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A comprehensive checklist of the angiosperms of a Cerrado fragment reveals outstanding species richness in the state of Maranhão, Brazil

Um *checklist* abrangente das angiospermas de um fragmento de Cerrado revela uma excepcional riqueza de espécies no estado do Maranhão, Brasil

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The Morros Garapenses Environmental Protection Area (EPA) is home to significant biodiversity and an important paleobotanical site, with Permian fossil records, being a strategic area for studies in Maranhão. The objective of this study was to provide a list of species of phanerogams from the Morros Garapenses EPA. The material was collected through the walking method on pre-existing trails at different elevations and phytophysiognomies. The collection, herborization, identification, and classification of species followed the usual methodology for this type of research. A total of 297 species distributed in 196 genera and 70 families were cataloged. The families with highest specific richness were Fabaceae (60 species), Malvaceae (20 spp.), Rubiaceae (18 spp.), Cyperaceae (16 spp.), Euphorbiacae (14 spp.), and Bignoniaceae (13 spp.). Forty-nine species were endemic to Brazil, fifteen are being reported for the first time from Maranhão, and five from Cerrado. Several phytophysiognomies were found in the area, namely, Cerradão (33 species), Campo sujo (7 spp.), typical Cerrado (154 spp.), veredas (10 spp.), riparian forest (5 spp.), and anthropized areas (5 spp.). The study revealed a significant number of species in the Morros Garapenses EPA, stressing the urgent need to create a management plan for the sustainable use of natural resources and recovery of degraded areas.

Keywords: Biological Reserves, Conservation Units, Maranhão Parks.

A Área de Proteção Ambiental (APA) dos Morros Garapenses, abriga uma biodiversidade significativa e um importante sítio paleobotânico, com registros fósseis do Permiano, sendo uma área estratégica para estudos no Maranhão. Com isso, objetivou-se elaborar uma lista de espécies de fanerógamas para Área de Proteção Ambiental (APA) dos Morros Garapenses. O material foi coletado através do método de caminhamento em trilhas pré-existentes em diferentes altitudes e fisionomias de vegetação. A coleta, herborização, identificação e classificação das espécies seguiu a metodologia usual para esse tipo de pesquisa. Foram catalogadas 297 espécies, distribuídas em 196 gêneros e 70 famílias, em que a maior riqueza específica foram para Fabaceae (60 espécies), Malvaceae (20 spp.), Rubiaceae (18 spp.), Cyperaceae (16 spp.), Euphorbiacae (14 spp.) e Bignoniaceae (13 spp.). Foi verificado a ocorrência de 49 espécies endêmicas para a área pesquisada, quinze novos registros para o Maranhão e cinco para o Cerrado. Além disso, foram encontradas diversas fisionomias, Cerradão (33 espécies), Campo sujo (7 spp.), Cerrado típico (154 spp.), veredas (10 spp.), Mata ciliar (5 spp.) e áreas antropizadas (5 spp.). Através do estudo foi possível constatar um número significativo de espécies para a APA dos Morros Garapenses, com a necessidade urgente da criação do plano de manejo, para a utilização sustentável dos recursos naturais e a recuperação de áreas degradadas.

Palavras-chave: Reservas Biológicas, Unidades de Conservação, Parques do Maranhão.

1. INTRODUCTION

Brazil is considered the most relevant among the megadiverse countries, presenting the highest biodiversity worldwide [1]. It is a country of continental dimensions with a variety of terrestrial and aquatic habitats which culminate in different phytogeographic domains, namely, the Amazon, Caatinga, Atlantic Forest, Pampa, and Pantanal [2]. Brazil also has the greatest richness of Neotropical plants and is one of the four countries in the world that continues to yield the largest number of new species described annually, increasing the richness of endemic species [3]. Such floristic diversity and endemism levels have led to the identification of two hotspots for global biodiversity: the Atlantic Forest and Cerrado [4].

For the Protection of the Cerrado and the Atlantic Forest the creation of Conservation Units (CUs) is one of the main mechanisms to protect the Brazilian biodiversity and they have become the main tool to maintain species richness, since the effective management of strategic areas for biodiversity is a determining factor to ensure the conservation of nature [5]. Conservation units are areas with relevant natural characteristics for the preservation of species legally established by the public authorities (federal, state, municipal, and private) and managed according to a management plan [6]. Conservation units can be of two types: Integral Protection CUs, in the case of protected areas that require more restrictive actions, allowing the indirect use of natural resources that do not pose risks to the environment, and Sustainable Use CUs, in which the allowed activities combine the protection of nature and the sustainable use of natural resources [7].

The state of Maranhão has CUs at different levels of management (federal, state, municipal and private), although in a low number when compared to other states. These CUs are distributed in the following categories: Environmental Protection Area (EPA), Park, Forest Biological Reserve, and Extractive Biological Reserve. They amount to a total of 40 CUs, being 30 sustainable use CUs and 10 Integral Protection CUs [8, 9]. At the state level, Maranhão has 13 CUs, among which the best known within the EPA category are: Baixada Maranhense EPA, Serra da Tabatinga EPA, Reentrâncias Maranhenses EPA, Maracanã Region EPA, Upaon-Açu/Miritiba/Alto Preguiças EPA, and Morro Garapenses EPA, one of the main CUs in the eastern region of Maranhão [10].

The vegetation of the Morro Garapenses EPA is found in an ecotone region [10] between the Amazonian and the northeastern semi-arid climates [11, 12]. The CU has a variety of ecosystems with a rich biota influenced by the formation of different phytophysiognomies (Caatinga, Mata de Cocais and Cerrado) and climatic variation [13]. One of the main features of this EPA is the presence of Permian fossils, around 250 million years old, inserted in the Pedra de Fogo formation of the Parnaíba basin, which provide one of the best records of climate change at a global level [14, 15].

Among the fossil materials found in Morro Garapenses EPA, there are remains of animals that lived millions of years ago such as dinosaur bones, fossils of gastropods, fish, ferns, gymnosperms and woody formations of angiosperms [16] and mainly in Duque Bacelar city, where the Museum of Natural and Environmental History of the Parnaíba Valley (MUHNAP) is located [17]. Recently, a new species of fossil gymnosperm was described from the EPA, *Europoxylon garapensis* Conceição et al. (2022) [18], which demonstrates the importance of the region and of studies that help in its conservation.

Floristic surveys can greatly contribute to the conservation of the Morro Garapenses EPA for generating information on the geographic distribution of species, their abundance in different locations and providing bases for species conservation strategies and plans [11]. There is only one preliminary list of angiosperm species (68 species) for the area, which hardly represents the real diversity of the flora, especially when considering the diversity of Maranhão [10]. The flora of Maranhão has 3,334 angiosperm species (704 endemic to Brazil) [19]. Despite the high potential of Maranhão to be among the most biodiverse states in Brazil due to its geographical position and variety of habitats, knowledge gaps place it among the least known, especially regarding its flora [20]. Maranhão is considered under-sampled compared to other states, but several floristic surveys have been carried out [21-27], many new species have been described [28-30], and new

records have been reported [31-34] in the last ten years, demonstrating the floristic diversity of the state which still needs to be cataloged.

Carrying out a floristic study in Morros Garapenses EPA is extremely important for the conservation of the eastern vegetation of Maranhão, mainly due to increasing anthropic actions and urbanization in the vicinity of this CU. The vegetation has been devastated by the local population through fires, wood felling, civil construction and agricultural activities. In addition, the absence of data to characterize the flora of the EPA precludes the creation of the management plan of this CU and the guarantee of its conservation.

Thus, this study aimed to prepare a list of phanerogam species through systematic collections in Morros Garapenses EPA, presenting the life habit, distribution in the geographic territory and phytogeographic domains of Brazil of all species, the most representative taxa, the endemic species for Brazil, and the new records for Maranhão and the Brazilian Cerrado.

2. MATERIAL AND METHODS

2.1 Study area

The study was carried out in Morros Garapenses EPA, created through State Decree nunber 25.087/2008, with an area of 234,767 ha. The EPA encompasses the territory of the municipalities of Duque Bacelar, Coelho Neto, Buriti de Inácia Vaz, and Afonso Cunha [9], located between the coordinates of 4°9’27.54” S and 42°57’1.21” W (Figure 1).

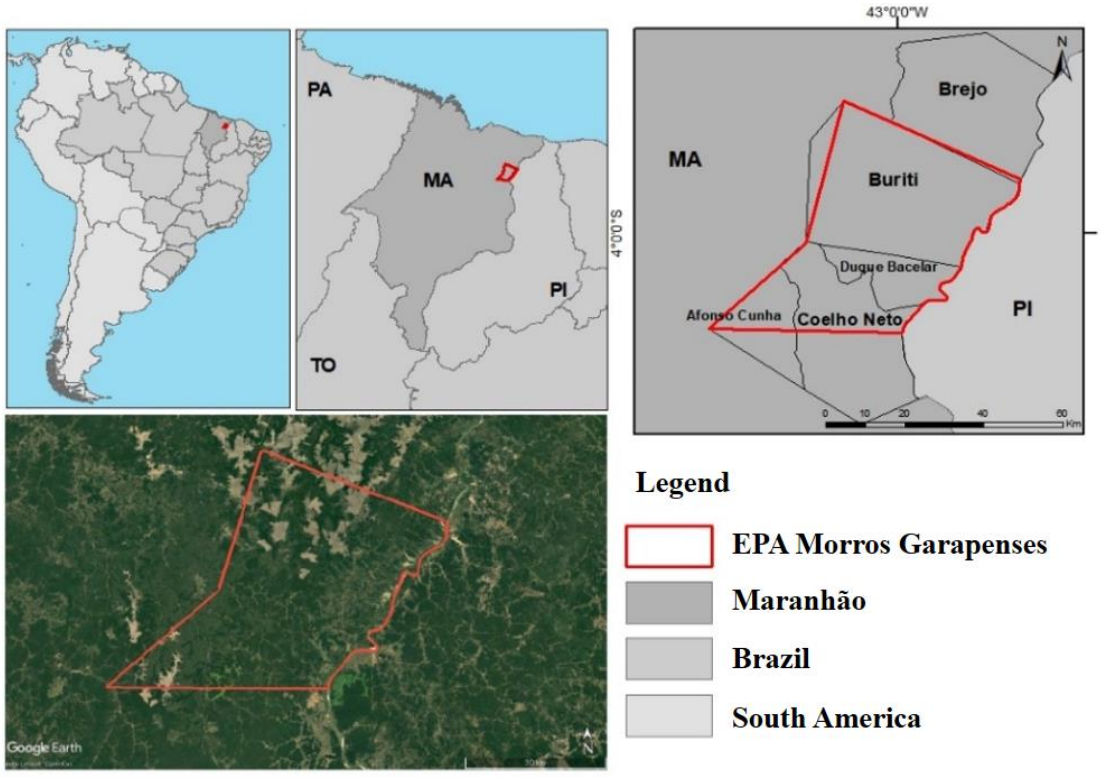

Figure 1: Geographic delimitation of Environmental Protection Area Morros Garapenses.

