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Reproductive phenology of the cerrado plant community in Emas National Park (central Brazil)

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Abstract. The cerrado, a savanna-like formation, is the second-most widespread vegetation type in Brazil. Its core region occupies the Brazilian Central Plateau, with a seasonal climate, including wet summer and dry winter. We studied the reproductive phenological patterns of the cerrado plant community in Emas National Park (central Brazil). Monthly field trips revealed 601 species, classified, according to their dispersal syndromes, into anemo-, auto-, or zoochorous species, when they were dispersed by wind, explosion or gravity, or animals, respectively. We analysed the flowering and fruiting patterns of the community in relation to dispersal syndromes, comparing the herbaceous and the woody components. The herbaceous component was characterised by a majority of autochorous species, and the woody component, by a majority of zoochorous species. There was a striking seasonality in the community-wide pattern of flowering and fruiting, although this was different between the herbaceous and the woody components. Woody species flowered mainly during late dry and early wet seasons, whereas herbaceous species flowered especially during late wet season. In the dry season, when their diaspores can be dispersed more efficiently, the proportions of anemo- and autochorous fruiting species were higher. During the rainy season, when their fruits can be kept attractive for longer time, the number of fruiting zoochorous species reached its peak.

Introduction

Savannas are tropical and subtropical formations where the grass layer is almost continuous, interrupted only by shrubs and trees in varying proportions, and where the main growth patterns are closely associated with alternating wet and dry seasons (Bourlière and Hadley 1983). In tropical savannas, the temporal patterns in growth and reproduction are strongly linked to the climatic seasonality (Williams *et al.* 1997).

The Cerrado Domain occupied formerly 2 million km^2 of the Brazilian territory (Ratter *et al.* 1997), especially in the Central Plateau. As its name implies, in the Cerrado Domain, the cerrado vegetation prevails. The cerrado vegetation is not uniform in physiognomy (Coutinho 1990), ranging from grassland to tall woodland; however, most of its physiognomies are within the range defined as tropical savanna (Bourlière and Hadley 1983).

The cerrado species, like those of other savannas, present periodic variations in flower and fruit production that may represent adaptations to biotic and abiotic factors (Schaik *et al.* 1993). Rizzini (1963) proposed that the herbaceous and the woody components of the cerrado flora are floristically distinct and antagonistic. Scholes and Archer (1997) postulated that the climatic seasonal pattern of tropical savannas, with alternating warm dry seasons and hot wet seasons, provides a potential axis of niche separation by phenology for the herbaceous and woody components.

Phenology is a major component of plant fitness (O'Neill 1997) and knowledge of plant phenology is fundamental to understand the community dynamics, since the timing, duration and degree of synchrony of the various phenological phases have major implications for plant community structure, function, regeneration and the quantity and quality of resources available for consumer organisms (Williams *et al.* 1999).

Phenological data for the cerrado vegetation are fragmentary, with studies normally involving isolated species or small group of species, and different methods and approaches (Oliveira 1998). The relationship between the phenological patterns of cerrado plant species and the climatic seasonality had already been discussed by Warming (1892), in his pioneer work on the cerrado vegetation. Since this study, many papers discussed some aspects of the phenology of cerrado species (e.g. Gottsberger and Silberbauer-Gottsberger 1983; Oliveira and Sazima 1990; Proença and Gibbs 1994; Miranda 1995—see Oliveira 1998

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for other references), but few of them dealt with the community level (Mantovani and Martins 1988; Batalha *et al*. 1997; Batalha and Mantovani 2000; Oliveira and Gibbs 2000).

Until now, most community-wide studies in the cerrado were carried out at outlying sites, in the southern São Paulo State (Mantovani and Martins 1988; Batalha *et al*. 1997; Batalha and Mantovani 2000). In the cerrado core area, only Oliveira and Gibbs (2000) analysed the reproductive biology of 59 woody species at a 40-ha site. The aim of this study was to analyse the reproductive phenological patterns of the plant species at a core cerrado site on the community level. We discuss the phenological variations of both herbaceous and woody components, relating them to dispersal syndromes. We attempt to answer the following questions: (i) do the cerrado species flower uniformly throughout the year; (ii) are the mean flowering periods for the herbaceous and the woody species different; (iii) is the number of species in flower correlated with rainfall; (iv) are the proportions of anemo- and autochorous species higher in the herbaceous component; (v) is the proportion of zoochorous species higher in the woody component; and (vi) do the anemo-, auto- and zoochorous species fruit uniformly throughout the year?

Material and methods

We carried out this work in Emas National Park (ENP), a reserve with about 133000 ha, located in the Brazilian Central Plateau, in the cerrado core region, south-western Goiás State (17°49′–18°28′S and 52°39′–53°10′W). Regional climate is tropical and humid, with wet summer and dry winter, which is classified as Aw following Köppen (1931) or as ZBII following Walter (1971). Annual rainfall varies from 1200 to 2000 mm, concentrated from October to March, and mean annual temperature is about 24.6°C (Ramos-Neto and Pivello 2000).

The cerrado in ENP presents almost all physiognomies found in this vegetation type, from *campo limpo* (a grassland) to *cerrado sensu stricto* (a woodland). In the reserve, open cerrado physiognomies—*campo limpo*, *campo sujo* and *campo cerrado*—prevail, covering 68.1% of the total area (Ramos-Neto and Pivello 2000). The more closed *cerrado sensu stricto* covers 25.1% of the reserve. About every 3–4 years, uncontrollable wildfires occur in ENP due to dry biomass accumulation (Ramos-Neto and Pivello 2000).

We analysed the flowering and fruiting patterns of the cerrado species from data obtained in the floristic survey carried out monthly from November 1998 to October 1999 (Batalha and Martins 2002). We made a basic collection and registered monthly the reproductive phenological stage of each species along pre-established trails, with a 50–60-h monthly sampling effort (Batalha and Martins 2002). These trails included all cerrado physiognomies found in the reserve and, thus, provided us with a representative sample of the cerrado vegetation in ENP. The voucher material was lodged mainly at the São Paulo State Botanical Institute herbarium (SP), but also at the following herbaria: CESJ, FLOR, HRCB, HUEFS, IAC, SP, SPF, UB and UEC.

We observed whether the species at reproductive stage were flowering or fruiting. The observations were simply qualitative, i.e. in a given month, if we found at least one individual of a determined species producing flowers, we considered the species to be on its flowering period. We expressed the number of species in any month producing flowers or fruits as a percentage of the total number of species. We compared these data to climatic records collected from 1993 to 1998 at the Benedictine Monks Monastery, in the nearby city of Mineiros (17°33′25″S, 52°33′05″W), with which we constructed a climatic diagram following Walter (1971).

We classified the species in families according to the system proposed by Judd *et al*. (1999) and in life forms in accordance with Raunkiaer's (1934) system adapted by Mueller-Dombois and Ellenberg (1974). We considered the chamaephytes, epiphytes, geophytes, hemicryptophytes, lianas, therophytes and vascular parasites as belonging to the herbaceous component, and the phanerophytes, as belonging to the woody component. We classified all species, according to their dispersal syndromes (Pijl 1972), into anemo-, auto-, or zoochorous species, when they were dispersed by wind, explosion or gravity, or animals, respectively.

When our data were normally distributed according to the Kolmogorov–Smirnov test (Zar 1999), we applied parametric circular statistics to them. To test whether the cerrado species flower and fruit uniformly throughout the year, we applied Rayleigh test (Zar 1999): January corresponded to 0°, February to 30°, March to 60°, and so on. We also applied this test to verify whether the herbaceous and the woody species flower uniformly throughout the year. To test whether the mean flowering periods were different between the herbaceous and woody components, we used the Watson–Williams test (Zar 1999). We correlated monthly rainfall, obtained from climatic records collected at the Benedictine Monks Monastery, to the number of herbaceous and woody species in flower. To verify whether the proportions of anemo-, auto-, and zoochorous species were significantly different to an even distribution, we applied the chi-square test (Zar 1999). To test whether the anemo-, auto-, and zoochorous species fruit uniformly throughout the year, we again used Rayleigh test (Zar 1999). To test whether the mean fruiting periods for the anemo-, auto-, and zoochorous species were different, we applied the Watson–Williams test for three samples (Zar 1999).

