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Floristic patterns along the altitudinal gradient of dry forests on one of the world's oldest landscapes

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Abstract

Seasonally Dry Forests of South America are under threat. On the border of the Pantanal wetland in Central-Western Brazil, remnants of forests grow over the world's oldest landscapes. This is the first floristic treatment for a landscape spanning an altitudinal gradient in the Urucum uplands. We recorded 629 species from 395 genera and 96 families. The richest families were Fabaceae (87 species), Malvaceae (30), Euphorbiaceae (25), and Bignoniaceae (24). The richest genera were *Ficus* (9), *Aspidosperma*, *Eugenia*, and *Piper* (8). Most species were trees and shrubs (322). We observed deciduous forests below 400 m a.s.l. and semideciduous forests at 400–800 m a.s.l., with more epiphytes at higher altitudes. The semideciduous forest was similar to plateau gallery forests, suggesting it serves as a corridor for these species. Deciduous forests were more similar to those 250 km from Urucum than to adjacent semideciduous forests. The humidity gradient with altitude is the main driver of these differences. These forests are an essential component of the central South American Seasonally Dry Tropical Forests (SDTFs) species pool, harboring 70 species endemic to Mato Grosso do Sul. Despite their conservation value, they are increasingly threatened by mining and deforestation, emphasizing the urgent need for effective conservation actions.

Keywords: deciduous forest, legumes, Pantanal, semideciduous forest, vegetation ecology

Introduction

Tropical seasonally dry forests occur predominantly where annual rainfall is below 1600 mm, with a dry period of at least 5-6 months and total rainfall under 100 mm (Gentry, 1995; Graham & Dilcher, 1995; Pennington *et al.*, 2000; Pennington *et al.*, 2006). Such forests were recognised as a new vegetation unit in the Neotropics (Prado, 2000). These forests are subdivided into Seasonal Semideciduous Forests (SSF), which may lose 20 to 50% of their leaves during the dry season, and Seasonal Deciduous Forests (SDF), which may lose over 50% of their leaves during the dry season (IBGE, 1992). The SDFs are characterised by a strong presence of thorny species with pinnate

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leaves and/or photosynthetic and water-storing stems (Killeen *et al.*, 1998). They are mostly forests of small stature, generally related to the number of months with less than 200 mm of rain (Holbrook *et al.*, 1995). In central Brazil, SDFs occur scattered throughout the *cerrados*, the Brazilian savanna characterized by acid, dystrophic soils with high aluminum levels (Furley & Ratter, 1988). In contrast, SDFs generally grow on fertile soils with high base saturation and neutral to alkaline pH (Ratter *et al.*, 1978).

In South America, Seasonally Dry Tropical Forests (SDTFs) are discontinuous and fragmented in nuclei distributed in the form of an arc, named by Prado & Gibbs (1993) the Pleistocenic Arc, due to their possible origin in the Pleistocene and subsequent fragmentation in the Holocene, resulting from changes from a dry to a wet climate. These nuclei are: 1) *caatingas*; 2) Misiones, from Corumbá-MS in Brazil to Misiones in Argentina, part of Santa Catarina and of Paraguay; and 3) Piedemont, from Santa Cruz de La Sierra in Bolivia to Tucuman and the sierras of Catamarca in NW of Argentina (Prado & Gibbs, 1993). Besides these nuclei, there are disjunct patches in dry valleys in the Andes in Bolivia, Peru, Ecuador, and Colombia (Pennington *et al*., 2000). Such SDFs have been the object of various studies (Prado & Gibbs, 1993; Killeen *et al.*, 1998; Prado, 2000; Bridgewater *et al.,* 2003; Linares-Palomino *et al*., 2003). A high degree of endemism is attributed to SDFs, often derived from vicariance (Pennington *et al.*, 2004). This phenomenon resulted from habitat fragmentation following the return of a wetter climate in the Quaternary, preceded by dry periods at the end of the Tertiary and the beginning of the Quaternary (Pennington *et al.,* 2000; 2004).