The region is characterized by a hot and semi-humid tropical climate (Aw) influenced by the transition between the Amazonian and the northeastern semi-arid climates [35]. There are two well-defined climatic seasons: a dry season with lower rainfall during from June to November, and a rainy season with higher rainfall from December to May; the average annual rainfall is 1,600 mm [36] and average annual temperature is over 24 °C. The predominant soils in the region

are classified as Yellow Latosol, Yellow Red Podzolic, Plintosol, Planosol, and Alluvial soils [37]. According to the classification of Feitosa (1983) [38], the relief of the region presents plains and terrains with altimetric amplitudes up to 200 m.

The EPA consists of six hills in the urban area of the municipality of Duque Bacelar (Morro do Urubu, Morro Garapa, Morro dos Patins, Morro dos Estudantes, Morro Zeca Barão, and Morro dos Ambientalistas) (Figure 2). It is inserted in the phytogeographic domain of Cerrado (about 90%) and some areas have characteristics of Caatinga (about 9%) [18]. The vegetation comprises different phytophysiognomies, varying from more open vegetation (fields) to closed forests of tall trees, and gallery forests with the presence of buriti palm swamps (buritizais) and sandy soil [9, 39].

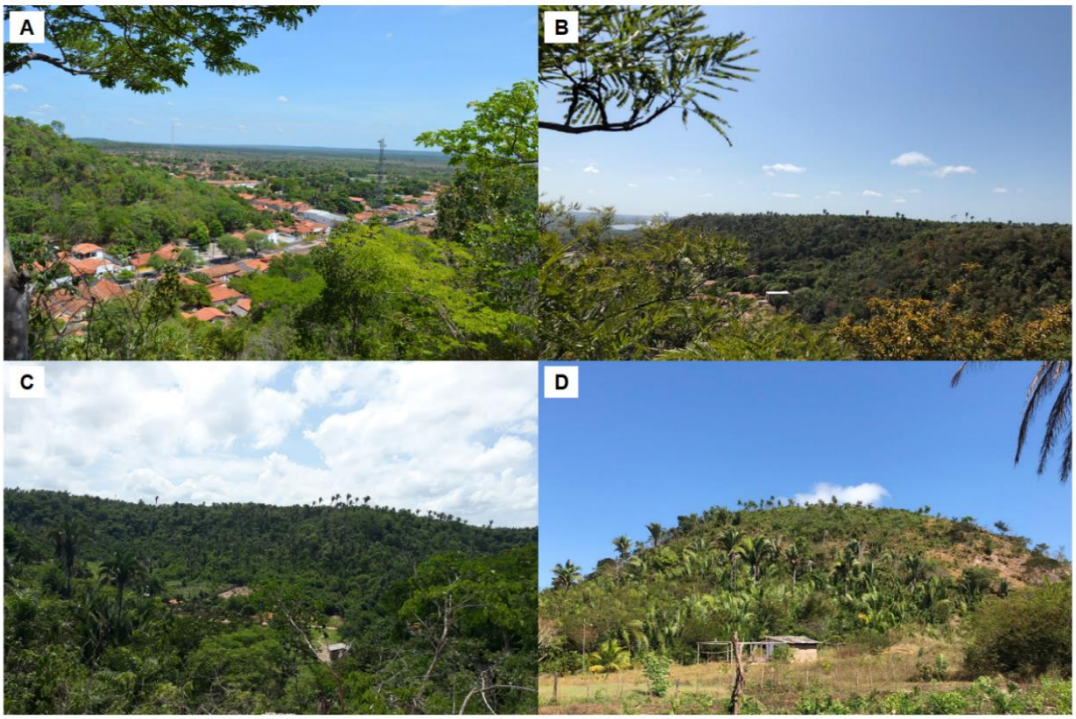

Figure 2: Vegetation formations of Morros Garapenses EPA. A. Vegetation in the Urban Area of the Municipality of Duque Bacelar; B. Vegetation on hills in the Municipality of Duque Bacelar; C. Vegetation in the Municipality of Afonso Cunha; D. Anthropized vegetation in the Municipality of Duque Bacelar.

The area of the EPA comprises part of two large hydrographic basins: the Parnaíba basin, in the lower course of the river, and the Munim basin, in the upper course of the river. There are some lagoons in the area; the main ones are the Lagoa do Ramalho, Lagoa da Tapera and Lagoa Pintada, where the main springs of the Pretos, Bacuri and Estrela rivers are found. Streams and natural lagoons are also abundante in the region, enhancing the drainage network, mainly on the banks of the Parnaíba River [9].

2.2 Floristic study

The floristic study consisted of collections, herborization, identification of botanical material, and field observations. Bimonthly collections were carried out from January 2019 to February 2021, totaling twelve expeditions covering the dry and rainy seasons. Collections were made along pre-established trails through the walking method, according to Filgueiras et al. (1994) [40].

Samples were composed of fertile branches (flowers and/or fruits) of each individual. At the moment of collection, notes were taken on the flowering, fruiting, growth habit of the individuals and the physiognomies where they occurred, and a photographic record was made. The collected

material was herborized following standard botanical herborization techniques [41]. The material was identified to the family, genus and species level by comparison with the type material and the aid of specialized bibliographies, scientific articles, and books [42-44], following the APGIV (2016) [45] classification. The material identified was incorporated into the collection of the Professor Aluízio Bittencourt Herbarium/HABIT of the State University of Maranhão/UEMA, Campus Caxias.

After identifications, a checklist was prepared listing the species names, vouchers, life habit, phytogeographic domains and physiognomies where the species occur, and indication of new records and species endemic to Brazil. We provide the number of species, genera and families as a measure of floristic richness of the area, highlighting the most representative taxa.

The [19, 46-48] networks were consulted to confirm the name and authorship of the species. Data on distribution in the Brazilian territory, phytogeographic domains, endemisms, and new occurrences to the state were retrieved from [19].

3. RESULTS AND DISCUSSION

A total of 297 species distributed in 196 genera and 70 families were cataloged in the study area (Figure 3) (Table 1), which corresponds to 9.3% of the flora of Maranhão according to Flora e Funga do Brasil (2023) [19]. Among the families recorded, the most representative were Fabaceae (60 species), Malvaceae (20), Rubiaceae (18), Cyperaceae (16), Euphorbiaceae (14), and Bignoniaceae (13), representing 46.6% of the sampled flora (Figure 4A). These families are widely distributed in Brazil and are often well represented in floristic studies [44, 49].

Fabaceae, Malvaceae, Rubiaceae and Cyperaceae were representative in other CUs in Maranhão, as reported by Rodrigues et al. (2019) [50] in Lençóis Maranhenses National Park, in the Municipality of Barreirinhas. Fabaceae, Malvaceae, Cyperaceae and Euphorbiaceae were well represented in Mirador State Park in the study by Silva et al. (2020) [51], other area influenced by Cerrado. Also similar to the present study, in the work by Silva-Moraes (2019) [52] conducted in 12 areas of Cerrado in Maranhão, Fabaceae, Malvaceae and Bignoniaceae were the most representative families.

The most representative families in the present study are among the 10 most diverse in Maranhão, including Fabaceae, the richest in number of species in the state [19]. Fabaceae has a cosmopolitan distribution and is the third-largest plant family worldwide, after Asteraceae and Orchidaceae [53, 54]. Of the total number of Fabaceae species cataloged in the present study, 50% (30 spp.) belong to the subfamily Papilionoideae, considered the largest subfamily of Fabaceae with about 14,000 species distributed in 503 genera worldwide [54, 55]. Fabaceae shows high adaptability to various environments, growing in disturbed or conserved areas, especially due to the nitrogen fixation mechanism [56] conferred by the ability to form root nodules with nitrogen-fixing bacteria in the case of about 97% of the species of the Papilionoideae subfamily [57]. Due to this ability, the Leguminosae have high potential for use in agroforestry systems and degraded land restoration, especially in areas with poor and fragile soils [58].

It is noteworthy that 27 (44.1%) of the families recorded in the study were represented by only one species, namely: Acanthaceae, Alstroemeriaceae, Aristolochiaceae, Caryocaraceae, Celastraceae, Connaraceae, Cucurbitaceae, Heliconiaceae, Hypericaceae, Krameriaceae, Lauraceae, Linderniaceae, Loganiaceae, Loranthaceae, Moraceae, Ochnaceae, Olacaceae, Onagraceae, Plumbaginaceae, Portulacaceae, Rhamnaceae, Santalaceae, Sapotaceae, Smilacaceae, Trigoniaceae, Verbenaceae, and Ximeniaceae. Several factors may have contributed to these data, as for example, the sampling method that may have led to random collections, not favoring the sampling of less diverse families. The distribution and biology of some botanical families is another factor, since some of them are composed of few species and present a restricted distribution [59].