Results

The climatic diagram (Fig. 1) showed that the dry period of the year goes from June to August, and the wet period from September to May. Annual rainfall and mean annual temperature were 1745 mm and 24.6°C, respectively. Of the 601 species collected (Appendix 1), 149 were phanerophytes and thus considered as belonging to the woody component. The remaining 452 species presented other life forms and were considered as belonging to the herbaceous component. A total of 8 (1.33%) of the 601 species were not found at reproductive stage, neither flowering nor fruiting.

The number of flowering species was not uniformly distributed throughout the year ($z = 9.21$, $P < 0.001$). The mean angle for the flowering species was 26°, which corresponds to the end of January (Fig. 2). The number of fruiting species was also not uniformly distributed throughout the year ($z = 4.51$, $P = 0.013$). The mean angle for the fruiting species was 77°, which corresponds to the middle of March (Fig. 2).

The herbaceous and woody species did not flower uniformly throughout the year ($z = 39.80$ and $z = 26.60$, respectively; $P < 0.001$ in both cases). The mean angle for the flowering herbaceous species was 37°, which corresponds to the beginning of February, whereas the mean angle for the flowering woody species was 229°, which corresponds to the end of August (Fig. 3). The mean angles

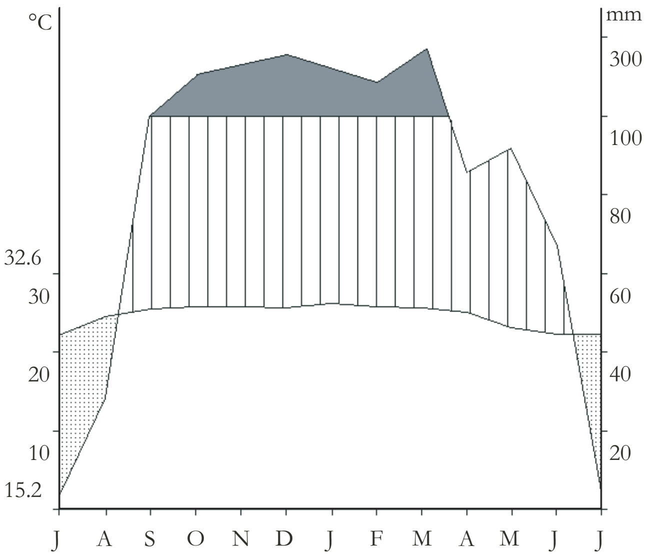

Fig. 1. Climatic diagram (Walter 1971), constructed from data obtained at the Benedictine Monks Monastery, Mineiros, Goiás State, central Brazil (17°33′25′′S, 52°33′05′′W, 800 m a.s.l.). Absolute minimum and maximum temperatures were not available in the original data. Mean annual temperature = 24.6°C, total annual precipitation = 1745 mm.

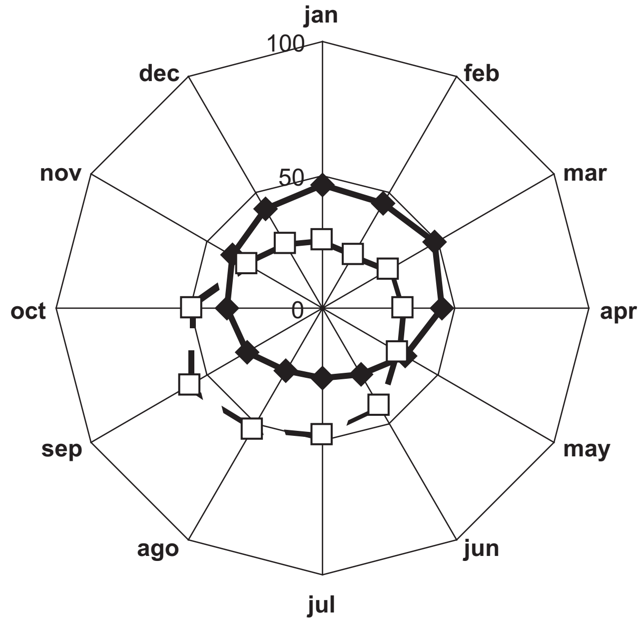

Fig. 3. Percentage of flowering herbaceous (◆) and woody (□) species throughout the year in Emas National Park, (17°49′–18°28′S, 52°39′–53°10′W), Goiás State, central Brazil.

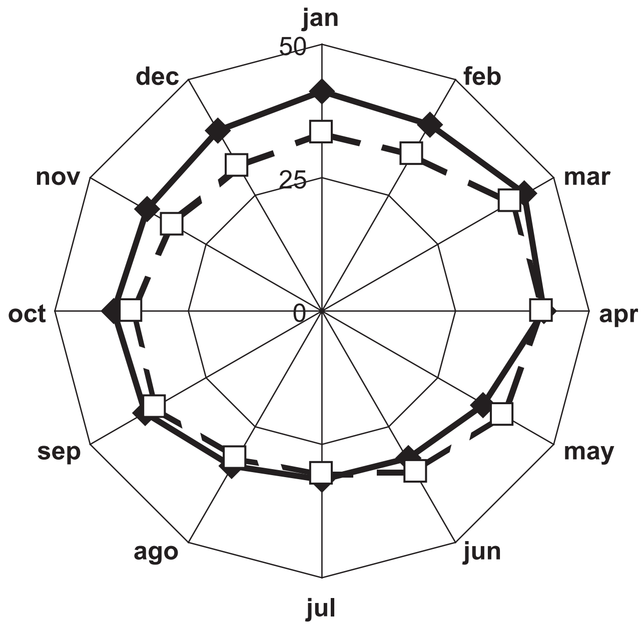

Fig. 2. Percentage of flowering (◆) and fruiting (□) species throughout the year in Emas National Park, (17°49′–18°28′S, 52°39′–53°10′W), Goiás State, central Brazil.

for the flowering periods of the herbaceous and woody components were significantly different (F = 678.49, d.f. = 2,719, P < 0.001).

On the one hand, the number of flowering herbaceous species was positively correlated with rainfall (r^2 = 0.65, t = 4.35, P = 0,001) (Fig. 4); on the other hand, the number of flowering woody species was negatively correlated with rainfall (r^2 = 0.39, t = –2.54, P = 0.029) (Fig. 5). In the herbaceous component, the late rainy season was the peak period in flowering, whereas in the woody component, the late dry to early rainy season was the peak period.

Regarding their diaspore syndrome, 183 species (30.45%) were anemochorous, 228 (37.94%) autochorous and 182 (31.61%) zoochorous (Fig. 6). These proportions were not significantly different from an even distribution according to the chi-square test (χ^2 = 5.85, P = 0.054). In the herbaceous component, however, the distribution of diaspore dispersal syndromes was significantly different from an even distribution (χ^2 = 46.01, P < 0.001), with an excess of autochorous species. In the woody component, the distribution of diaspore syndromes was also uneven (χ^2 = 65.65, P < 0.001), but with a higher proportion of zoochorous species.

The proportions of anemo-, auto-, and zoochorous fruiting species (Fig. 7) were not uniformely distributed throughout the year (z = 23.54, z = 12.57 and z = 10.20, respectively; P < 0.001 in all three cases). The mean angle for the anemochorous fruiting species was 166°, which corresponds to the middle of June; the mean angle for the autochorous fruiting species was 79°, which corresponds to the middle of March; and the mean angle for the zoochorous fruiting species was 292°, which corresponds to the end of October. The anemochorous species fruited especially from April to September, the autochorous species from January to

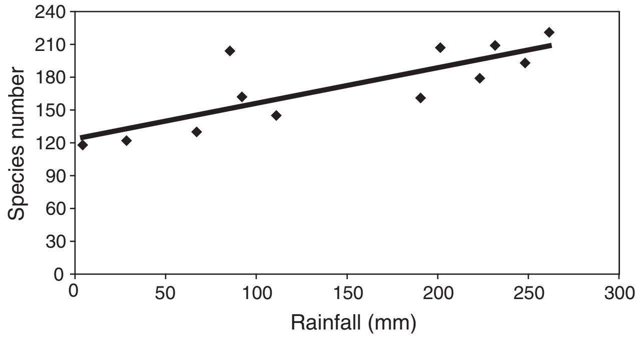

Fig. 4. Correlation between rainfall and the number of flowering herbaceous species in Emas National Park, (17°49′–18°28′S, 52°39′-53°10′W), Goiás State, central Brazil.