SDTFs have been the theme of various scientific reports in South America, mainly in Southeastern Brazil (Cesar & Leitão-Filho, 1990; Custodio-Filho *et al*., 1994; Oliveira-Filho *et al*., 1994a; b; Salis *et al*., 1995; Oliveira-Filho *et al*., 1997; Oliveira-Filho *et al.,* 2001; Paula *et al.,* 2004; Oliveira-Filho *et al.,* 2006; Damasceno-Junior *et al.*, 2024). Occurring in fertile soils, they have been severely destroyed and are considered among the most threatened vegetation types in the Americas. They have lost more than 98% of their original cover in Central America (Janzen, 1988). From 1992 to 2020, in all of South America, the number of patches increased, and the size of these patches decreased, with a loss of over 152,000 km^2 (Rivas & Navarro-Cerrillo, 2024). Yet the SDTFs have been little studied and have only recently drawn the attention of researchers. In Brazil, SDTFs have been more studied lately in terms of floristic and structural aspects (Pedralli, 1997; Rodriguez & Araújo, 1997; Ivanauskas & Rodrigues,

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2000; Silva & Scariot, 2003; Damasceno-Junior *et al.,* 2009; Damasceno-Junior *et al.,* 2018), although they remain poorly known from some biogeographic (*e.g.*, Oliveira-Filho *et al.,* 2006), biological, and ecological perspectives (Rodrigues et al., 1989; Rodrigues & Shepherd, 1992 Salis 2000; Villers-Ruiz et al., 2003).

Emerging from the Pantanal wetland edge, west of the Paraguay River, ranges of hills with residual relief, such as Amolar, Conselho, and Urucum, host various areas of seasonal forests (Damasceno-Junior & Bezerra 2004; Damasceno-Junior *et al.*, 2009; 2018). The first reports upon the vegetation in this region were written by botanists who made collections, such as Riedel in 1825-1829, Manso in 1830-1839, Weddel in 1845, Spencer Moore in 1891, and Hoehne himself (Hoehne, 1923). The SDTFs are located near the Gran Chaco, a neighbouring vegetation domain that influences their flora. Prado *et al.* (1992) established the limits between STDFs and the Chaquenian vegetation in Mato Grosso do Sul. In addition to the influence of the Chaco, which can call attention to conservation efforts, this vegetation is also protected by the Brazilian Atlantic Rainforest law. Still, the application of this law to prevent deforestation is controversial, and implementing it is difficult for official organizations (Damasceno-Junior *et al.*, 2024). The region of the Urucum residual plateaus is recognised as one of the oldest landscapes in the world, dating back to chemical weathering that began approximately 70 million years ago (Vasconcelos *et al.*, 2019).

Some studies were performed for the characterization of STDF on the hills along the western border of the Pantanal (Bao *et al.*, 2018; Pott *et al.,* 2000; Ratter *et al*., 1988; Salis *et al.,* 2004; Urbanetz *et al.,* 2012); however, very few presented lists with species other than arboreal species (Juracy *et al*., 1999; Prance & Schaller, 1982). The available information remains scarce on these STDFs, as many studies in the region have identified species never cited (Pott *et al.,* 2000; Salis *et al.,* 2004; Takahasi & Meirelles, 2014; Lima *et al.*, 2019).

The Urucum uplands are under strong human pressure due to intense surface mining for iron ore, which removes the shallow soil and leaves sterile rejects. Around the hills, already, *ca.* 30% of the natural vegetation has been replaced by pastures or polyculture, and 15% is secondary vegetation (Pott *et al.,* 2000). On the foothill laterite, xerophytic cacti and bromeliads grow (Lima *et al.*, 2019; Takahasi & Meirelles, 2014). Nonetheless, the region offers a good opportunity for floristic studies, as it still preserves various intact areas and, moreover, exhibits a striking altitudinal variation,

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with the highest point of the State of Mato Grosso do Sul (Bortolotto *et al.*, 1999). The top is covered by grassland and cerrado (Neves & Damasceno-Junior, 2011). Some endemic plants occur there, *e.g.*, *Aspilia grazielae* U. Santos and *Discocactus hartmannii* (K.Schum.) Britton & Rose.

The floristic study of the SDTFs is biogeographically important, as these forests harbor a unique biota of closely related species with restricted or disjunct distributions across the Caatinga, the Central-West of South America, and the Andean-Caribbean region (Colli-Silva *et al.*, 2021; Pennington & Lavin, 2016). One of the main questions is whether these species, which nowadays occur in isolated patches, had a more widespread distribution in the past, or whether this is a product of long-distance dispersal (Branco *et al.*, 2024; Pennington *et al.*, 2010).