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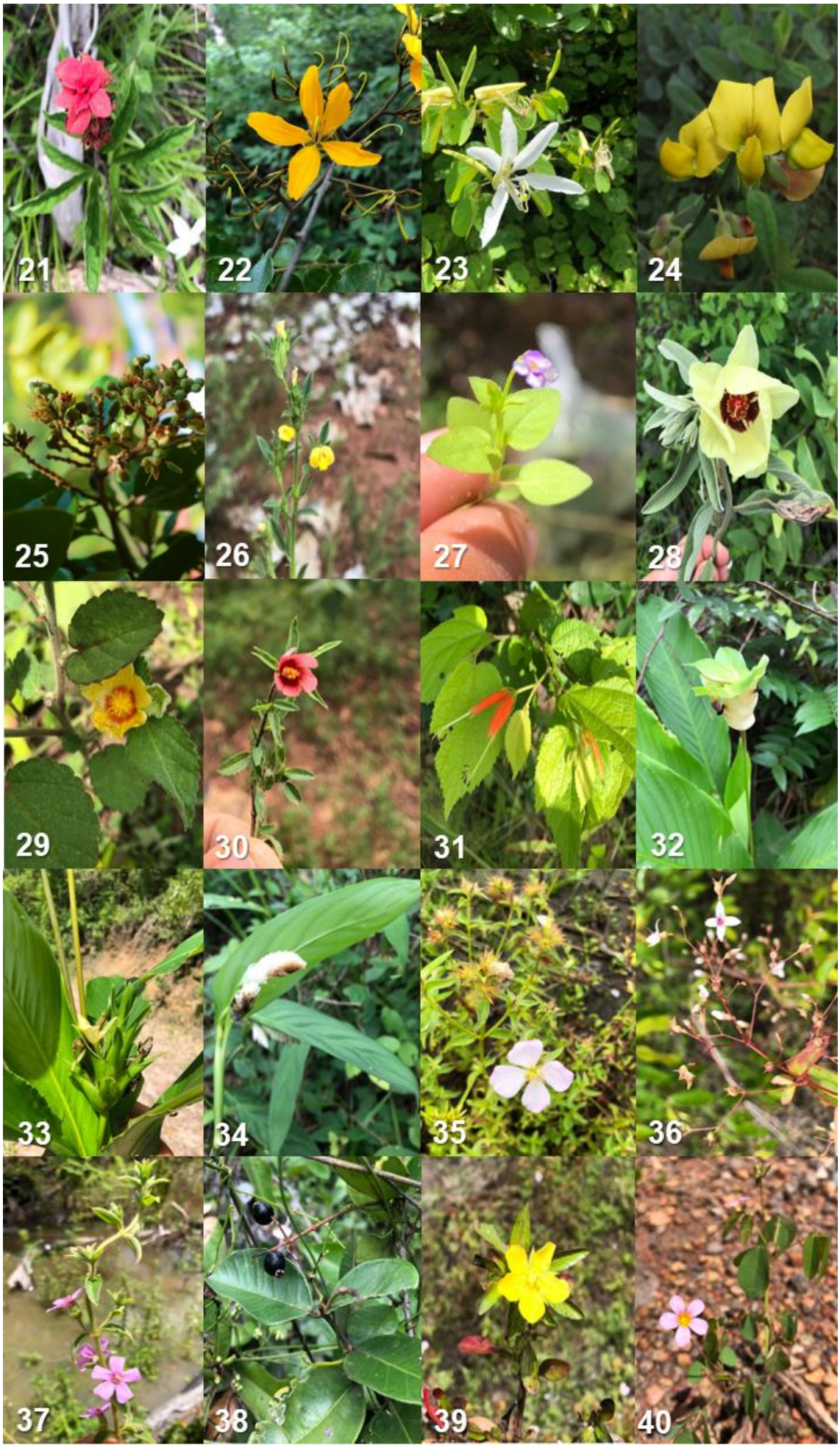
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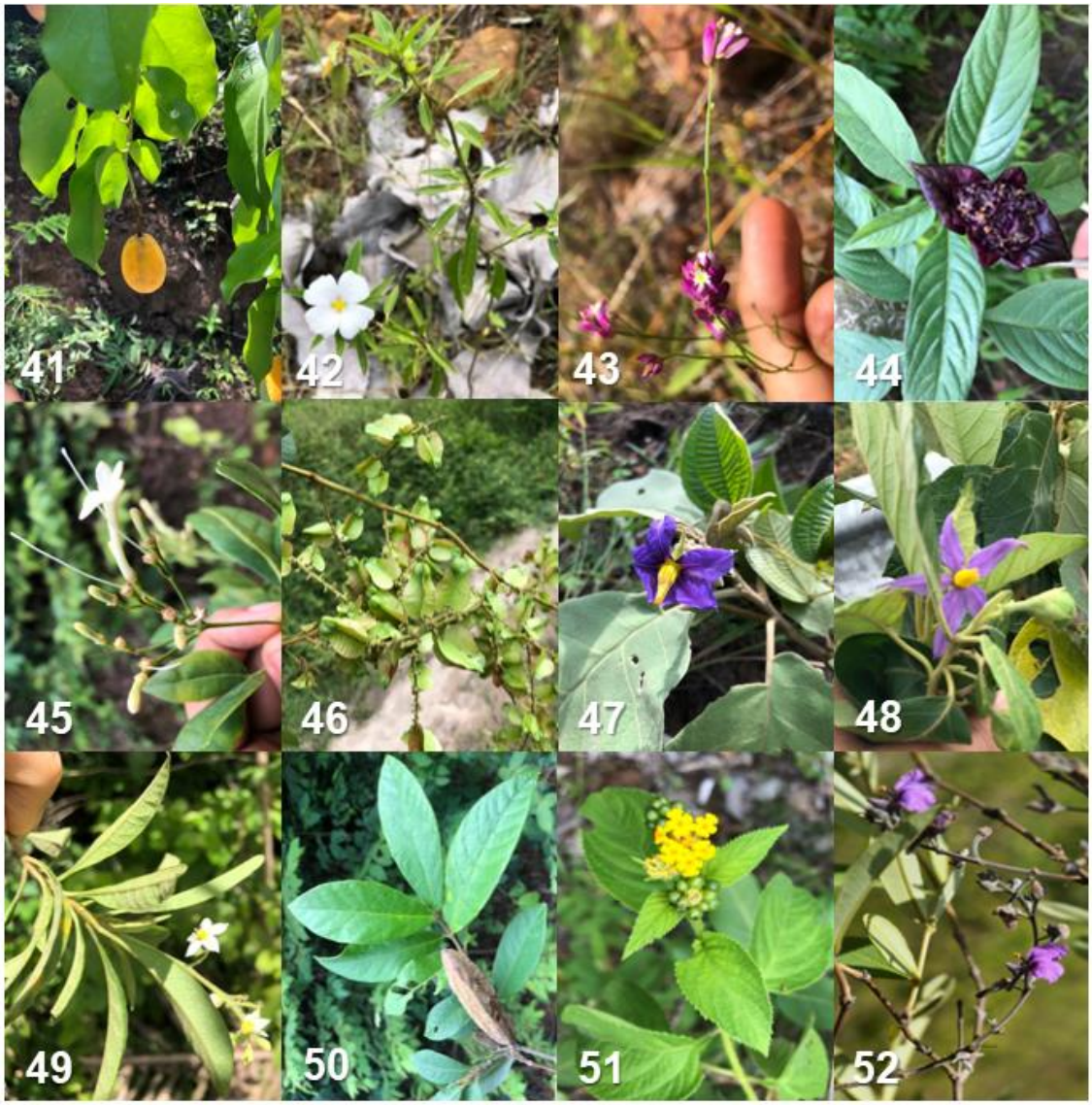

Figure 3: Species cataloged in Flora of Environmental Protection Area Morros Garapense. 1. Aspidosperma pyrifolium 2. Cryptostegia grandiflora 3. Himatanthus obovatus 4. Tabernaemontana catharinensis 5. Syagrus comosa 6. Centratherum punctatum 7. Tilesia baccata 8. Lundia helicocalyx 9. Cordia superba 10. Varronia multispicata 11. Bromelia antiacantha 12. Combretum duarteanum 13. Ceratosanthes hilariana 14. Rhynchospora nervosa 15. Scleria latifolia 16. Doliocarpus major 17. Croton heliotropiifolius 18. Dalechampia affinis 19. Heliconia psittacorum 20. Trimezia martinicensis 21. Amasonia campestris 22. Martiodendron mediterraneum 23. Bauhinia platypetala 24. Crotalaria retusa 25. Hymenaea stigonocarpa 26. Stylosanthes viscosa 27. Lindernia crustacea 28. Cienfuegosia affinis 29. Sida rhombifolia 30. Sida ciliaris 31. Helicteres heptandra 32. Goeppertia gardneri 33. Goeppertia squarrosa 34. Myrosma cannifolia L.f. 35. Pterolepis trichotoma 36. Nepsera aquatica 37. Desmoscelis villosa 38. Myrcia guianensis 39. Ludwigia decurrens 40. Oxalis cratensis 41. Passiflora glandulosa 42. Turnera melochioides 43. Polygala paniculata 44. Palicourea colorata 45. Galipea trifoliata Aubl. 46. Serjania noxia 47. Solanum crinitum 48. Solanum paludosum 49. Solanum asperum 50. Trigonia nivea 51. Lantana camara 52. Qualea parviflora.

The most representative genus was *Cyperus* L. with 10 species, followed by *Sida* L. with seven, *Mimosa* L. with six, and *Croton* L., *Erythroxylum* P. Browne, and *Borreria* G.Mey. with five each. These genera represented 12.75% of the total (Figure 4B). The most representative genera are included in the families with the highest number of species sampled in the area and they are genera with a high number of species and wide distribution, with occurrences in all

Brazilian phytogeographic domains, namely, the Amazon, Caatinga, Cerrado, Atlantic Forest, Pampa, and Pantanal [19].

Cyperus comprises about 550 species with cosmopolitan distribution and high representation in the tropics [60]. A total of 125 (28 endemic) species are recorded and widely distributed in Brazil, colonizing different phytophysiognomies but mainly humid and arid areas such as savannas, pastures and rocky outcrops, and some species are considered as invasive plants [60-62]. *Cyperus* is frequently well represented in floristic surveys. For example, in the survey conducted in rocky outcrops of the Serra Talhada biological reserve in Alagoas by Correia et al. (2021) [63] and in studies conducted in the Inhamum EPA, in the state of Maranhão, by Sousa et al. (2021) [64], *Cyperus* was well represented.

As for the most frequent life habit of the species (Figure 4C), the arboreal habit predominated (66 spp.), followed by the herbaceous (65 spp.), subshrubby (62 spp.), shrubby (54 spp.), and climbing (42 spp.) habits. In Cerrado, greater nutrient and water availability promotes larger and more abundant trees. Thus the predominance of trees in the Morro Garapenses EPA indicates that despite the fact that the area is under anthropic pressure, there are still plentiful nutritional resources to maintain the arboreal vegetation [65]. Some species of the tree community of the Morro Garapenses EPA are common species of Cerrado. One of them was *Caryocar brasiliense* Cambess., a species popularly known as Pequi, with considerable biological and economic value, and widely distributed in the Morro Garapenses EPA [66]. Ratter et al. (2003) [67] mentions that *C. brasiliense* is one of the most common woody species in Cerrado.

The genus *Qualea* Aubl. of the Volchysiaceae family was also well represented among the trees, with the species *Qualea grandiflora* Mart. and *Qualea parviflora* Mart. Vochysiaceae species are well adapted to Cerrado soils due to their ability to accumulate aluminum [68]. Silva Neto et al. (2016) [69] explain that the individuals of this family have competitive advantages in dystrophic soils with low saturation of exchangeable bases, low cation exchange capacity, high acidity, and high aluminum concentrations. In addition, they are able to adapt their reproduction according to the seasons in Cerrado [70].

Another relevant finding was the predominance of herbaceous species in the Morro Garapenses EPA, what may be an indication of anthropization because ruderal species generally have a short life cycle and are adapted to extreme temperature and rainfall conditions [71]. These species become abundant in secondary vegetation. Zenni and Ziller (2011) [72] state that the increase of the herbaceous layer may cause serious disturbances in local biodiversity.

During the expeditions in this study, several vegetation formations were observed: cerradão (forest savana), campo sujo (grassy vegetation with interspersed small shrubs), typical Cerrado, veredas (palm swamps), and riparian forest (Figure 4D). Although the study area is located in a transition zone between the northeastern semi-arid region and the Amazon, most species were collected in typical Cerrado (154 species). This type of vegetation was observed to be proportionally more abundant than the others, mainly in relation to riparian forest, where only five species were recorded (vegetation formations with a smaller number of species).

This same pattern of vegetation cover was found by Saraiva et al. (2020) [73] in the Cerrado physiognomies of the Chapada das Mesas National Park, in which 113 records of the 242 listed species were from typical Cerrado areas. This vegetation type presents an arboreal-shrubby phytophysiognomy with species ranging from 3 to 6 meters in height [74]. Generally, these areas have irregularities in the vegetation, with twisted branches, and, sometimes, also evidence of fires [73].