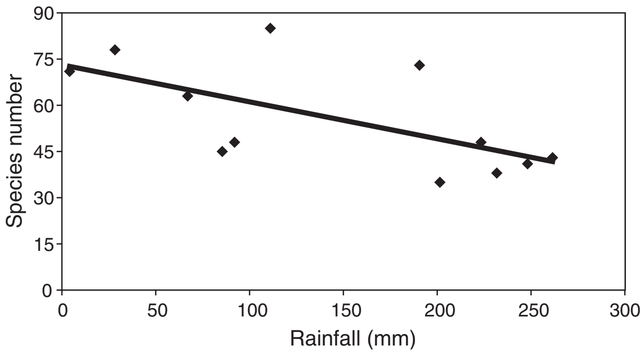

Fig. 5. Correlation between rainfall and the number of flowering woody species in Emas National Park, (17°49′–18°28′S, 52°39′–53°10′W), Goiás State, central Brazil.

Fig. 6. Percentual distribution of dispersion syndrome classes in the cerrado flora of Emas National Park, (17°49′–18°28′S, 52°39′–53°10′W), Goiás State, central Brazil. Anemochorous (white bars), autochorous (grey bars), zoochorous (black bars).

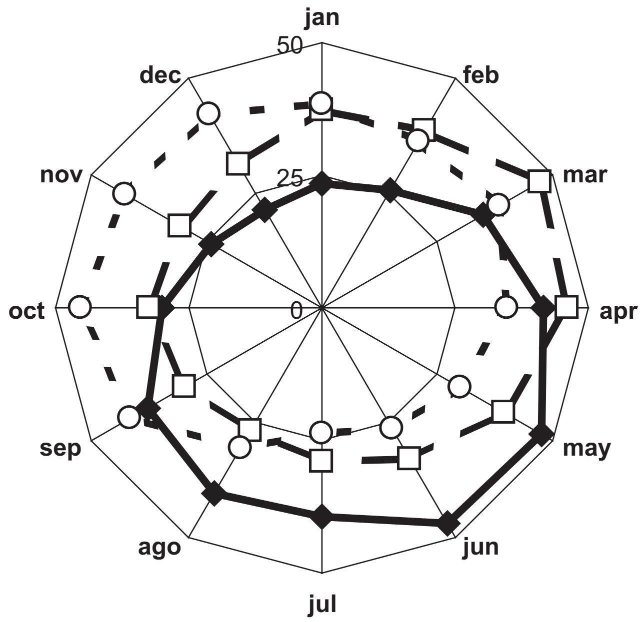

Fig. 7. Percentage of anemo- (◆), auto- (□) and zoochorous (○) fruiting species, according to their dispersion syndrome, throughout the year in the cerrado of Emas National Park, (17°49′–18°28′S, 52°39′–53°10′W), Goiás State, central Brazil.

May and the zoochorous species from September to December (Fig. 7).

The mean fruiting periods for the anemo, auto, and zoochorous species were significantly different ($F = 315.43$, d.f. = 2,531, $P < 0.001$). In the dry season, the proportions of anemo- and autochorous species producing fruits were higher than those of zoochorous ones. In the rainy season, on the other hand, the proportion of fruiting zoochorous species was higher than those of anemo and autochorous species.

Discussion

In the cerrado plant community of ENP, flowering and fruiting were not uniformly distributed throughout the year, reflecting the seasonality of the cerrado climate (Sarmiento and Monasterio 1983). As expected from other studies carried out at outlying cerrado sites (Mantovani and Martins 1988; Batalha *et al*. 1997; Batalha and Mantovani 2000), the flowering patterns of the two components of the cerrado flora were very different. The flowering pattern of the herbaceous species, with a higher number of flowering species late in the rainy season, is also found in other tropical savannas (Sarmiento and Monasterio 1983). The vegetative phase in grasses allows accumulation of carbohydrates, which are later used in flowering and fruiting (Figueiredo and Dietrich 1981). Accumulation of carbohydrates in herbaceous species before flowering was also observed by Isejima and Figueiredo-Ribeiro (1993) and Vieira and Figueiredo-Ribeiro (1993).

Changes in the concentration of carbohydrates, especially fructans, throughout the year in cerrado herbaceous plants are part of the mechanism for resistance to drought-induced stress (Isejima and Figueiredo-Ribeiro 1993; Vieira and Figueiredo-Ribeiro 1993). Sarmiento and Monasterio (1983) postulated that this strategy would guarantee the reproduction in the safest period in respect of water availability. During the period of water shortage, the aerial biomass rapidly decays, and then, as the rainy season progresses, the plants gradually develop their shoots and reproductive structures, reaching the maximum growth rates during the reproductive phenophases that occur in the period with higher water availability. The importance of water availability for herbs and subshrubs was shown by the positive correlation between the number of flowering herbaceous species and rainfall.

The woody species presented a flowering pattern different from that of the herbaceous species. The flowering period of the woody species was concentrated in late dry and early wet seasons. At outlying cerrado sites, in the southern São Paulo State, Mantovani and Martins (1988), Batalha *et al*. (1997) and Batalha and Mantovani (2000) found a higher proportion of woody species flowering at the beginning of the rainy season. In the Federal District, located in the core cerrado area, at a lower latitude than ENP, Aoki and Santos (1980) found most woody species flowering in the dry period of the year, but Oliveira and Gibbs (2000) found peaks for flowering activity associated with the beginning of the rainy season. In Pará State, close to Equator, most woody species flowered in the dry period of the year (Miranda 1995). In ENP, therefore, we found an intermediate pattern between the southern outlying sites (Mantovani and Martins 1988; Batalha *et al*. 1997; Batalha and Mantovani 2000) and the northern sites (Aoki and Santos 1980, Miranda 1995). Differences in flowering pattern of the woody species could be related to smaller variation of solar radiation throughout the year at northern sites (Schaik *et al*. 1993).

Pioneering experiments carried out by Rawitscher (1942) and Ferri (1944) at an outlying cerrado site showed that trees and shrubs have a deep root system and, thus, water access during the whole year. Jackson *et al*. (1999), studying soil water partitioning among woody species, suggested that there might be a strong selective pressure for plants to develop a deep root system. Sarmiento and Monasterio (1983) suggested that if savanna trees and shrubs have water access during the whole year because of their deep root systems, they would be at advantage in reproducing during the period of water shortage and leaving to the rainy season the function of storing reserves to support activities in the dry season. The negative correlation between the number of woody species in flower and rainfall highlighted the access of trees and shrubs to water deeper in the soil profile.

Most cerrado woody species are pollinated by bees (Oliveira and Gibbs 2000). Pollinating-bee activity may be increased at the end of the dry season because of leaf fall, which would make the flowers more conspicuous, and lack of heavy rains that would damage the flowers (Janzen 1975). Large bees are some of the most characteristic pollinators in tropical communities, visiting especially well exposed emergent trees in forests (Frankie *et al*. 1983). In cerrado communities during the dry period of the year, plants would be exposed to similar conditions of radiation, humidity and wind.

Proença and Gibbs (1994) found that flowering concentrated in the transition between dry and rainy seasons for six of the eight myrtaceous species they investigated. Flowering at this transitional time is a favoured strategy, because the most marked fluctuations in humidity occur at this time of the year, and thus there is greater scope for humidity-linked synchronisation (Proença and Gibbs 1994). This pattern was also found in Australian savannas by Williams *et al*. (1999), where the majority of woody species were flowering or fruiting at the transition between dry and wet seasons, referred by these authors as the 'build-up' period.