Our study aimed to conduct the first comprehensive floristic treatment for a threatened landscape along an altitudinal gradient in the Urucum uplands, in the Lagoa Negra basin, and its surroundings. In addition, the study aims to (1) verify whether species composition varies along the gradient; (2) to compare upland forests with adjacent seasonally flooded riparian forests and other nearby SDTFs; (3) to identify endemic and threatened species; and (4) to assess the conservation significance of the Urucum uplands.

Material and Methods

Study area

The main study area is on the hill Santa Cruz of the residual upland of Urucum, south of the towns of Corumbá and Ladário, on the border of the large Pantanal wetland. This upland range comprises the hills Urucum, Santa Cruz, São Domingos, Grande, Rabichão, and Tromba dos Macacos, and extends into Bolivia. The residual relief is from Tertiary tectonic movements, with iron and manganese rocks. On the tableland tops of the Santa Cruz hill lies the highest point (1065 m a.s.l.) of the State of Mato Grosso do Sul, with slopes between 20 and 40% (Okida & Anjos, 2000). The Urucum mountain massif is surrounded by lower, older limestone and near the Quaternary floodplain (at <100 m a.s.l.).

In general, the studied area is characterized by a dendritic-lateritic Pleistocene cover composed of conglomeratic sediments and talus deposits, with a predominance of iron-rich rocks from the Santa Cruz geological formation. Outcropping blocks and rolled

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boulders are frequent inside the forest. In the foothills, a lateritic encrustation forms under the influence of sedimentation from the hills and emerges along drainage lines (Brasil, 1982; Haralyi & Walde, 1986; Anjos & Okida, 2000; Lima *et al.*, 2019), which was not sampled here. The main soils are lithic, often eutrophic, with a chernozemic A horizon *ca.* 30 cm deep, directly on a rocky base, along the slopes, and eutrophic cambisol with a chernozemic A over an incipient B of medium texture, little gravelly, predominant on the plain (Spera *et al.*, 1997), and sometimes with ill-drained patches in the rainy season. Soil depth decreases upward on the hills.

The region's climate is tropical megathermal (mean temperature of the coolest month > 18 °C), with dry winters and summer rains, and is classified as Aw (savanna) under the Köppen classification (Soriano, 1997). In the 1975-1996 series, the mean annual temperature was 25.1ºC (21.4-27.7ºC); the mean maximum was 30.6ºC, with an absolute maximum of 40ºC between October and January; and the mean minimum was 21ºC, with an absolute minimum near 0ºC (Soriano, 1997). The annual average relative humidity was 76.8% (71.8-80.9%), with an average annual rainfall of 1070 mm. The rainiest period (68% of rainfall) occurred from November to March, while the driest period was from June to August, accounting for 7% of the total rainfall. The data are from the INMET (National Institute of Meteorology) weather station 20 km away, in Corumbá, at 141 m a.s.l. However, on the hills, microclimates occur, as we observed a logarithmic increase in rainfall with altitude along the studied altitudinal gradient (GA Damasceno-Junior, unpublished data; see supplementary material, Fig. S1).

The vegetation of the region is very variable, comprised mainly of seasonal forests (deciduous and semideciduous); rupestrian vegetation (cerrado grasslands and cerrado *lato sensu*) on the top of the hills; gallery forests of the streams from the upper parts of the hills; xerophytic vegetation of the lateritic foothills; riparian forests of the Paraguay river; floodable palm savanna (with *Copernicia alba* Morong) and aquatic vegetation of the lakes Negra and Arroz and riverine areas of the Pantanal wetland (Bortolotto *et al.*, 1999), besides deciduous forest on nearby limestone.

Data collection

The main sampling areas are located in the municipality of Ladário-MS, in the basin of Baía Negra lake (Figure 1). The altitudinal gradient in the region varies from 80 m to 1065 m a.s.l. (Okida & Anjos, 2000). Plant collections were made in five areas

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placed along this altitudinal gradient. The first point, at 100 m a.s.l., was placed in the ranch São Sebastião do Carandá, in an area of flood-free plain between the hills Santa Cruz and Rabichão (19º 06' 15.5" S; 57º 31' 12.5" W). The second was marked in the ranch São João, at 200 m a.s.l. (19º 11' 25.9"S; 57º 31' 46"W). The third and fourth were located in the ranch São Marcelo at 400 (19º 10' 58.5" S; 57º 35' 04.7" W) and 600 m a.s.l. (19º 11' 24.5"S; 57º 34' 52.5"W). The fifth area was established in the ranch Paraíso, at 800 m a.s.l. (19º 11' 50.9"S; 57º 36' 0.3"W). (Figures 1 and 2).