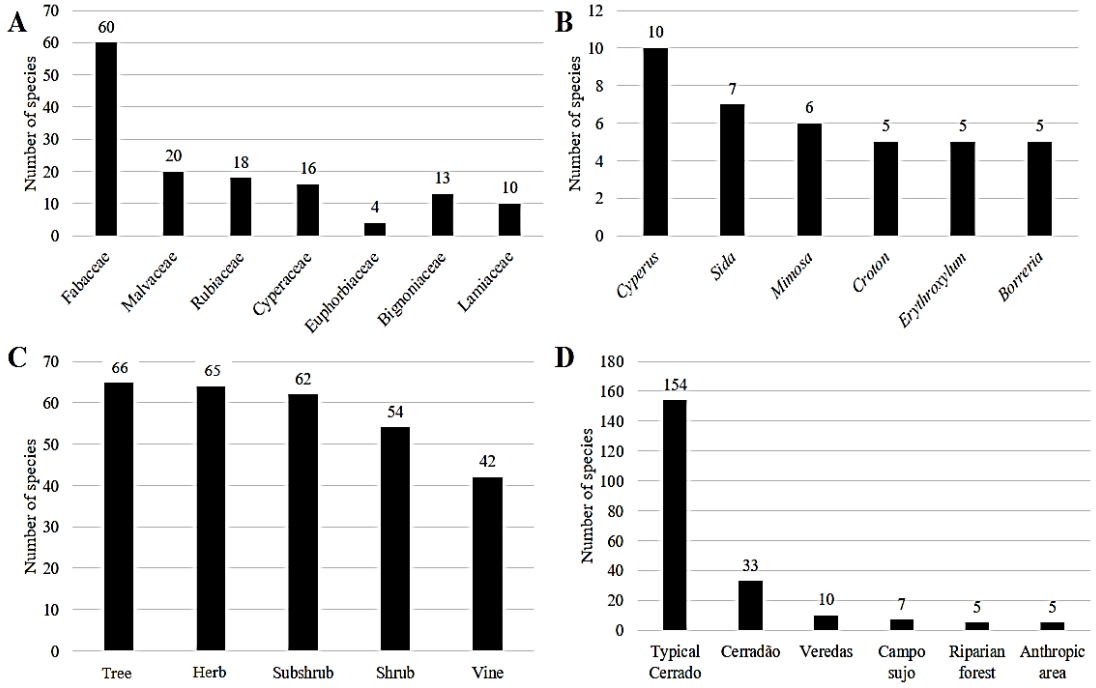

Figure 4: Representativeness of Family, genera, life habit and vegetation formations in relation to the number of species sampled in Environmental Protection Area Morros Garapense. 4A. Distribution of the number of species in relation to the most representative families; 4B. Distribution of the number of species in relation to the most representative genera; 4C. Distribution of the number of species in relation to life habit; 4D. Distribution of the number of species in relation to vegetation formations.

Among the cataloged species, five occurred exclusively in anthropized areas within the EPA and 55 species occurred in both anthropized areas and other physiognomies. *Cryptostegia grandiflora* R.Br. was one of the species found exclusively in anthropized areas and is a new record from Maranhão and Cerrado. This means that the persistence of this species in the area is uncertain. Besides anthropization, the Cerrado of Maranhão undergoes an accelerated process of degradation generated by agroindustrial activities, which is mitigated but still present within EPAs. Changes in the Cerrado landscape and threats to endemic species can be important justifications for the creation of CUs to ensure a more effective and efficient preservation of the environment and to change the current scenario of the Cerrado of Maranhão [75].

Fifteen specis are being reported for the first time from Maranhão: *Acalypha communis* Müll.Arg., *Borreria virgata* Cham. & Schltdl., *Ceratosanthes hilariana* Cogn., *Cnidoscolus urens* (L.) Arthur, *C. grandiflora*, *Dalechampia olfersiana* Müll.Arg., *Dioscorea scabra* Humb. & Bonpl. ex Willd., *Erythroxylum pelleterianum* A.St.-Hil., *Fridericia dispar* (Bureau ex K.Schum.) L.G.Lohmann, *Hexasepalum radula* (Willd.) Delprete & J.H. Kirkbr., *Malvastrum coromandelianum* (L.) Garcke, *Myrciaria floribunda* (H.West ex Willd.) O.Berg, *Myrcia sylvatica* (G.Mey.) DC., *Portulaca grandiflora* Hook., and *Pleonotoma clematis* (Kunth) Miers. (Figure 5). There are many knowledge gaps on the occurrence and distribution of species in Maranhão mainly due to the low investment in comprehensive field studies. Even so, Maranhão stands out in the Brazilian scenario as one of the states with the highest estimated but not yet cataloged biodiversity [39].

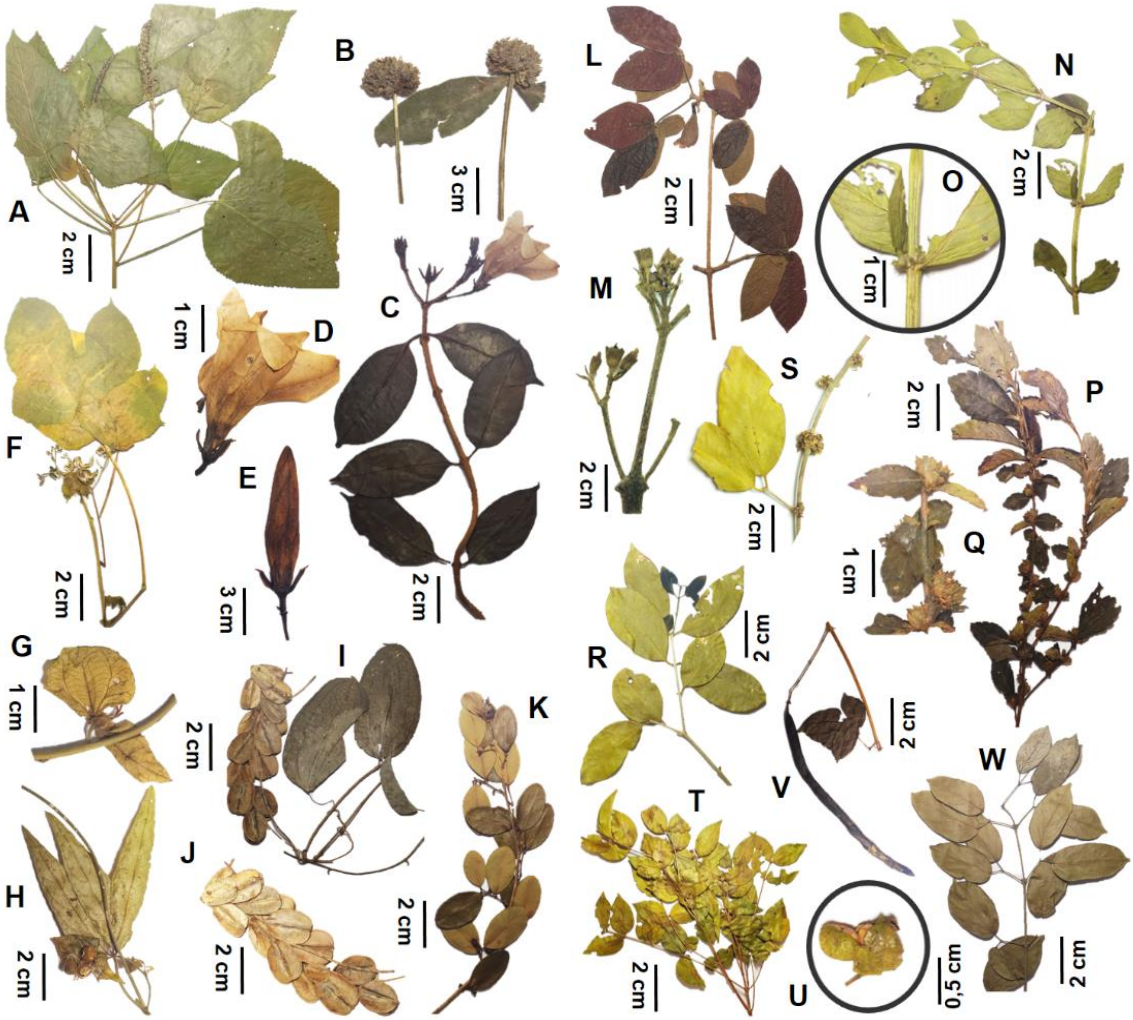

Figure 5: New record registered for Maranhão and Brazilian Cerrado. A. Branches of A. communis; B. Flowers of B. virgata; C. Branches of C. grandiflora; D. Flower of C. grandiflora; E. Flower bud of C. grandiflora; F. Branch of C. urens; G. Bracts of D. olfersiana; H. Leaf and Fruit of D. olfersiana; I. Branches of D. scabra; J. D. scabra fruits; K. Branches of E. pelleterianum; L. Branch of F. dispar; M. Flower calyx of F. dispar; N. Branches of H. radula; O. Flowers of H. radula; P. Branch of M. coromandelianum; Q. Flowers of M. coromandelianum; R. Branches of M. floribunda; S. Flores de M. floribunda; T. Branch of M. sylvatica; U. Fruit of M. sylvatica; V. Branches of P. clematis; W. Fruit of P. clematis. Material Examined: A. GASPAR, J.C. 79 (HABIT); B. GASPAR, J.C. 55 (HABIT); C. D. E. GASPAR, J.C. 432 (HABIT); F. GASPAR, J.C. 41 (HABIT); G. H. GASPAR, J.C. 382 (HABIT); I. J. GASPAR, J.C. 30 (HABIT); K. GASPAR, J.C. 45 (HABIT); L. GASPAR, J.C. 24 (HABIT); M. GASPAR, J.C. 257; N. GASPAR, J.C. 67 (HABIT); O. GASPAR, J.C. 121 (HABIT); P. Q. GASPAR, J.C. 1 (HABIT); R. S. GASPAR, J.C., 176 (HABIT); T. U. GASPAR, J.C. 339 (HABIT); V. GASPAR, J.C. 178 (HABIT); W. GASPAR, J.C. 297 (HABIT).

The other new occurrences reported in the present study are distributed in sites (states) far from Maranhão, indicating that they have a disjunct distribution or that there is a sampling deficit in other Brazilian states. The geographic distribution of these species is being expanded with the present study, contributing to the advancement of knowledge of the Flora of Maranhão. Several new occurrences of species have been published in recent years, such as those mentioned in the studies [76-78], among others. According to Santos-Silva et al. (2018) [77], initiatives such as these directly contribute to the growing body of knowledge of the flora of Maranhão and help in the development of conservation strategies for the phytophysiognomies and species cataloged in this study.

Five of the species recorded in the present study are new occurrences from Cerrado: *B. virgata*, *C. grandiflora*, *D. olfersiana*, *P. clematis* and *Taccarum ulei* Engl. & K.Krause. These species

occur in at most two phytogeographic domains; the species *C. grandiflora*, *D. olfersiana* and *T. ulei* have records in the Atlantic Forest and Caatinga, *P. clematis* only in the Amazon, and *B. virgata* only in the Atlantic Forest.

According to Machado et al. (2015) [10], the Morros Garapenses EPA is in a transition zone between the northern Cerrado of Maranhão and Mata de Cocais, providing the EPA with a diversity of physiognomies, high species richness, and high potential for new occurrences [79]. Transition areas present heterogeneous vegetation influenced by factors that act on them, such as soil texture and fertility, slope, elevation, and ground water mining [80, 81].