There was a clear distinction between herbaceous and woody species, regarding flowering time. Scholes and Archer (1997) stated that the coexistence of herbaceous and woody species in the savannas is a result of the interaction of several stresses and disturbances, acting differentially on each component and patchily in time and space. Niches of herbaceous and woody species differ in both rooting depth and phenology, but there is more opportunity for phenological separation (Scholes and Archer 1997). Batalha and Mantovani (2000), at an outlying cerrado site, found striking differences between the patterns of the two components of the cerrado flora. We also found such differences in ENP, corroborating the postulate of niche separation by phenology between herbaceous and woody species.

The higher proportion of autochorous species, which we found in the herbaceous component of the cerrado flora in ENP, was mainly responsible for the significance of the chi-square value. In the woody component, on the other hand, the zoochorous species predominated. At other sites (Gottsberger and Silberbauer-Gottsberger 1983; Mantovani and Martins 1988; Batalha *et al*. 1997; Batalha and Mantovani 2000), a similar distribution was also found, but with a higher proportion of anemochorous species in the herbaceous component.

During the driest months, the proportions of anemo- and autochorous fruiting species were higher than those of zoochorous ones, a pattern also found by Gottsberger and Silberbauer-Gottsberger (1983), Mantovani and Martins (1988), Miranda (1995), Batalha *et al*. (1997) and Batalha and Mantovani (2000). The anemo- and autochorous fruits are generally dry and thus their pericarp dehydrates during the drought, releasing their seeds. Augspurger and Franson (1987) observed that, in areas under seasonal climate, anemochorous diaspore dispersal is more efficient in the dry season. Leaf fall, observed mainly in the anemochorous species, also facilitates diaspore dispersal (Mantovani and Martins 1988).

Zoochorous species, on the contrary, fruited especially at the wettest period of the year, when their fleshy fruits can be kept attractive for a longer time, as observed by Gottsberger and Silberbauer-Gottsberger (1983), Bianco and Pitelli (1986), Mantovani and Martins (1988), Miranda (1995), Batalha *et al*. (1997) and Batalha and Mantovani (2000). The seasonal presence or activity of animal dispersers could select for temporally clumped fruiting (Schaik *et al*. 1993). For instance, at a southern cerrado site, the number of frugivorous birds increased during the wet season, from September to May, because of the arrival of migratory birds (Francisco and Galetti 2002). The timing of the arrival of migratory birds may have selected for the timing of fruiting of bird-dispersed plants (Schaik *et al*. 1993).

Previous studies of other seasonal vegetation types in which the phenology of woody species was followed (Frankie *et al*. 1974; Morellato *et al*. 1989) showed similar patterns, i.e. flowering after first rainfalls, fruiting of anemo- and autochorous species peaking in dry season, and fruiting of zoochorous species peaking in rainy season. In Costa Rica, however, Frankie *et al*. (1974) found a higher number of species in flower in the dry season. The same pattern was found at cerrado sites located at lower latitudes (Aoki and Santos 1980; Miranda 1995).

When compared with other cerrado sites where reproductive phenological patterns of the plant community were studied, the patterns in ENP were generally very similar, with the exception of the flowering of the woody species. Nevertheless, even if these patterns seem to be consistent, quantitative and manipulative experiments are still lacking. With this approach, we could obtain insights into the adaptive role of the phenology of the cerrado plant community. Since, in ENP, fire plays an important role in the community dynamics (Ramos-Neto and Pivello 2000), burnt and unburnt areas could be compared to test the influence of fire in flowering and fruiting on community level. Furthermore, observations longer than one year should be carried out to detect supra-annual patterns that may occasionally happen in the reproductive events of the cerrado plant species.

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Appendix 1. Species surveyed in the cerrado of Emas National Park, (17°49′–18°28′S, 52°39′–53°10′W), Goiás State, central Brazil, and habit assignation

Family/species	Habit
Acanthaceae	
Hygrophila brasiliensis (Spreng.) Lindau	Herbaceous
Ruellia geminiflora Kunth	Herbaceous
R. incompta (Nees) Lindau	Herbaceous
Alstroemeriaceae	
Alstroemeria gardneri Bak.	Herbaceous
Amaranthaceae	
Froelichia procera (Seub.) Pedersen	Herbaceous
Gomphrena arborescens L.f.	Herbaceous
G. macrocephala A. St-Hil.	Herbaceous
G. pohlii Moq.	Herbaceous
Pfaffia helychrysoides (Moq.) Kuntze	Herbaceous
P. jubata Mart.	Herbaceous
Anacardiaceae	
Anacardium humile A.St-Hil.	Herbaceous
Tapirira guianensis Aubl.	Woody
Annonaceae	
Annona coriacea Mart.	Woody
A. crassiflora Mart.	Woody
A. monticola Mart.	Herbaceous
A. tomentosa R.E.Fries	Herbaceous
A. warmingiana Mello-Silva & Pirani	Herbaceous
Annona sp. nov.	Woody
Bocageopsis mattogrossensis (R.E.Fries) R.E.Fries	Woody
Duguetia furfuracea (A.St-Hil.) Benth. & Hook.f.	Woody
D. glabriuscula (R.E.Fries) R.E.Fries	Herbaceous
Xylopia aromatica (Lam.) Mart.	Woody
Apiaceae	
Didymopanax malmei Harms	Woody
D. vinosum March.	Woody
Eryngium ciliatum Cham. & Schltdl.	Herbaceous
E. junceum Cham. & Schltdl.	Herbaceous
Apocynaceae	
Asclepias mellodora A.St-Hil.	Herbaceous
Aspidosperma macrocarpon Mart.	Woody
A. nobile Müll. Arg.	Woody
A. tomentosum Mart.	Woody
Barjonia cymosa Fourn.	Herbaceous
B. erecta (Vell.) K.Schum.	Herbaceous
Blepharodon bicuspidatum Fourn.	Herbaceous
Gyrostelma sp. nov.	Herbaceous
Hancornia speciosa Gomez	Woody
Hemipogon acerosus Decne.	Herbaceous
Himatanthus obovatus (Müll. Arg.) Woods.	Woody
Macrosiphonia longiflora Müll. Arg.	Herbaceous
M. velame (A.St-Hil.) K.Schum.	Herbaceous
Mandevilla coccinea (Hook & Arn.) Woods.	Herbaceous
M. pohliana (Standelm.) A.Gentry	Herbaceous
Odontadenia lutea (Vell.) Markgr.	Herbaceous
Oxypetalum aequaliflorum Fourn.	Herbaceous
Rauwolfia weddelliana Müll. Arg.	Herbaceous
Rhodocalyx rotundifolius Müll. Arg.	Herbaceous
Araceae	
Scaphispatha gracilis Brongn. ex Schott	Herbaceous
Arecaceae	
Acrocomia aculeata (Jacq.) Lodd. ex Mart.	Woody
A. hassleri (Barb. Rodr.) Hahn	Herbaceous
Allagoptera campestris (Mart.) Kuntze	Herbaceous
A. leucocalyx (Mart.) Kuntze	Herbaceous
Attalea geraensis Barb. Rodr.	Herbaceous
Syagrus flexuosa (Mart.) Becc.	Herbaceous
Aristolochiaceae	
Aristolochia gibertii Hook.	Herbaceous
A. gracilis Duch.	Herbaceous
Asteraceae	
Acanthospermum australe (Loefl.) Kuntze	Herbaceous
Achyrocline satureoides (Lam.) A.DC.	Herbaceous
Apopyros warmingii (Baker) Nesom	Herbaceous
Aspilia foliacea (Spreng.) Baker	Herbaceous
A. laevissima Baker	Herbaceous
A. leucoglossa Malme	Herbaceous
A. platyphylla (Baker) Blake	Herbaceous
Ayapana amygdalina (Lam.) King & H.Rob.	Herbaceous
Baccharis camporum A.DC.	Herbaceous
B. humilis Sch. Bip.	Herbaceous
Bidens gardneri Gardner	Herbaceous
Calea clausseniana Baker	Herbaceous
C. cuneifolia A.DC.	Herbaceous
C. hymenolepis Baker	Herbaceous
C. platylepis Sch. Bip. ex Baker	Herbaceous
Campuloclinium chlorolepis Baker	Herbaceous
C. megacephalum (Mart.) King & H.Rob.	Herbaceous
Chaptalia integerrima (Vell.) Burk	Herbaceous
Chromolaena chaeseae H.Rob.	Herbaceous
C. leucocephala Gardner	Herbaceous
C. squalida (A.DC.) King & H.Rob.	Herbaceous
C. stachyophylla (Spr.) King & H.Rob.	Herbaceous
Conyza bonariensis (L.) Cronq.	Herbaceous
Dasyphyllum sprengelianum (Gardner) Cabrera	Herbaceous
Dimmerostema asperatum Blake	Herbaceous
D. brasilianum Cass.	Herbaceous
D. retifolium (Sch. Bip.)Blake	Herbaceous
Dimmerostema sp. nov.	Herbaceous
Elephantopus biflorus Less.	Herbaceous
E. mollis L.	Herbaceous
E. racemosus Gardner	Herbaceous
Emilia coccinea (Sims.) Sweet	Herbaceous
Erechtites hieracifolia (L.) Raf.	Herbaceous
Eremanthus erythropappus Sch. Bip.	Woody
E. glomerulatus Less.	Woody
E. sphaerocephalus Baker	Herbaceous
Eupatorium betonicaeforme Baker	Herbaceous
E. campestre A.DC.	Herbaceous
E. lanigerum Hook & Arn.	Herbaceous
E. myriocephalum Gardner	Herbaceous
E. purpurascens Sch. Bip.	Herbaceous
E. urticifolium L.f.	Herbaceous
Eupatorium sp.	Herbaceous
Gochnatia barrosoae Cabrera	Herbaceous
G. pulchra Cabrera	Herbaceous
Hoehnephyton trixoides (Gardner) Cabrera	Herbaceous
Ichthyothere sp. 1	Herbaceous
Ichthyothere sp. 2	Herbaceous
Ichthyothere sp. 3	Herbaceous
Isostigma megapotamicum Scherff	Herbaceous
Isostigma sp.	Herbaceous