In addition to the chosen areas, we made complementary collections along access trails and roads, on the northern slopes of the hills, and in the dryland surroundings, also in the municipality of Corumbá (Figure 1). We excluded the species of the Paraguay River floodplain that had already been reported (Damasceno-Junior, 1997). Since we were interested only in SDTFs, we also excluded species from open vegetation (cerrado grasslands and lateritic foothills) as well as those from *cerrado lato sensu*. The inventory covered the SDF and SSF species found between the Pantanal wetland and the savanna tops of the Urucum hills.

We collected all phanerogamic species of trees, shrubs, herbs, climbers (including voluble herbs and lianas), epiphytes, parasites, and hemiparasites found to be fertile within the forests. Collections were made at fortnightly intervals in 2001 and 2002. We also updated the list with previous and more recent collections made in the area, which are deposited in the herbaria COR, CGMS, and CPAP, as well as other recent records registered in SpeciesLink (Canhos *et al.*, 2022) and Flora e Funga do Brasil (2026). We also added the species found during a phytosociological survey (G. A. Damasceno-Junior, unpublished data). Exotic and ruderal species were not included. The collected samples were pressed and dried using standard botanical procedures (Fidalgo & Bononi, 1989), then mounted, labeled, and stored in the Herbarium COR. Duplicates were sent to the herbaria CPAP, CGMS, E, HUFU, and UEC. Abundance data were not added here because the main objective of this study was taxonomic completeness. Also, we listed additional Fabaceae (Rodrigues Silva *et al.*, 2007), Bromeliaceae (Fernandes, 1999), and Orchidaceae (Rodriguez *et al.*, 2009) from the same area.

Species were identified by consulting bibliographies and botanists from the Department of Botany at UNICAMP, visiting the herbaria COR, CPAP, E, ESA, HRCB, SPF, SP, NY, UEC, and USZ, and sending vouchers to specialists. The scientific names and

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families were updated using Flora e Funga do Brasil (2026), with assistance from the Flora package in R (Carvalho, 2013).

The Venn Diagrams were performed using the R package VennDiagram (Chen, 2022). In the data analysis, we compared the flora of the sampled SSF and SDF with that of the adjacent riparian forest along the Paraguay River (Damasceno-Junior, 1997). The comparisons between the researched flora and nearby floras were performed using the list of species of Las Trancas (Killeen *et al.*, 1998) and Serra da Bodoquena National Park (Damasceno-Junior *et al.*, 2024). We included only tree and shrub species to perform the similarity by using the Jaccard index and the UPGMA grouping method. All these analyses were carried out using the Vegan package in the R environment (Oksanen *et al.*, 2019).

Results

We registered 629 botanical species, 395 genera, and 96 families (Table S1). Most species were identified, except two at the subfamily level and 11 at the genus level (Figure 3). The family with the highest number of species is by far Fabaceae with 87 species, followed by Malvaceae (30), Euphorbiaceae (25), Bignoniaceae (24), Orchidaceae, and Sapindaceae (22), Asteraceae (20), Poaceae (19), Convolvulaceae, Malpighiaceae, and Rubiaceae (18), Apocynaceae (16), and Bromeliaceae (13). The richest genera were *Ficus* L. (nine spp.), *Aspidosperma* Mart. & Zucc., *Eugenia* P. Micheli ex L., and *Piper* L. (eight each), *Ipomoea* L., *Serjania* Plum. ex Schumach., *Tillandsia* L., and *Trichilia* P. Browne (seven each), and *Bauhinia* L., *Machaerium* Pers., *Mimosa* L., and *Senegalia* Raf. (six each).