Forty-nine of the cataloged species were endemic to Brazil, according to data from Flora e Funga do Brasil (2023) [19]. The significant number of endemic species indicates the importance of the creation and management of conservation strategies aimed at the local flora. The high richness and endemism of Cerrado makes it an important hotspot for biodiversity conservation [79].

Six of the endemic species (*T. ulei*; *Pectis decumbens* Baker, *Lundia helicocalyx* A.H.Gentry, *Mimosa caesalpiniifolia* Benth., *Sida galheirensis* Ulbr. and *Turnera stipularis* Urb.) are regionally endemic. Brazil is a country of continental dimensions and this contributes to the high number of endemic species. When these species are widely distributed in the country, their endemic status may not affect their conservation, but when they present restricted distribution at the regional and/or state level, management plans, conservation status assessments, and conservation measures are necessary to ensure their survival [82].

Regarding the vulnerability of the surveyed species, according to the red list [83], only *M. caesalpiniifolia*, *Stryphnodendron adstringens* (Mart.) Coville and *Aspilia attenuata* (Gardner) Baker have been evaluated for their conservation status. They were classified in the category of Least Concern (LC). Despite being susceptible to some anthropic pressure, they present good distribution and are not under threat of extinction. There is a large gap in the evaluation of the conservation status of plant species, especially those endemic to the tropical region, which are found in greater abundance, thus increasing their vulnerability and risk in threatened areas [84].

While the Morros Garapenses EPA showed a high diversity of species, life forms, physiognomies, what led to a high number of new occurrences from Maranhão and Cerrado, this area is affected by several anthropic factors, mainly in the more urbanized parts. The main factors are clear-cut logging and slash burning for agricultural activities and environmental pollution. All of them threaten the flora characterized in the present study. The deforestation rate in Cerrado has reached 3 million hectares per year, mainly as a result of woodland exploitation for charcoal production and clearing of forested lands for agriculture, with direct impacts on the Cerrado of Maranhão [85].

The management plan of the Morros Garapenses EPA has not been created until the present date, but there are competent bodies that help in the conservation of this CU. However, we highlight that the creation of CUs alone does no not ensure the conservation of the species. To fulfill their role, CUs need an effective management, with an administrative body and security personnel to provide protection against invasions, depredation and fires, as well as technical professionals to implement the management plans. This all involves high administrative and operational costs. In view of all the governmental obstacles, it is evident that CUs alone are ineffective to achieve biodiversity conservation [86].

4. CONCLUSION

The data exposed here revealed significant richness and diversity values (297 species and 68 families), life forms, and endemic taxa to Brazil, demonstrating the floristic relevance of the Morros Garapenses EPA in the scenario of state CUs. The study also showed that the flora of the EPA is threatened by the degradation caused by human interference, mainly wood extraction, agricultural activities and environmental pollution. Thus, the information is useful for future conservation actions aimed at this EPA, reinforcing the importance of applying public policies and creating a management plan for the conservation and sustainable use of natural resources and recovery of degraded areas in this CU. Furthermore, the new occurrences of species from

Maranhão and the Brazilian Cerrado reported in this study contribute to expand the knowledge of the flora of this state and biome, respectively.

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Table 1. List of species of Angiosperms collected in the Environmental Protection Area of Morros Garapenses, Maranhão Brazil, with indication of the life habit, vegetation formations, Phytogeographic Domain and Voucher. (Endemic species for Brazil/ + New occurrence for Maranhão/ ^ New occurrence for the Brazilian Cerrado). Abbreviations for vegetation formations: C: Cerradão; AA: Anthropogenic Area; CS: Campo Sujo; CT: Typical Cerrado; MC: riparian forest; VE: Vereda. Life habit: Arb: Shrub; Arv: Tree; Erv: Herb; Est: Stipe; Sub: Subshrub; Tre: Vine. Phytogeographic Domains: AM: Amazon rainforest; CA: Caatinga; CE: Cerrado; MA: Atlantic Rainforest; PA: Pantanal; PP: Pampa.*

Family/Species	Voucher	Vegetation formations	Life habit	Phytogeographic Domain
Acanthaceae				
Ruellia inundata Kunth	GASPAR, J.C. 126, 127	C MC	Sub	CA, CE, MA
Alstroemeriaceae				
Bomarea edulis (Tussac) Herb.	GASPAR, J.C. 390	C	Tre	AM, CA, CE, PA, MA
Amaranthaceae				
Alternanthera brasiliana (L.) Kuntze	GASPAR, J.C. 66, 72	AA CT	Sub	AM, CA, CE, MA, PA, PP
Alternanthera dentata (Moench) Stuchlík ex R.E.Fr.	GASPAR, J.C. 253	CT	Sub	AM, CA, CE, MA
Anacardiaceae				
Spondias mombin L.	GASPAR, J.C. 175	C MC	Arv	CE, AM, MA
Tapirira guianensis Aubl.	GASPAR, J.C. 104	CT	Arv	AM, CE, CA, MA, PA
Annonaceae				
Annona crassiflora Mart.	GASPAR, J.C. 185	C MC	Arv	AM, CE, PA
Oxandra sessiliflora R.E.Fr. *	GASPAR, J.C. 157	CT	Arv	AM, CE, MA
Apocynaceae				
Aspidosperma pyrifolium Mart. & Zucc.	GASPAR, J.C. 148, 149	CT	Arv	CA, CE, MA
Cryptostegia grandiflora R.Br. +^	GASPAR, J.C. 432	AA	Arb	AM, CA
Himatanthus obovatus (Müll. Arg.) Woodson	GASPAR, J.C. 154	CT	Arv	AM, CA, CE
Mandevilla hirsuta (A.Rich.) K.Schum	GASPAR, J.C. 393	C	Tre	AM, CA, CE MA
Mandevilla scabra (Hoffmanns. ex Roem. & Schult.) K.Schum.	GASPAR, J.C. 248	CT	Tre	AM, CA, CE, MA
Tabernaemontana catharinensis A.DC.	GASPAR, J.C. 165	CT	Arv	CE, MA, PP
Tabernaemontana linkii A.DC.	GASPAR, J.C. 183	C MC	Arv	AM, CE, CA
Schubertia grandiflora Mart.	GASPAR, J.C. 437	VE	Tre	AM, CA, CE, MA
Araceae				
Philodendron brevispathum Schott	GASPAR, J.C. 449	VE	Erv	AM, CE
Taccarum ulei Engl. & K.Krause *^	GASPAR, J.C. 197	C	Erv	CA, MA
Arecaceae				
Syagrus cocoides Mart. *	GASPAR, J.C. 159	CT	Arv	AM, CE
Syagrus comosa (Mart.) Mart.	GASPAR, J.C. 260	CT	Arv	AM, CE

Aristolochiaceae				
Aristolochia odoratissima L.	GASPAR, J.C. 78	AA CT	Tre	AM, CE, MA
Asteraceae				
Aspilia attenuata (Gardner) Baker *	GASPAR, J.C. 125	C MC	Sub	AM, CE, MA
Centratherum punctatum Cass.	GASPAR, J.C. 83, 84, 85, 86, 87, 88, 89	AA CT	Sub	AM, CA, CE, MA, PA, PP
Emilia fosbergii Nicolson	GASPAR, J.C. 375	CT	Erv	AM, CA, CE, MA, PP, PA
Pectis decumbens Baker *	GASPAR, J.C. 328	CT	Sub	CA, CE
Tilesia baccata (L.) Pruski	GASPAR, J.C. 40, 251, 280	CT	Arb	AM, CA, CE, MA
Bignoniaceae				
Adenocalymma scabriusculum Mart. ex DC.	GASPAR, J.C. 392, 440	AA CT	Arb	CA, CE
Bignonia aequinoctialis L.	GASPAR, J.C. 177, 186	C MC	Lia	AM, CE, MA
Bignonia corymbosa (Vent.) L.G.Lohmann	GASPAR, J.C. 189, 233	C MC	Lia	AM, CE, MA
Bignonia noterophila Mart. ex DC	GASPAR, J.C. 397	C	Lia	AM, CE, CA
Dolichandra quadrivalvis (Jacq.) L.G.Lohmann	GASPAR, J.C. 456	CT	Lia	AM, CA, MA, PA, CE
Fridericia dispar (Bureau ex K.Schum.) L.G.Lohmann *+	GASPAR, J.C. 24, 257	CT	Arb/ Tre	CA, CE
Handroanthus serratifolius (Vahl) S.Grose	GASPAR, J.C. 230	AA CS	Arv	AM, CA, CE, MA, PA
Jacaranda brasiliana (Lam.) Pers. *	GASPAR, J.C. 324	CT	Arv	AM, CE
Lundia helicocalyx A.H.Gentry *	GASPAR, J.C. 22, 252, 398	CT	Lia	CA, CE
Pleonotoma clematis (Kunth) Miers +∧	GASPAR, J.C. 178, 179, 297, 303	C CT MC	Lia	AM
Stizophyllum perforatum (Cham.) Miers	GASPAR, J.C. 209	CT	Lia	CE, MA
Tanaecium dichotomum (Jacq.) Kaehler & L.G.Lohmann	GASPAR, J.C. 129	C MC	Lia	AM, CA, CE, PA
Tabebuia aurea (Silva Manso) Benth. & Hook.f. ex S.Moore	GASPAR, J.C. 231	AA CS	Lia	AM, CE, CA, MA, PA
Bixaceae				
Bixa orellana L.	GASPAR, J.C. 190	C MC	Arb	AM, CE, MA
Cochlospermum regium (Mart. ex Schrank) Pilg.	GASPAR, J.C. 164, 187	C CT MC	Arb	AM, CA, CE, PA
Boraginaceae				
Cordia superba Cham. *	GASPAR, J.C. 144, 270	CT	Arv	CA, CE, MA
Varronia multispicata (Cham.) Borhidi *	GASPAR, J.C. 311	CT	Arb	AM, CE, MA, PA
Heliotropium elongatum (Lehm.) I.M.Johnst.	GASPAR, J.C. 218	AA CS	Sub	AM, CA, CE, MA, PA, PP
Bromeliaceae				
Bromelia antiacantha Bertol.	GASPAR, J.C. 331, 378	CT	Erv	MA, PP, CE
Bromelia eitenorum L.B.Sm. *	GASPAR, J.C. 458	CT	Erv	AM, CE
Capparaceae				
Cynophalla flexuosa (L.) J.Presl	GASPAR, J.C. 188	C	Árv	AM, CA, CE, MA, PA
Mesocapparis lineata (Dombey ex Pers.) Cornejo & Iltis *	GASPAR, J.C. 174	C MC	Tre	AM, CA, CE, MA