Appendix 1. (*continued*)

Family/species	Habit
Mikania cordifolia (L.) Willd.	Herbaceous
Orthopappus angustifolius (Sw.) Gleason	Herbaceous
Piptocarpha rotundifolia (Less.) Baker	Woody
Porophyllum angustissimum Gardner	Herbaceous
Pseudobrickellia pinifolia (Spr.) King & H.Rob.	Herbaceous
Pterocaulon virgatum (L.) A.DC.	Herbaceous
Riencourtia oblongifolia Gardner	Herbaceous
R. tenuifolia Gardner	Herbaceous
Spilanthes nervosa Chod.	Herbaceous
Stilpnopappus glomerulatus Gardner	Herbaceous
S. speciosus Baker	Herbaceous
Stomatanthes dictyophyllum (A.DC.) King & H.Rob.	Herbaceous
Vernonia argentea Less.	Herbaceous
V. bardanoides Less.	Herbaceous
V. brevipetiolata Sch. Bip.	Herbaceous
V. buddleiifolia Sch. Bip. ex Baker	Herbaceous
V. compactiflora Mart. ex Baker	Herbaceous
V. desertorum Mart. ex A.DC.	Herbaceous
V. erythrophylla Mart.	Herbaceous
V. ferruginea Less.	Herbaceous
V. grandiflora Less.	Herbaceous
V. herbacea (Vell.) Rusby	Herbaceous
V. ignobilis Less.	Herbaceous
V. polyanthes (Spreng.) Less.	Herbaceous
V. psilophylla A.DC.	Herbaceous
V. rubricaulis Humb. & Bonpl.	Herbaceous
V. rubriramea Mart.	Herbaceous
V. simplex Less.	Herbaceous
V. tomentella Mart. ex A.DC.	Herbaceous
V. tragiaefolia A.DC.	Herbaceous
V. varroniifolia A.DC.	Herbaceous
V. venosissima Sch. Bip. ex Baker	Herbaceous
V. virgulata Mart.	Herbaceous
Viguiera bakeriana Blake	Herbaceous
Viguiera sp. 1	Herbaceous
Viguiera sp. 2	Herbaceous
Wedelia macedoi H.Rob.	Herbaceous
Balanophoraceae	
Langsdorffia hypogea Mart.	Herbaceous
Bignoniaceae	
Anemopaegma arvense (Vell.) Stellfeld ex de Souza	Herbaceous
A. glaucum Mart. ex A.DC.	Herbaceous
A. scabriusculum Mart. ex A.DC.	Herbaceous
Arrabidaea brachypoda (A.DC.) Bur.	Herbaceous
A. pulchra (Cham.) Sandw.	Herbaceous
Cybistax antisyphillitica Mart.	Woody
Jacaranda caroba (Vell.) A.DC.	Herbaceous
J. decurrens Cham.	Herbaceous
J. rufa Silva Manso	Herbaceous
Memora pedunculata (Vell.) Miers.	Herbaceous
Tabebuia aurea (Silva Manso) S.Moore	Woody
T. ochracea (Cham.) Standl.	Woody
Zeyheria montana Mart.	Woody
Boraginaceae	
Cordia villicaulis Fresen.	Herbaceous
Bromeliaceae	
Aechmea bromeliifolia (Rudge) Baker	Herbaceous
Ananas ananassoides L.B.Sm.	Herbaceous
Billbergia magnifica Mez	Herbaceous
Bromelia balansae Mez	Herbaceous
Dickia tuberosa (Vell.) Beer	Herbaceous
Burseraceae	
Protium ovatum Engl.	Woody
Cactaceae	
Epyphyllum phyllanthus (L.) Haw.	Herbaceous
Caryocaraceae	
Caryocar brasiliense Cambess.	Woody
Caryophyllaceae	
Polycarpea corymbosa (L.) Lam.	Herbaceous
Celastraceae	
Plenckia populnea Reissek	Woody
Tontelea micrantha (Mart.) A.C.Sm.	Woody
Chrysobalanaceae	
Couepia grandiflora (Mart. & Zucc.) Benth. ex Hook.f.	Woody
Licania humilis Cham. & Schltdl.	Woody
Parinari excelsa Sabine	Herbaceous
Clusiaceae	
Kielmeyera abdita Saddi	Herbaceous
K. coriacea Mart.	Woody
K. grandiflora (Wawra) Saddi	Woody
K. rubriflora Cambess.	Woody
K. trichophora Mart.	Herbaceous
K. variabilis Mart.	Herbaceous
Cochlospermaceae	
Cochlospermum regium (Mart.) Pilg.	Herbaceous
Combretaceae	
Buchenavia tomentosa Eichl.	Woody
Combretum hilarianum D.Dietr.	Herbaceous
Commelinaceae	
Commelina obliqua Vahl	Herbaceous
Connaraceae	
Connarus suberosus Planch.	Woody
Rourea induta Planch.	Woody
Convolvulaceae	
Evolvulus cressoides Mart.	Herbaceous
E. fuscus Meisn.	Herbaceous
E. macroblepharis Mart.	Herbaceous
Ipomoea argentea Meisn.	Herbaceous
I. campestris Meisn.	Herbaceous
I. procumbens Mart. ex Choisy	Herbaceous
I. procurrens Meisn.	Herbaceous
Ipomoea sp. nov.	Herbaceous
I. virgata Meisn.	Herbaceous
Jacquemontia guaranitica Hassl.	Herbaceous
Jacquemontia sphaerocephala Meisn.	Herbaceous
Merremia contorquens (Choisy) Hall.f.	Herbaceous
M. digitata Meisn.	Herbaceous
Turbina abutiloides (Kunth) O'Donnel	Herbaceous
Convolvulaceae sp. 1, gen. sp. nov.	Herbaceous
Cucurbitaceae	
Cayaponia espelina Cogn.	Herbaceous
Ceratosanthes hilariana Cogn.	Herbaceous
Melancium campestre Naud.	Herbaceous
Cyperaceae	
Bulbostylis junciformis (Kunth) C.B.Clarke	Herbaceous