Trees, treelets, shrubs, and palms are the majority, totaling 323 species (51.2%). Herbs and subshrubs comprised 136 species (21.6%), whereas climbers, epiphytes, and parasites comprised 129 (20.4%), 33 (5.2%), and six (1%) species, respectively (Figure 4). Regarding trees, treelets, and shrubs, the richest families were Fabaceae (64 species), Euphorbiaceae (18), Malvaceae (17), Rubiaceae (16), Myrtaceae (12), Asteraceae (11), and Moraceae (10). For herbs and subshrubs, the richest families are Poaceae (19), Malvaceae (13), Acanthaceae (10), Asteraceae, Cyperaceae, and Fabaceae (seven each), Amaranthaceae and Commelinaceae (five species each). The richest families of climbers are Bignoniaceae (17 spp.), Fabaceae (16), Malvaceae (15), Convolvulaceae (14), Sapindaceae (13), and Cucurbitaceae (eight spp.). Among the

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epiphytes, Orchidaceae stands out with 17 species and Bromeliaceae with nine. The hemiparasites belong to Loranthaceae (three spp.), Santalaceae (two), and a single Balanophoraceae species (Table S1).

The survey also documents two species that were unknown at the beginning of the fieldwork: *Serjania chacoensis* Ferrucci & Acev.-Rod. (Sapindaceae) (Ferrucci and Acevedo-Rodríguez, 2005) and *Muellera variabilis* (R.R.Silva & A.M.G.Azevedo) M.J.Silva & A.M.G.Azevedo (Fabaceae), originally described as *Lonchocarpus variabilis* R.R.Silva & A.M.G.Azevedo (Rodrigues Silva and Tozzi, 2008) (Table S1). These two species are endemic to the Urucum hills and to San Miguel Cerro in Bolivia, a similar hill. Another novelty is the new occurrence of *Stigmaphyllon jatrophifolium* A.Juss., with previous records in South Brazil (Forzza *et al.*, 2010), Argentina, and Paraguay (SpeciesLink – Canhos *et al.*, 2022); and *Vasconcellea glandulosa* A.DC., previously known in Mato Grosso, Goiás, Acre, and Maranhão (Flora e Funga do Brasil, 2026). There is also a new subspecies of *Qualea glaziovii* Warm. not yet described (Table S1). In addition, 70 species or subspecies are cited in Flora e Funga do Brasil only in Mato Grosso do Sul (44 species) or in Mato Grosso do Sul and another state in Brazil (26 species) (Table 1).

Considering the different altitudes in the studied area, we observed two large vegetation groups distributed along the altitudinal gradient: one of seasonal deciduous forest (SDF), of lowlands and submontane, up to approximately 300 m a.s.l., and another of seasonal semideciduous forest (SSF), submontane and montane, from 400 to 800 m a.s.l. The SDF shows candelabra-like *Cereus bicolor* Rizzini & A.Mattos, bottle trees, and spiny understory. The SSF shares some species with the cerrado woodland, including *Blepharocalyx salicifolius* (Kunth) O.Berg*, Protium heptaphyllum* (Aubl.) Marchand*,* and *Qualea cryptantha* (Spreng.) Warm. Above this belt of vegetation, there is a transition to a cerrado vegetation over rocky soils (Cerrado rupestre). Some species are very easily found in these forests, such as *Guarea guidonia* (L.) Sleumer, *Guapira areolata* (Heimerl) Lundell, and *Myrciaria floribunda* (H.West ex Willd.) O.Berg. On the adjacent São Domingos hill, a similar zonation of arboreal species is observed between 100 and 500 m a.s.l. (Urbanetz *et al.,* 2012). In overall floristics, both large groups of vegetation types show differences in the number of species per growth habit. The proportions of tree-shrubs/herbs/subshrubs are similar in both formations (Figure 4). In SDF, there are 52% trees, shrubs, and palms, and in SSF, 54%. The proportion of climber species is higher in SDF (22%), reaching 16% in SSF (Figure 4). On the other hand, the number of

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epiphytes and hemi-epiphytes is higher in SSF (8,6% compared with only 1,8% in SDF), which are found mainly at higher altitudes. The parasites were observed only in SDF (Figure 4).