Caryocaraceae				
Caryocar brasiliense Cambess.	GASPAR, J.C. 196	C	Arv	AM, CA, CE, MA
Celastraceae				
Salacia elliptica (Mart.) G. Don	GASPAR, J.C. 450	CT	Arb/ Tre	AM, CA, CE, MA, PA
Combretaceae				
Combretum duarteanum Cambess.	GASPAR, J.C. 228, 350, 400	C CS CT	Arb	AM, CA, CE, MA
Terminalia fagifolia Mart.	GASPAR, J.C. 350	CT	Arv	CA, CE
Terminalia lucida Hoffmanns. ex Mart. & Zucc.	GASPAR, J.C. 17, 181, 192, 211	C CT MC	Arv	AM, CE
Commelinaceae				
Commelina benghalensis L.	GASPAR, J.C. 199	C	Erv	AM, CA, CE, MA, PA, PP
Dichorisandra hexandra (Aubl.) C.B.Clarke	GASPAR, J.C. 117	AA CT	Erv/ Tre	AM, CA, CE, MA, PP, PA
Murdannia nudiflora (L.) Brenan	GASPAR, J.C. 242, 434	CT VE	Erv	AM, CA, CE, MA
Connaraceae				
Rourea doniana Baker *	GASPAR, J.C. 160, 255	CT	Lia	AM, CA, CE, MA
Convolvulaceae				
Evolvulus nummularius (L.) L.	GASPAR, J.C. 418	AA MC	Erv	AM, CA, CE, MA
Ipomoea asarifolia (Desr.) Roem. & Schult.	GASPAR, J.C. 143, 435	AA CS VE	Tre	AM, CA, MA, CE
Ipomoea bahiensis Willd. ex Roem. & Schult. *	GASPAR, J.C. 443	CT	Tre	AM, CA, CE, MA
Ipomoea hederifolia L.	GASPAR, J.C. 102	CT	Tre	AM, CA, CE, MA
Operculina hamiltonii (G.Don) D.F.Austin & Staples	GASPAR, J.C. 101, 103, 204	C CT	Tre	AM, CA, CE, MA, PA
Cucurbitaceae				
Ceratosanthes hilariana Cogn.+	GASPAR, J.C. 161	CT	Tre	CE, MA, PP
Cyperaceae				
Bulbostylis capillaris (L.) C.B.Clarke	GASPAR, J.C. 330	CT	Erv	AM, CA, CE, MA, PA, PP
Bulbostylis juncoides (Vahl) Kük. ex Osten	GASPAR, J.C. 305	CT	Erv	AM, CA, CE, MA, PA, PP
Cyperus aggregatus (Willd.) Endl.	GASPAR, J.C. 357	CT	Erv	AM, CA, CE, MA, PA, PP
Cyperus odoratus L.	GASPAR, J.C. 290	CT	Erv	AM, CA, CE, MA, PA, PP
Cyperus digitatus Roxb.	GASPAR, J.C. 261	CT	Erv	AM, CA, CE, MA, PA
Cyperus sesquiflorus (Torr.) Mattf. & Kük.	GASPAR, J.C. 34	CT	Erv	AM, CA, CE, MA PA, PP
Cyperus esculentus L.	GASPAR, J.C. 48	CT	Erv	AM, CA, CE, MA PA, PP
Cyperus haspan L.	GASPAR, J.C. 338	CT	Erv	AM, CA, CE, MA PA, PP
Cyperus iria L.	GASPAR, J.C. 359	CT	Erv	AM, CA, CE, MA, PA, PP
Cyperus luzulae (L.) Retz	GASPAR, J.C. 312, 316	CT	Erv	AM, CA, CE, MA, PA, PP
Cyperus polystachyos Rottb.	GASPAR, J.C. 82	CT	Erv	AM, CA, CE, MA, PA, PP
Cyperus rotundus L.	GASPAR, J.C. 43, 120	AA CT	Erv	AM, CA, CE, MA PA, PP

Eleocharis equisetoides (Elliott) Torr.	GASPAR, J.C. 50	AA CT	Erv	CE, MA, CA
Rhynchospora cephalotes (L.) Vahl	GASPAR, J.C. 23, 35, 356	CT	Erv	AM, CA, CE, MA
Rhynchospora nervosa (Vahl) Boeckeler *	GASPAR, J.C. 219	AA CS	Erv	AM, CA, CE, MA, PA
Scleria latifolia Sw.	GASPAR, J.C. 306	CT	Erv	AM, CA, CE, MA, PA, PP
Dilleniaceae				
Curatella americana L.	GASPAR, J.C. 220	CS	Arv	AM, CA, CE, MA
Davilla cearensis Huber *	GASPAR, J.C. 155	CT	Lia	AM, CE, MA
Doliocarpus major J.F.Gmel.	GASPAR, J.C. 334	CT	Arb/ Tre	AM, MA, CE
Discoreaceae				
Dioscorea orthogoneura Uline ex Hochr.	GASPAR, J.C. 156	CT	Tre	CA, CE
Dioscorea scabra Humb. & Bonpl. ex Willd. *+	GASPAR, J.C. 30	CT	Tre	CE
Erythroxylaceae				
Erythroxylum deciduum A.St.-Hil.	GASPAR, J.C. 16	CT	Arv	AM, CE, MA
Erythroxylum laetevirens O.E.Schulz *	GASPAR, J.C. 25, 258	CT	Arb	CA, CE
Erythroxylum pelleterianum A.St.-Hil. +	GASPAR, J.C. 45, 250	CT	Arb	AM, CE, MA
Erythroxylum pruinosum O.E.Schulz	GASPAR, J.C. 243	CT	Arb	AM, CE
Erythroxylum subracemosum Turcz	GASPAR, J.C. 10	CT	Arv	AM, CE, MA
Euphorbiacaee				
Acalypha communis Müll.Arg. +	GASPAR, J.C. 79	AA CT	Arb	CA, CE, MA, PA, PP
Croton glandulosus L.	GASPAR, J.C. 5, 313	CT	Sub	AM, CA, CE, MA, PA, PP
Croton heliotropiifolius Kunth	GASPAR, J.C. 8, 16, 19, 26, 116, 214, 239, 347, 355	AA CT	Sub	CA, CE, MA
Croton hirtus L'Hér.	GASPAR, J.C. 222, 332	AA CS	Erv	AM, CA, CE, MA
Croton pedicellatus Kunth	GASPAR, J.C. 273	CT	Sub	CA, CE, MA
Croton triqueter Lam.	GASPAR, J.C. 369	CT	Sub	CA, CE, MA, PA,
Dalechampia affinis Müll. Arg.	GASPAR, J.C. 412	MC	Tre	AM, CA, CE
Dalechampia olfersiana Müll.Arg. *+^	GASPAR, J.C. 382	CT	Tre	CA, MA,
Cnidoscolus urens (L.) Arthur +	GASPAR, J.C. 438	VE	Sub	AM, CA, CE, MA
Cnidoscolus vitifolius (Mill.) Pohl	GASPAR, J.C. 41, 173	MC CT	Arb	AM, CA, CE, PA
Euphorbia hirta L.	GASPAR, J.C. 80, 98	AA CT	Erv	AM, CA, CE, MA, PP
Euphorbia hyssopifolia L.	GASPAR, J.C. 298	CT	Erv	AM, CA, CE, MA, PP
Jatropha gossypiifolia L.	GASPAR, J.C. 420	AA	Arb	AM, CA, CE, MA
Mabea pohliana (Benth.) Müll.Arg.	GASPAR, J.C. 373	CT	Arb	AM, CE
Fabaceae				
Andira vermifuga (Mart.) Benth.	GASPAR, J.C. 406	C	Arv	AM, CA, CE, MA
Arachis hypogaea L.	GASPAR, J.C. 327	CT	Erv	AM, CA, CE, MA, PA, PP

Arachis palustris Krapov. et al. *	GASPAR, J.C. 224	AA CS	Erv	CE
Aeschynomene filosa Mart.	GASPAR, J.C. 110	CT	Arb	AM, CA, CE, MA
Bauhinia acuruana Moric. *	GASPAR, J.C. 36, 383	C, CT	Arb	CA, CE
Bauhinia platypetala Burch. ex Benth.	GASPAR, J.C. 431	VE	Arb	AM, CE
Cassia grandis L.f.	GASPAR, J.C. 428	CT	Arv	AM, CE, MA PA
Cenostigma macrophyllum Tul.	GASPAR, J.C. 426	CT	Arv	AM, CE, CA
Centrosema brasilianum (L.) Benth.	GASPAR, J.C. 69, 70, 73, 76, 124, 134, 135, 361, 362	AA CS CT	Tre	AM, CA, CE, MA, PA
Centrosema pubescens Benth.	GASPAR, J.C. 133	AA CS	Tre	AM, CA, CE, MA, PA
Chamaecrista ensiformis (Vell.) H.S.Irwin & Barneby	GASPAR, J.C. 128	C MC	Arv	AM, CA, CE, MA
Chamaecrista hispidula (Vahl) H.S.Irwin & Barneby	GASPAR, J.C. 272	CT	Arb	AM, CA, CE, MA
Chamaecrista supplex (Mart. ex Benth.) Britton & Rose ex Britton & Killip	GASPAR, J.C. 343	CT	Sub	AM, CA, CE, MA
Chloroleucon acacioides (Ducke) Barneby & J.W.Grimes	GASPAR, J.C. 212	C	Arv	AM, CA, CE, MA,
Clitoria fairchildiana R.A.Howard *	GASPAR, J.C. 169	C	Arv	AM, CA, CE, MA
Copaifera oblongifolia Mart. ex Hayne	GASPAR, J.C. 158	CT	Arv	AM, CE
Cratylia argentea (Desv.) Kuntze	GASPAR, J.C. 172	C	Lia	AM, CA, CE
Crotalaria pallida Aiton	GASPAR, J.C. 56	CT	Sub	AM, CE, MA, PP
Crotalaria retusa L.	GASPAR, J.C. 325	CT	Sub	AM, CA, CE, MA, PP
Ctenodon histrix (Poir.) D.B.O.S.Cardoso, P.L.R.Moraes & H.C.Lima	GASPAR, J.C. 63, 106, 108, 326, 384	AA CS CT	Arb	AM, CA, CE, MA, PA
Desmodium adscendens (Sw.) DC.	GASPAR, J.C. 407	C	Sub	AM, CA, CE, MA, PP
Desmodium barbatum (L.) Benth.	GASPAR, J.C. 47, 360	AA CT	Sub	AM, CA, CE, MA PA, PP
Desmodium distortum (Aubl.) J.F.Macbr.	GASPAR, J.C. 58, 115	AA CT	Arb	AM, CA, CE, MA, PP
Desmodium triflorum (L.) DC.	GASPAR, J.C. 475	MC	Sub	AM, CA, CE, MA, PA
Dimorphandra gardneriana Tul.	GASPAR, J.C. 38	CT	Arv	CA, CE
Galactia jussiaeana Kunth	GASPAR, J.C. 137, 229, 271	AA CT CS	Sub	AM, CA, CE, MA
Hymenaea stigonocarpa Mart. ex Hayne	GASPAR, J.C. 146	CT	Arv	AM, CA, CE, PA
Hymenaea parvifolia Huber	GASPAR, J.C. 263	CT	Arv	AM, CE
Indigofera hirsuta L.	GASPAR, J.C. 74, 445	CT	Arb	AM, CA, CE, MA
Indigofera suffruticosa Mill.	GASPAR, J.C. 439	CT	Arb	AM, CA, CE, MA, PP, PA
Inga vera Willd.	GASPAR, J.C. 188	C	Arv	AM, CE, MA, PP, PA
Libidibia ferrea (Mart. ex Tul.) L.P.Queiroz	GASPAR, J.C. 396	C	Arv	CA, CE, MA
Lonchocarpus sericeus (Poir.) Kunth ex DC.	GASPAR, J.C. 472	AA CT	Arv	AM, CA, CE, MA
Macropsychanthus bicolor (Benth.) L.P.Queiroz & Snak	GASPAR, J.C. 57	CT	Lia	AM, CE
Macroptilium gracile (Poepp. ex Benth.) Urb. *	GASPAR, J.C. 109	CT	Tre	AM, CA, CE, MA
Macroptilium lathyroides (L.) Urb.	GASPAR, J.C. 140	AA CS	Sub/ Tre	AM, CA, CE, MA, PA, PP
Martiodendron mediterraneum (Mart. ex Benth.) R.C.Koeppen *	GASPAR, J.C. 424	C	Arv	AM, CA, CE, MA