Appendix 1. (*continued*)

Family/species	Habit
B. paradoxa (Spreng.) Lindm.	Herbaceous
B. sphaerocephala (Nees) C.B.Clarke	Herbaceous
B. truncata (Nees) M.T.Strong	Herbaceous
Cyperus aggregatus (Willd.) Endl.	Herbaceous
C. meyenianus Kunth	Herbaceous
Killinga odorata Vahl.	Herbaceous
Rhynchosphora diamantina (C.B.Clarke) Kukenth	Herbaceous
R. emaciata Boeckm.	Herbaceous
R. exaltata Kunth	Herbaceous
R. rugosa (Vahl.) Gale	Herbaceous
Scleria scabra Willd.	Herbaceous
Dilleniaceae	
Davilla elliptica A.St-Hil.	Woody
D. nitida (Vahl.) Kubitzki	Herbaceous
Dioscoreaceae	
Dioscorea amaranthoides Presl.	Herbaceous
D. claussenii Uline	Herbaceous
Ebenaceae	
Diospyros hispida A.DC.	Woody
Erythroxylaceae	
Erythroxylum campestre A.St-Hil.	Woody
E. deciduum A.St-Hil.	Woody
E. suberosum A.St-Hil.	Woody
Euphorbiaceae	
Chamaesyce caecorum (Mart. ex Boiss.) Croizat	Herbaceous
Cnidosculus quercifolius Pohl	Herbaceous
Croton aberrans Müll. Arg.	Herbaceous
C. antisyphiliticus Mart.	Herbaceous
C. cinctus Müll. Arg.	Herbaceous
C. glandulosus Müll. Arg.	Herbaceous
C. goyazensis Müll. Arg.	Herbaceous
C. lundianus Müll. Arg.	Herbaceous
C. pohlianus Müll. Arg.	Herbaceous
C. sclerocalyx Müll. Arg.	Herbaceous
Croton sp.	Herbaceous
Dalechampia humilis Müll. Arg.	Herbaceous
D. linearis Baill.	Herbaceous
Julocroton humilis Didr.	Herbaceous
Manihot caerulescens Pohl	Herbaceous
M. tripartita (Spreng.) Müll. Arg.	Herbaceous
Maprounea guianensis Aubl.	Woody
Phyllanthus orbiculatus Müll. Arg.	Herbaceous
Sapium glandulatum (Vell.) Pax	Herbaceous
Sebastiania bidentata (Mart.) Pax	Herbaceous
Fabaceae	
Acosmium subelegans (Mohl.) Yakovlev	Woody
Aeschynomene marginata Benth.	Herbaceous
A. oroboides Benth.	Herbaceous
Anadenanthera falcata (Benth.) Speg.	Woody
Andira cuiabensis Benth.	Woody
A. laurifolia Benth.	Herbaceous
A. vermifuga (Mart.) Benth.	Woody
Arachis tuberosa Bong. ex Benth.	Herbaceous
Bauhinia rufa Steud.	Woody
Bowdichia virgilioides Kunth	Woody
Calliandra dysantha Benth.	Herbaceous
C. macrocalyx Harms	Woody
Calopogonium sericeum (Benth.) Chodat ex Hassl.	Herbaceous
Camptosema ellipticum (Desv.) Burkart	Herbaceous
Centrosema venosum Mart. ex Benth.	Herbaceous
Chamaecrista basifolia (Vogel) Irwin & Barneby	Herbaceous
C. campestris Irwin & Barneby	Herbaceous
C. cotonifolia (G.Don.) Killip.	Herbaceous
C. desvauxii (Collad.) Killip.	Herbaceous
C. filicifolia (Benth.) Irwin & Barneby	Herbaceous
C. flexuosa (L.) Greene	Herbaceous
C. lundii (Benth.) Irwin & Barneby	Herbaceous
C. nictitans (L.) Moench.	Herbaceous
C. planaltoana (Harms) Irwin & Barneby	Herbaceous
C. rotundifolia (Pers.) Greene	Herbaceous
C. setosa (Vogel) Irwin & Barneby	Herbaceous
Clitoria densifolia (Presl.) Benth.	Herbaceous
Copaifera langsdorffii Desf.	Woody
Crotalaria maypurensis Kunth	Herbaceous
C. nitens Benth.	Herbaceous
C. velutina Benth.	Herbaceous
Dalbergia cuiabensis Benth.	Woody
D. miscolobium Benth.	Woody
Desmodium barbatum (L.) Benth.	Herbaceous
D. incanun (Sw.) A.DC.	Herbaceous
D. platycarpum Benth.	Herbaceous
Dimorphandra mollis Benth.	Woody
Dioclea bicolor Benth.	Herbaceous
Dyptichandra aurantiaca Tul.	Woody
Eriosema crinitum (Kunth) Gardner	Herbaceous
E. cupreum Harms.	Herbaceous
E. glabrum Mart. ex Benth.	Herbaceous
E. heterophyllum Benth.	Herbaceous
E. longifolium Benth.	Herbaceous
E. rufum Kunth	Herbaceous
Galactia decumbens (Benth.) Chodat & Hassl.	Herbaceous
G. dimorpha Burk.	Herbaceous
G. martii A.DC.	Herbaceous
Harpalyce brasiliana Benth.	Woody
Hymenaea stigonocarpa Mart.	Woody
Indigofera gracilis Bong.	Herbaceous
Lupinus subsessilis Benth.	Herbaceous
Machaerium acutifolium Vogel	Woody
Mimosa amnis-atri Barneby	Woody
M. distans Benth.	Herbaceous
M. foliolosa Benth.	Woody
M. gemmulata Barneby	Woody
M. gracilis Benth.	Herbaceous
M. hebecarpa Benth.	Woody
M. nuda Humb. & Bonpl.	Herbaceous
M. polycephala Benth.	Herbaceous
M. radula Benth.	Herbaceous
M. xanthocentra Mart.	Herbaceous
Periandra mediterranea (Vell.) Taub.	Herbaceous
Phaseolus firmulus Mart.	Herbaceous
Plathymenia reticulata Benth.	Woody
Poiretia angustifolia Vogel	Herbaceous
P. latifolia Vogel	Herbaceous
P. longipes Harms.	Herbaceous
Pterodon pubescens Benth.	Woody
Rhynchosia platyphylla Benth.	Herbaceous

Appendix 1. (*continued*)

