Aubl.*	SMI	MON	ORN
Sapotaceae	*Chrysophyllum gonocarpum (Mart.& Eichler) Engl.*	VSI	DIO	ORN
Sapotaceae	*Chrysophyllum marginatum (Hook & Corn.) Radlk.*	SMI	HER	MAM
Sapotaceae	*Micropholis venulosa (Mab. & Eichl.) Pierri*	VSI	HER	MAM
Sapotaceae	*Pouteria gardneri (Gartn. F.) Ducke*	NID	MON	MAM
Sapotaceae	*Pouteria torta (Mart.) Radlk.*	SMI	MON	MAM
Siparunaceae	*Siparuna guianensis Aubl.*	VSI	DIO	ORN
Styracaceae	*Styrax camporum Pohl.*	LGB	HER	ORN
Symplocaceae	*Symplocos pubescens klotzsh. ex Benth.*	NID	DIO	ORN
Urticaceae	*Urera baccifera (L.) Gaudich. Ex Benth.*	NID	NID	ORN
Verbenaceae	*Aloysia virgata (Ruiz & Pav) A.Juss.*	SMI	NID	ANE
Vochysiaceae	*Callisthene major Mart.*	SMI	HER	ANE
Vochysiaceae	*Qualea dichotoma (Mart.) Warm.*	LGB	HER	ANE
Vochysiaceae	*Qualea jundiahy Warm.*	SMI	HER	ANE
Vochysiaceae	*Vochysia magnifica Warm.*	LGB	HER	ANE
Vochysiaceae	*Vochysia tucanorum (Spr.) Mart.*	LGB	HER	ANE
Urticaceae	*Cecropia pachystachya Troc.*	SMI	DIO	CHI