Mimosa caesalpiniifolia Benth. *	GASPAR, J.C. 61	AA CT	Arb	CA, CE, MA, AM
Mimosa diplotricha C.Wright ex Sauvalle	GASPAR, J.C. 62	AA CT	Sub	AM, CA, CE, MA, PP
Mimosa pigra L.	GASPAR, J.C. 414	MC	Arb	AM, CA, CE, MA, PA
Mimosa pudica L.	GASPAR, J.C. 112	AA CT	Sub	AM, CA, CE, MA
Mimosa sensitiva L.	GASPAR, J.C. 60, 77, 105, 145	AA CT	Lia	AM, CA, CE, MA, PA
Mimosa xanthocentra Mart.	GASPAR, J.C. 411	MC	Sub	AM, CE, MA
Periandra coccinea (Schrad.) Benth. *	GASPAR, J.C. 39, 279	CT	Sub	AM, CA, CE, MA
Plathymenia reticulata Benth.	GASPAR, J.C. 427	C	Arv	AM, CA, CE, MA
Platymiscium floribundum Vogel *	GASPAR, J.C. 470	CT	Arv	AM, CA, CE, MA
Schnella glabra (Jacq.) Dugand	GASPAR, J.C. 42, 238, 349	CT MC	Arb/ Lia	AM, CE
Schnella outimouta (Aubl.) Wunderlin	GASPAR, J.C. 111, 113	CT	Arb/ Lia	AM, CE, MA
Senegalia polyphylla (DC.) Britton & Rose	GASPAR, J.C. 348	CT	Arb	AM, CA, CE, MA, PA
Senna georgica H.S.Irwin & Barneby	GASPAR, J.C. 136	CS	Arb	AM, CA, CE, MA
Senna obtusifolia (L.) H.S.Irwin & Barneby	GASPAR, J.C. 59, 107, 119	AA CT CS	Arb	AM, CA, CE, MA, PP, PA
Senna occidentalis (L.) Link	GASPAR, J.C. 436	VE	Arb	AM, CA, CE, MA, PA
Senna reticulata (Willd.) H.S.Irwin & Barneby	GASPAR, J.C. 141	CS	Arb	AM, CA, CE
Stryphnodendron adstringens (Mart.) Coville *	GASPAR, J.C. 118	CT	Arv	CA, CE, MA
Stylosanthes angustifolia Vogel	GASPAR, J.C. 301	CT	Erv	AM, CA, CE, MA
Stylosanthes grandifolia M.B.Ferreira & Sousa Costa	GASPAR, J.C. 403, 417	C	Sub	AM, CE, MA
Stylosanthes viscosa (L.) Sw.	GASPAR, J.C. 287	CT	Sub	AM, CA, CE, MA, PA, PP
Swartzia psilonema Harms *	GASPAR, J.C. 259	CS	Arv	CE, MA
Tephrosia domingensis (Willd.) Pers.	GASPAR, J.C. 329	CT	Sub	AM, CE, MA
Zornia latifolia Sm.	GASPAR, J.C. 64	CT	Sub	AM, CA, CE, MA, PA, PP
Heliconiaceae				
Heliconia psittacorum L.f.	GASPAR, J.C. 372	CT	Erv	AM, CA, CE, MA, PA
Hypericaceae				
Vismia guianensis (Aubl.) Choisy	GASPAR, J.C. 288	CT	Arb	AM, CA, CE, MA
Iridaceae				
Cipura paludosa Aubl.	GASPAR, J.C. 268, 296	CT	Erv	AM, CE, CA, MA
Trimezia martinicensis (Jacq.) Herb.	GASPAR, J.C. 430	VE	Erv	AM, CA, CE, MA
Krameriaceae				
Krameria tomentosa A.St.-Hil.	GASPAR, J.C. 281	CT	Arb	AM, CA, CE, MA
Lamiaceae				
Aegiphila integrifolia (Jacq.) Moldenke	GASPAR, J.C. 457	C	Arb	AM, CA, CE, MA, PP, PA
Amasonia campestris (Aubl.) Moldenke	GASPAR, J.C. 44, 275, 314	CT	Sub	AM, CA, CE, MA

Hyptis crenata Pohl ex Benth.	GASPAR, J.C. 286	CT	Erv	AM, CE
Hyptis parkeri Benth.	GASPAR, J.C. 322	CT	Erv	AM, CE
Marsypianthes chamaedrys (Vahl) Kuntze	GASPAR, J. C. 93, 97, 122, 223, 380	CT	Sub	AM, CA, CE, MA, PA
Mesosphaerum suaveolens (L.) Kuntze	GASPAR, J. C. 304	CT	Sub	AM, CA, CE, MA, PA
Vitex capitata Vahl	GASPAR, J.C. 28, 33	CT	Arv	AM, CA, CE, MA
Vitex panshiniana Moldenke*	GASPAR, J.C. 167, 473	CT	Arv	AM, CE, CA
Vitex rufescens A.Juss. *	GASPAR, J.C. 408	AA MC	Arv	CA, CE, MA
Vitex schaueriana Moldenke *	GASPAR, J.C. 152, 267	CT	Arv	AM, CA, CE
Lauraceae				
Cassytha filiformis L.	GASPAR, J.C. 321	CT	Tre	AM, CA, CE, MA
Linderniaceae				
Lindernia crustacea (L.) F.Muell.	GASPAR, J.C. 387	C	Erv	AM, CA, CE, MA, PA
Loganiaceae				
Strychnos parvifolia A.DC.	GASPAR, J.C. 302	CT	Sub/Lia	AM, CA, CE, MA
Loranthaceae				
Passovia pedunculata (Jacq.) Kuijt	GASPAR, J.C. 291	CT	Sub	CE, MA
Lythraceae				
Cuphea antisyphilitica Kunth	GASPAR, J.C. 245	CT	Sub	AM, CE, MA
Cuphea micrantha Kunth	GASPAR, J.C. 282, 340	CT	Sub	AM, CA, CE, MA
Malpighiaceae				
Byrsonima cydoniifolia A.Juss.	GASPAR, J.C. 402	C	Arv	CA, CE, PA
Mascagnia sepium (A.Juss.) Griseb.	GASPAR, J.C. 195	C	Lia	CA, CE, MA
Malvaceae				
Allobriquetia spicata (Kunth) Bovini	GASPAR, J.C. 96	CT	Arb	AM, CA, CE, MT, PA
Cienfuegosia affinis (Kunth) Hochr.	GASPAR, J.C. 474	CT	Sub	AM, CA, CE, PA
Guazuma ulmifolia Lam.	GASPAR, J.C. 20, 21, 206	C CT	Arv	AM, CA,CE, MA, PA, PP
Helicteres brevispira A.St.-Hil.	GASPAR, J.C. 191, 283	MC CT	Arb	AM, CA, CE, MA, PA
Helicteres heptandra L.B.Sm.	GASPAR, J.C. 371	CT	Arb	CA, CE, MA
Malvastrum coromandelianum (L.) Garcke +	GASPAR, J.C. 1	CT	Sub	AM, CA, CE, MA, PA
Melochia parvifolia Kunth	GASPAR, J.C. 213	AA CS	Sub	AM, CA, CE, PA.
Melochia pyramidata L.	GASPAR, J.C. 71, 94	AA CS	Sub	AM, CA, CE, MA
Pavonia cancellata (L.) Cav.	GASPAR, J.C. 415	AA MC	Erv	AM, CA, CE, MA
Sida acuta Burm.f.	GASPAR, J.C. 95, 276	CT	Sub	AM, CA, CE, MA
Sida ciliaris L.	GASPAR, J.C. 244, 413	AA CT MC	Sub	CA, MA, CE, AM, PA
Sida cordifolia L.	GASPAR, J.C. 433	VE	Sub	AM, CA, CE, MA PA

Sida galheirensis Ulbr. *	GASPAR, J.C. 92	CT	Sub	CA, CE, MA
Sida glomerata Cav.	GASPAR, J.C. 91, 278	CT	Sub	AM, CA, CE, MA, PA
Sida linifolia Cav.	GASPAR, J.C. 221	AA CS	Sub	AM, CA, CE, MA, PA
Sida rhombifolia L.	GASPAR, J.C. 469	AA MC	Erv	AM, CA, CE, MA, PP, PA
Sterculia striata A.St.-Hil. & Naudin *	GASPAR, J.C. 182, 207	C	Arv	AM, CA, CE, MA
Triumfetta bartramia L.	GASPAR, J.C. 65	C	Sub	AM, CA, CE, MA
Waltheria bracteosa A.St.-Hil. & Naudin*	GASPAR, J.C. 285	CT	Erv	CA, CE
Waltheria indica L.	GASPAR, J.C. 142, 419	CS	Sub	AM, CA, CE, MA, PA, PP
Marantaceae				
Goeppertia gardneri (Baker) Borchs. & S.Suárez *	GASPAR, J.C. 18, 391	C CT	Erv	CA, CE, AM
Goeppertia squarrosa (Anderss. & Kennedy) Borchs. & S.Suárez *	GASPAR, J.C. 389	C	Erv	CA, CE
Goeppertia villosa (Lindl.) Borchs. & S.Suárez	GASPAR, J.C. 247	CT	Erv	AM, CA, CE
Maranta pohliana Körn.	GASPAR, J.C. 4, 198, 366	AA CT MC	Sub	AM, CA, CE
Maranta ruiziana Körn.	GASPAR, J.C. 423	MC	Erv	AM, CE
Myrosma cannifolia L.f.	GASPAR, J.C. 308	CT	Erv	AM, CE, MA, PA
Melastomataceae				
Clidemia hirta (L.) D.Don	GASPAR, J.C. 377	CT	Arb	AM, CA, CE, MA, PP, PA
Desmoscelis villosa (Aubl.) Naudin	GASPAR, J.C. 448	VE	Sub	AM, CE, MA
Pterolepis glomerata (Rottb.) Miq.	GASPAR, J.C. 451	AA	Erv	AM, CA, CE, MA
Pterolepis trichotoma (Rottb.) Cogn.	GASPAR, J.C. 114	CT	Erv	AM, CA, CE, MA
Nepsera aquatica (Aubl.) Naudin	GASPAR, J.C. 471	VE	Erv	AM, CA, MA, CE
Moraceae				
Maclura tinctoria (L.) D.Don ex Steud.	GASPAR, J.C. 139	AA CS	Arv	AM, CA, CE, MA, PA, PP
Myrtaceae				
Eugenia dysenterica (Mart.) DC. *	GASPAR, J.C. 341	CT	Arv	CA, CE, MA
Eugenia flavescens DC.	GASPAR, J.C. 365	CT	Arv	AM, CA, CE, MA
Eugenia punicifolia (Kunth) DC. *	GASPAR, J.C. 249	CT	Arb	AM, CA, CE, MA, PA
Myrciaria floribunda (H.West ex Willd.) O.Berg +	GASPAR, J.C. 176	C MC	Arv	AM, CA, CE, MA
Myrcia guianensis (Aubl.) DC.	GASPAR, J.C. 31, 194, 316, 401	C CT	Arb	AM, CA, CE, MA, PA
Myrcia sylvatica (G.Mey.) DC. +	GASPAR, J.C. 339	CT	Arv	AM, CA, CE, MA
Myrcia splendens (Sw.) DC.	GASPAR, J.C. 346	CT	Arv	AM, CA, CE, MA, PA
Ochnaceae				
Ouratea hexasperma (A.St.-Hil.) Baill.	GASPAR, J.C. 295	CT	Arv	CE
Onagraceae				
Ludwigia decurrens Walter	GASPAR, J.C. 452	AA	Erv	AM, CE, MA, PP, PA