Family/species	Habit
Senna rugosa (G.Don.) Irwin & Barneby	Woody
S. silvestris (Vell.) Irwin & Barneby	Woody
S. velutina (Vogel) Irwin & Barneby	Woody
Stryphnodendron adstringens (Mart.) Coville	Woody
S. obovatum Benth.	Woody
Stylosanthes bracteata Vogel	Herbaceous
S. gracilis Kunth	Herbaceous
S. guianensis Sw.	Herbaceous
S. scabra Vogel	Herbaceous
Tephrosia adunca Benth.	Herbaceous
Vatairea macrocarpa (Benth.) Ducke	Woody
Vigna linearis Kunth	Herbaceous
Zornia latifolia Sm.	Herbaceous
Z. reticulata Sm.	Herbaceous
Z. virgata Moric.	Herbaceous
Fabaceae sp. 1	Woody
Flacourtiaceae	
Casearia grandiflora Cambess.	Woody
C. sylvestris Sw.	Woody
Casearia sp.	Herbaceous
Gentianaceae	
Deianira nervosa Cham. & Schltdl.	Herbaceous
Irlbachia alata (Aubl.) Maas	Herbaceous
Irlbachia speciosa (Cham. & Schltdl.) Maas	Herbaceous
Gesneriaceae	
Sinningia elatior (Kunth) Chautems	Herbaceous
Hypoxidaceae	
Curculigo sp.	Herbaceous
Icacinaceae	
Emmotum nitens (Benth.) Miers.	Woody
Iridaceae	
Sisyrinchium vaginatum Spreng.	Herbaceous
Trimezia juncifolia (Kl.) Kunth	Herbaceous
Lamiaceae	
Eriope crassipes Benth.	Herbaceous
Hypenia macrantha (A.St-Hil. ex Benth.) Harley	Herbaceous
Hyptidodendron canum (Pohl ex Benth.) Harley	Woody
Hyptis adpressa A.St-Hil. ex Benth.	Herbaceous
H. capriariifolia Pohl ex Benth.	Herbaceous
H. caudata Epling & Sativa	Herbaceous
H. crinita Benth.	Herbaceous
H. desertorum Pohl ex Benth.	Herbaceous
H. eriophylla Pohl	Herbaceous
H. ferruginosa Pohl ex Benth.	Herbaceous
H. interrupta Pohl ex Benth.	Herbaceous
H. lythroides Pohl ex Benth.	Herbaceous
H. multiflora Pohl ex Benth.	Herbaceous
H. recurvata Poit.	Herbaceous
H. saxatilis A.St-Hil. ex Benth.	Herbaceous
H. villosa Pohl ex Benth.	Herbaceous
H. virgata Benth.	Herbaceous
Hyptis sp.	Herbaceous
Marsipianthes chamaedrys (Vahl) Kuntze	Herbaceous
M. montana Benth.	Herbaceous
Ocimum sp.	Herbaceous
Peltodon pusillus Pohl	Herbaceous
P. tomentosus Pohl	Herbaceous
Salvia sp.	Herbaceous
Lauraceae	
Aiouea trinervis Meisn.	Woody
Cassytha filiformis L.	Herbaceous
Lecythidaceae	
Eschweilera nana (Berg.) Miers	Woody
Loganiaceae	
Strychnos pseudoquina A.St-Hil.	Woody
Lythraceae	
Cuphea carthagenensis (Jacq.) Macbr.	Herbaceous
C. linarioides Koehne	Herbaceous
Lafoensia pacari A.St-Hil.	Woody
Malpighiaceae	
Banisteriopsis acerosa (Nied.) B.Gates	Woody
B. amplectens B.Gates	Herbaceous
B. campestris (A.Juss.) Little	Herbaceous
B. gardneriana (A.Juss.) W.Anderson & Sattl.	Herbaceous
B. laevifolia (A.Juss.) B.Gates	Herbaceous
B. schizoptera (A.Juss.) B.Gates	Herbaceous
B. stellaris (Griseb.) B.Gates	Herbaceous
B. variabilis B.Gates	Herbaceous
Byrsonima basiloba A.Juss.	Woody
B. coccolobifolia A.Juss.	Woody
B. crassa Nied.	Woody
B. gaultherioides Griseb.	Herbaceous
B. guilleminiana A.Juss.	Herbaceous
B. intermedia A.Juss.	Woody
B. rigida A.Juss.	Herbaceous
B. verbascifolia (Griseb.) B.Gates	Woody
Camarea affinis A.St-Hil.	Herbaceous
Heteropterys anoptera A.Juss.	Herbaceous
H. byrsonimifolia A.Juss.	Woody
H. campestris A.Juss.	Herbaceous
H. coriacea A.Juss.	Herbaceous
Peixotoa reticulata Griseb.	Herbaceous
Tetrapteris ambigua (A.Juss.) Nied.	Herbaceous
Malvaceae	
Byttneria oblongata Pohl	Herbaceous
Eriotheca gracilipes (K.Schum.) A.Robyns	Woody
E. pubescens (Mart. & Zucc.) A.Robyns	Woody
Helicteres sacarolha A.St-Hil.	Herbaceous
Krapovichasia macrodon (A.DC.) Fryxell	Herbaceous
Melochia villosa (Mill.) Fawc. & Rendle	Herbaceous
Pavonia rosa-campestris A.St-Hil.	Herbaceous
Peltaea edouardii (Hochr.) Krapov. & Cristóbal	Herbaceous
P. polymorpha (A.St-Hil.) Krapov. & Cristóbal	Herbaceous
Pseudobombax longiflorum (Mart. & Zucc.) A.Robyns	Woody
Sida cerradoensis Krapov.	Herbaceous
S. cordifolia L.	Herbaceous
S. linearifolia A.St-Hil.	Herbaceous
S. rhombifolia L.	Herbaceous
Waltheria douradinha A.St-Hil.	Herbaceous
W. indica L.	Herbaceous
Melastomataceae	
Miconia albicans Triana	Woody
M. fallax A.DC.	Woody
M. ferruginata A.DC.	Woody
M. ligustroides (A.DC.) Naud.	Woody

Appendix 1. (*continued*)

Family/species	Habit
M. rubiginosa (Bonpl.) A.DC.	Woody
Mouriri elliptica Mart.	Woody
Rhynchanthera ursina Naud.	Herbaceous
Tibouchina gracilis (Bonpl.) Cogn.	Herbaceous
T. stenocarpa (A.DC.) Cogn.	Woody
Menispermaceae	
Cissampelos ovalifolia Ruiz & Pav.	Herbaceous
Moraceae	
Brosimum gaudichaudii Trècul	Woody
Myristicaceae	
Virola sebifera Aubl.	Woody
Myrsinaceae	
Myrsine leuconeura Mart.	Woody
Myrtaceae	
Campomanesia adamantium (Cambess.) O.Berg	Woody
C. pubescens (A.DC.) O.Berg	Woody
Eugenia angustissima O.Berg	Herbaceous
E. aurata O.Berg	Woody
E. bimarginata A.DC.	Woody
E. calycina Cambess.	Herbaceous
E. complicata O.Berg	Herbaceous
E. cristaensis O.Berg	Herbaceous
E. piauhiensis O.Berg	Woody
E. piloesis Cambess.	Woody
E. punicifolia (Kunth) A.DC.	Woody
Eugenia sp. 1	Herbaceous
Eugenia sp. 2	Woody
Eugenia sp. 3	Herbaceous
Eugenia sp. 4	Herbaceous
Myrcia bella Cambess.	Woody
M. bracteata O.Berg	Woody
M. camapuanensis N.F.E. Silveira	Woody
M. crassifolia (O.Berg) Kiaersk.	Woody
M. decrescens O.Berg	Woody
M. fallax (Rich.) A.DC.	Woody
M. guianensis A.DC.	Woody
M. laruotteana Cambess.	Woody
M. lasiopus O.Berg	Herbaceous
M. linguaeformis Kiaersk.	Woody
M. rhodeosepala Kiaersk.	Woody
M. torta A.DC.	Herbaceous
M. uberavensis O.Berg	Woody
M. variabilis Mart. ex A.DC.	Woody
Myrcia sp. 1	Herbaceous
Myrcia sp. 2	Woody
Myrcia sp. 3	Herbaceous
Myrciaria delicatula (A.DC.) O.Berg	Herbaceous
Psidium australe Cambess.	Herbaceous
P. cinereum Mart.	Herbaceous
P. firmum O.Berg	Herbaceous
P. laruotteanum Cambess.	Woody
P. multiflorum Cambess.	Herbaceous
P. rufum Mart. ex A.DC.	Woody
Nyctaginaceae	
Guapira campestris (Netto) Lund.	Herbaceous
G. gracilifora (Mart. ex J.A.Schmidt) Lund.	Woody
G. noxia (Netto) Lund.	Woody
Neea macrophylla Poep. & Endl.	Woody
N. theifera Oerst.	Woody
Ochnaceae	
Ouratea acuminata (A.DC.) Engl.	Woody
O. castanaefolia (A.DC.) Engl.	Woody
O. floribunda (A.St-Hil.) Engl.	Herbaceous
O. nana (A.St-Hil.) Engl.	Herbaceous
O. spectabilis (Mart.) Engl.	Woody
Orchidaceae	
Epistephium sclerophyllum Lindl.	Herbaceous
Galeandra montana Barb. Rodr.	Herbaceous
Habenaria brevidens Lindl.	Herbaceous
H. nasuta Rchb.f. & Warm.	Herbaceous
H. obtusa Lindl.	Herbaceous
Oxalidaceae	
Oxalis sellowii Spreng.	Herbaceous
Passifloraceae	
Mitostemma brevifilis Gontsch.	Herbaceous
Passiflora mansoi (Mart.) Mast.	Herbaceous
Poaceae	
Actinocladum verticillatum (Nees) McClure ex Saderston	Woody
Andropogon bicornis L.	Herbaceous
A. fastigiatus Sw.	Herbaceous
A. leucostachys Kunth	Herbaceous
A. selloanus (Hack.) Hack.	Herbaceous
Anthaenantiopsis perforata (Nees) Parodi	Herbaceous
Apoclada arenicola McClure	Woody
Aristida longifolia Trin.	Herbaceous
A. riparia Trin.	Herbaceous
Axonopus aureus P.Beauv.	Herbaceous
A. barbigerus (Kunth) Hithc.	Herbaceous
A. brasiliensis (Spr.) Kuhlm.	Herbaceous
A. derbyanus Black	Herbaceous
Brachiaria decumbens Stapf.	Herbaceous
Ctenium chapadense (Trin.) Doell.	Herbaceous
Echinolaena inflexa (Poir.) Chase	Herbaceous
Elionurus latiflorus Nees	Herbaceous
Eragrostis airoides Nees	Herbaceous
E. articulata (Schrank) Nees	Herbaceous
E. maypurensis (Kunth) Steud.	Herbaceous
Gymnopogon foliosus (Willd) Nees	Herbaceous
Hyparrhenia bracteata (Humb. & Bonpl.) Stapf.	Herbaceous
H. rufa (Nees) Stapf.	Herbaceous
Ichnanthus procurrens (Nees) Sw.	Herbaceous
Leptocoryphium lanatum (Kunth) Nees	Herbaceous
Loudetiopsis chrysothryx (Nees) Conert	Herbaceous
Melinis minutiflora P. Beauv.	Herbaceous
Olyra taquara Sw.	Woody
Panicum olyroides Kunth	Herbaceous
P. rudgei Roem & Shult.	Herbaceous
Panicum sp.	Herbaceous
Paspalum carinatum Humb. & Bonpl. ex Fleug.	Herbaceous
P. convexum Humb. & Bonpl. ex Fleug.	Herbaceous
P. erianthum Nees	Herbaceous
P. gardnerianum Nees	Herbaceous
P. geminiflorum Steud.	Herbaceous
P. malacophyllum Trin.	Herbaceous
P. multicaule Poir.	Herbaceous