Opiliaceae				
Agonandra brasiliensis Miers ex Benth. & Hook.f.	GASPAR, J.C. 151	CT	Arv	AM, CA, CE, MA, PA
Orchidaceae				
Catasetum barbatum (Lindl.) Lindl.	GASPAR, J.C. 405	C	Erv	AM, CA, CE, MA, PA
Oeceoclades maculata (Lindl.) Lindl.	GASPAR, J.C. 367	CT	Erv	AM, CA, CE, MA
Oxalidaceae				
Oxalis cratensis Oliv. ex Hook.	GASPAR, J.C. 421	AA	Erv	AM, CA, CE, MA, PA
Oxalis divaricata Mart. ex Zucc. *	GASPAR, J.C. 370	AA MC	Erv	AM, CA, CE, MA
Passifloraceae				
Passiflora foetida L.	GASPAR, J.C. 227	AA CS	Tre	AM, CA, CE, MA, PA, PP
Passiflora glandulosa Cav.	GASPAR, J.C. 386	C	Tre	AM, CE
Turnera subulata Sm.	GASPAR, J.C. 68, 75, 99, 100, 131	CS CT	Sub	AM, CA, CE, MA
Turnera stipularis Urb. *	GASPAR, J.C. 100	CT	Arb	CE
Turnera melochioides Cambess.	GASPAR, J.C. 284	CT	Sub	AM, CA, CE, MA
Plantaginaceae				
Bacopa salzmannii (Benth.) Wettst. ex Edwall	GASPAR, J.C. 453	AA MC	Erv	AM, CA, CE, MA, PA
Scoparia dulcis L.	GASPAR, J.C. 216	CS	Sub	AM, CA, CE, MA, PA, PP
Plumbaginaceae				
Plumbago scandens L.	GASPAR, J.C. 435	VE	Arb	AM, CA, MA, CE
Poaceae				
Axonopus chrysoblepharis (Lag.) Chase	GASPAR, J.C. 90	CT	Erv	AM, CA, CE, MA
Aristida longifolia Trin.	GASPAR, J.C. 294	CT	Erv	AM, CA, CE
Paspalum gardnerianum Nees	GASPAR, J.C. 337	CT	Erv	AM, CA, CE
Streptostachys asperifolia Desv	GASPAR, J.C. 318	CT	Erv	AM, CA, CE, MA
Rugoloa pilosa (Sw.) Zuloaga	GASPAR, J.C. 364	CT	Erv	AM, CA, CE, MA, PA, PP
Polygalaceae				
Asemeia violacea (Aubl.) J.F.B.Pastore & J.R.Abbott	GASPAR, J.C. 246	CT	Erv	AM, CE, CA, MA
Polygala longicaulis Kunth *	GASPAR, J.C. 292	CT	Sub	AM, CA, CE, MA, PA, PP
Polygala paniculata L.	GASPAR, J.C. 299	CT	Sub	AM, CA, CE, MA, PP
Polygala trichosperma Jacq.	GASPAR, J.C. 454	AA MC	Erv	AM, CA, CE, MA
Portulacaceae				
Portulaca grandiflora Hook. +	GASPAR, J. 225	CS	Erv	CA, CE, MA, PP
Rhamnaceae				
Sarcomphalus joazeiro (Mart.)Hauenshild *	GASPAR, J.C. 9, 210	C CT	Arv	CA, CE, MA
Rubiaceae				

Alibertia edulis (Rich.) A.Rich.	GASPAR, J.C. 319, 344	CT	Arv	AM, CE
Augusta longifolia (Spreng.) Rehder *	GASPAR, J.C. 240	CT	Sub	AM, CA, CE, MA
Borreria ocymifolia (Roem. & Schult.) Bacigalupo & E.L.Cabral	GASPAR, J.C. 52	CT	Sub	AM, CA, CE, MA
Borreria multiflora (DC.) Bacigalupo & E.L.Cabral	GASPAR, J.C. 54	CT	Erv	AM, CA, CE, MA PA, PP
Borreria spinosa Cham. et Schltdl.	GASPAR, J.C. 51	CT	Sub	CA, CE, MA, PP
Borreria verticillata (L.) G.Mey.	GASPAR, J.C 130, 215, 354, 379	AA CS CT	Sub	AM, CA, CE, MA, PA, PP
Borreria virgata Cham. & Schltdl. +^	GASPAR, J.C. 55	CT	Sub	MA
Chomelia obtusa Cham. & Schltdl.	GASPAR, J.C 235	CT	Arb	AM, CA, CE, MA, PA, PP
Chomelia ribesioides Benth. ex A.Gray	GASPAR, J.C. 315	CT	Arb	AM, CE, MA, PA
Cordiera myrciifolia (K.Schum.) C.H.Perss. & Delprete	GASPAR, J.C. 147	CT	Arb	AM, CA, CE, MA
Faramea nitida Benth. *	GASPAR, J.C. 2	CT	Arb	AM, CA, CE, MA
Guettarda viburnoides Cham. & Schltdl.	GASPAR, J.C. 265	CT	Arb	AM, CA, CE, MA
Hexasepalum radula (Willd.) Delprete & J.H. Kirkbr. +	GASPAR, J.C. 67, 121	CT	Sub	CA, CE, MA
Hexasepalum teres (Walter) J.H.Kirkbr.	GASPAR, J.C. 410	C	Sub	AM, CA, CE, MA, PP, PA
Machaonia acuminata Bonpl.	GASPAR, J.C. 234	C	Arb	CA, CE, MA
Palicourea colorata (Willd. ex Roem. & Schult.) Delprete & J.H.Kirkbr	GASPAR, J.C. 374	CT	Arb	AM, CA, CE, MA
Richardia grandiflora (Cham. & Schltdl.) Steud.	GASPAR, J.C. 277	CT	Sub	CA, CE, MA, PP
Tocoyena formosa (Cham. & Schltdl.) K.Schum.	GASPAR, J.C. 274	CT	Arb	AM, CA, CE, MA
Rutaceae				
Ertela trifolia (L.) Kuntze	GASPAR, J.C. 376	CT	Sub	AM, CA, CE, MA
Galipea trifoliata Aubl.	GASPAR, J.C. 442	C	Arv	AM, CA, CE
Salicaceae				
Casearia grandiflora Cambess.	GASPAR, J.C. 14	CT	Arv	AM, CA, CE, MA
Casearia javitensis Kunth	GASPAR, J.C. 37, 153	CT, AA CS	Arv	AM, CA, CE, MA
Casearia sylvestris Sw.	GASPAR, J.C. 7, 429	CT C	Arv	AM, CA, CE, MA, PP, PA
Santalaceae				
Phoradendron crassifolium (Pohl ex DC.) Eichler	GASPAR, J.C. 333	CT	Erv	AM, CA, CE, MA, PA, PP
Sapindaceae				
Cupania diphylla Vahl	GASPAR, J.C. 123	C	Arv	AM, CE
Cupania latifolia Kunth *	GASPAR, J.C. 320	CT	Arv	AM, CE
Magonia pubescens A.St.-Hil.	GASPAR, J.C. 6, 166, 205	C CT	Arv	AM, CA, CE
Serjania noxia Cambess.	GASPAR, J.C. 395	C	Lia	AM, CE, MA
Urvillea ulmacea Kunth	GASPAR, J.C. 138, 170	AA CS, MC	Lia	AM, CA, MA, PA, CE
Sapotaceae				
Pouteria reticulata (Engl.) Eyma	GASPAR, J.C. 3	CT	Arv	AM, CA, CE, MA

Smilacaceae				
Smilax cissoides Mart. ex Griseb. *	GASPAR, J.C. 156, 200, 217, 394	CT C	Lia	AM, CA, CE, MA
Solanaceae				
Solanum asperum Rich.	GASPAR, J.C. 422	AA MC	Arb	AM, CA, CE, MA
Solanum crinitum Lam.	GASPAR, J.C. 385	C	Arb	AM, CA, CE, MA
Solanum paludosum Moric.	GASPAR, J.C. 409	AA MC	Arb	AM, CA, MA, CE
Solanum palinacanthum Dunal	GASPAR, J.C. 416	AA MC	Arb	AM, CA, CE, MA, PP, PA
Trigoniaceae				
Trigonia nivea Cambess.	GASPAR, J.C. 444	C	Tre	AM, CA, CE, MA
Verbenaceae				
Lantana camara L.	GASPAR, J.C. 81, 300	CT	Arb	AM, CA, CE, MA, PA, PP
Violaceae				
Pombalia calceolaria (L.) Paula-Souza	GASPAR, J.C. 317	CT	Erv	AM, CA, CE, MA, PA
Pombalia oppositifolia (L.) Paula-Souza	GASPAR, J.C. 15	CT	Sub	AM, CA,CE, MA, PA
Vitaceae				
Cissus duarteana Cambess.	GASPAR, J.C. 13	CT	Lia	CE
Clematicissus simsiana (Schult. & Schult.f.) Lombardi	GASPAR, J.C. 27, 180, 208, 264, 351	CT MC	Lia	CA, CE, MA
Vochysiaceae				
Callisthene fasciculata Mart.	GASPAR, J.C. 309	CT	Arv	AM, CE, MA, PA
Qualea grandiflora Mart.	GASPAR, J.C. 12, 202, 232, 262, 352	C CS CT	Arv	AM, CA, CE, MA
Qualea parviflora Mart.	GASPAR, J.C. 162, 342, 335	CT	Arv	AM, CA, CE, MA
Ximeniaceae				
Ximenia americana L.	GASPAR, J.C. 163	CT	Arv	AM, CA, CE, MA