Appendix 1. (*continued*)

Family/species	Habit
P. pectinatum Nees	Herbaceous
Paspalum sp. 1	Herbaceous
Paspalum sp. 2	Herbaceous
Pennisetum setosum (Sw.) L.C.Rich.	Herbaceous
Rhynchelitrum repens (Nees) C.E.Hubb.	Herbaceous
Schyzacchirium condensatum (Kunth) Nees	Herbaceous
Setaria geniculata (L.) P.Beauv.	Herbaceous
Sporobolus acuminatus Boechat & Longhi-Wagner	Herbaceous
S. ciliatus (Trin.) Hack.	Herbaceous
S. indicus (L.) R.Brown	Herbaceous
Trachypogon spicatus (L.f.) Kuntze	Herbaceous
Thrasya petrosa Nees	Herbaceous
Tristachya leiostachya Nees	Herbaceous
Polygalaceae	
Polygala angulata A.DC.	Herbaceous
P. aphylla A.W.Benn.	Herbaceous
P. opina Wurdack	Herbaceous
P. violacea Aubl.	Herbaceous
Securidaca tomentosa A.St-Hil.	Herbaceous
Polygonaceae	
Coccoloba densifrions Mart.	Woody
Polypodiaceae	
Adiantum serratodentatum Humb. & Bonpl. ex Willd.	Herbaceous
Proteaceae	
Roupala montana Aubl.	Woody
Rhamnaceae	
Crumenaria polygaloides Reissek	Herbaceous
Rubiaceae	
Alibertia sessilis (Vell.) K.Schum.	Herbaceous
Borreria suaveolens Meyers	Herbaceous
Chomelia ribesioides Benth. ex A.Gray	Woody
Declieuxia fruticosa (Willd.) Kuntze	Herbaceous
D. oenanthoides Schult. & Schult.	Herbaceous
D. verticilata Müll. Arg.	Herbaceous
Diodia schumanii Standl.	Herbaceous
D. teres Walt.	Herbaceous
Galianthe grandifolia Cabral	Herbaceous
Genipa americana L.	Woody
Palicourea coriacea (Cham.) K.Schum.	Herbaceous
P. rigida Kunth	Woody
Richardia humistrata (Cham. & Schltdl.) Steud.	Herbaceous
R. stellaris (Cham. & Schltdl.) Steud.	Herbaceous
Sipanea hispida Benth.	Herbaceous
Tocoyena formosa (Cham. & Schltdl.) K.Schum.	Woody
Rutaceae	
Hortia brasiliana Vand. ex A.DC.	Woody
Spiranthera odoratissima A.St-Hil.	Herbaceous
Sapindaceae	
Matayba guianensis Aubl.	Woody
Serjania cissoides Radlk.	Herbaceous
S. erecta Radlk.	Herbaceous
S. reticulata Cambess.	Herbaceous

Family/species	Habit
Talisia angustifolia Radlk.	Herbaceous
Toulicia tomentosa Radlk.	Herbaceous
Sapotaceae	
Pouteria ramiflora (Mart.) Radlk.	Woody
P. subcaerulea Pierre ex Dubard	Herbaceous
P. torta (Mart.) Radlk.	Woody
Pradosia brevipes (Pierre) Penn.	Herbaceous
Scrophulariaceae	
Buchnera lavandulacea Cham. & Schltdl.	Herbaceous
Esterhazia petiolata Barr.	Herbaceous
Scoparia dulcis L.	Herbaceous
Simaroubaceae	
Simaba suffruticosa Engl.	Herbaceous
Simarouba amara Aubl.	Woody
Smilacaceae	
Smilax cissoides Mart. ex Griseb.	Herbaceous
Solanaceae	
Solanum lycocarpum A.St-Hil.	Woody
S. subumbellatum Vell.	Herbaceous
Styracaceae	
Styrax ferrugineus Nees & Mart.	Woody
Turneraceae	
Piriqueta emasensis Arbo, sp. nov.	Herbaceous
P. sidifolia (Cambess.) Urban	Herbaceous
Turnera purpurascens Arbo	Herbaceous
Verbenaceae	
Aegiphila lanata Mould.	Herbaceous
A. lhotzkiana Cham.	Woody
Amasonia hirta Benth.	Herbaceous
Casselia chamaedryfolia Cham.	Herbaceous
Lippia hirta Schauer	Herbaceous
L. hoehnei Mould.	Herbaceous
L. lupulina Cham.	Herbaceous
L. martiana Schauer	Herbaceous
L. primulina S. Moore	Herbaceous
L. stachyoides Cham.	Herbaceous
L. turnerifolia Cham.	Herbaceous
Stachytarpheta maximilliani Schauer	Herbaceous
Stachytarpheta simplex Hayek.	Herbaceous
Violaceae	
Hybanthus poaya (A.St-Hil) Baill.	Herbaceous
Hybanthus sp. nov.	Herbaceous
Vitaceae	
Cissus erosa L.C.Rich	Herbaceous
Vochysiaceae	
Qualea grandiflora Mart.	Woody
Q. multiflora Mart.	Woody
Q. parviflora Mart.	Woody
Vochysia thyrsoidea Pohl	Woody
V. tucanorum Mart.	Woody
Unknown	
Unknown sp. 1	Herbaceous