When we compare the tree/shrub and liana species found in our study with those reported by Damasceno-Junior (1997) in the riparian forest of the Paraguay River, we observe low habitat overlap (Figure 5). For trees, we observe a higher proportion of species in SDF and SSF (14%). Few species are shared between the riparian forest and the SDF and SSF of the hills (2% and 3%, respectively). From 350 tree, shrub, and palm taxa, only seven species are common to all three forest formations (SDF, SSF, and riparian forest - RF), 13 species are common between SDF and RF, and 16 species are common between SSF and RF (Figure 4). Most of the species were exclusive to each environment. For trees and shrubs, 40% are exclusive to SDF, 29% to SSF, and 11% to RF. Regarding climbers, no species are common to all forest formations. Only three species are common between RF/SDF and RF/SSF (Figure 5). Seventeen species of climbers (10%) are common between SSF and SDF (Figure 5). 41% are exclusive to SDF, 19% to SSF, and 27% to RF.

We found that the deciduous forests (below 400 asl) are more similar to the forests of Bodoquena National Park (J = 0.23) and Chiquitania forests in Bolivia (J = 0.22) than to adjacent semideciduous forests (J = 0.17) (Figure 6). On the other hand, the riparian forests and the SSF differ from one another and are probably similar to other semi-deciduous forests in the region (Figure 6).

The researched area includes 96 species listed in the Red List as endangered (Brasil, 2022; Flora e Funga do Brasil, 2026). Most are Least Concern (77), and three are in the DD category (Table 1). Six species are vulnerable (VU); five species are Near Threatened (NT), and +five are endangered (EN) (Table 1).

Discussion

Our study unveiled a striking richness of legumes for the area. Another study also showed legumes as the richest on the nearby São Domingos hill (Urbanetz *et al.,* 2012). Gentry (1995) had already reported that Fabaceae was the most diverse family across various Neotropical seasonal forests. The high number of legumes, however, was likely enhanced by a targeted collection effort (Rodrigues Silva *et al.*, 2007; Rodrigues Silva & Tozzi, 2012). The reasons why the Fabaceae are successful in dry environments are not

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completely understood, but evidence such as the ability to obtain nitrogen through association with *Rhizobium* bacteria in root nodules; association with endophytic bacteria in the rhizosphere that promotes drought resistance; and the ability to close the leaflets during the night, reducing water loss, certainly are important adaptations (Feng *et al.*, 2022; Petrushin *et al.*, 2023). Other rich families, such as Euphorbiaceae, Rubiaceae, and Myrtaceae, which we recorded, also figure among the richest in various inventories of Neotropical SDFs and SSFs (Gentry, 1995; Ivanauskas & Rodrigues, 2000; Killeen *et al.*, 1998; Rodrigues & Araújo, 1997). However, some outstanding families, such as Apocynaceae and Moraceae, were not so rich in our survey, though they figured among the most numerous woody species in an SDF in the State of Goiás (Silva & Scariot, 2003). We recorded most of the frequent trees of low altitude and many of high altitude tropical seasonal forests cited for Central-West Brazil, and also the general SDF supertramp species listed by Oliveira-Filho *et al.* (2006). Nonetheless, the absence of the generally common wide-range species of *Balfourodendron*, *Calophyllum*, *Copaifera,* and *Ocotea* (Oliveira-Filho *et al.,* 2006) seems odd, perhaps missed due to restricted, hidden habitats. Notably, Capparaceae, typical of tropical arid environments (Mercado Gómez, 2020), showed a large number of species, attributed to limestone outcrops. A few species of Chaco SDF flora occurred on calcareous soils, *e.g. Aspidosperma quebracho-blanco* Schltdl., *Gonopterodendron sarmientoi* (Lorentz ex Griseb.) A.C.Godoy-Bürki., *Cappariocordis tweediana* (Eichler) Iltis & Cornejo, *Diplokeleba floribunda* N.E.Br., *Geoffroea spinosa* Jacq., *Libidibia paraguariensis* (D.Parodi) G.P.Lewis, *Melicoccus lepidopetalus* Radlk. and *Microlobius foetidus* subsp. *paraguensis* (Benth.) M.Sousa & G.Andrade. These trees also occur in the Bolivian Chiquitano SDF (Jardim *et al.,* 2003).

The second most important component of the studied vegetation is the lianas represented by Bignoniaceae, Sapindaceae, and Malpighiaceae, which is congruent with various inventoried seasonal forests (Damasceno-Junior *et al.,* 1999; Gentry, 1995; Killeen *et al.,* 1998; Morellato *et al.*, 1996; Solórzano *et al.,* 2002). Although species composition differed, Fabaceae, Bignoniaceae, and Malpighiaceae were also among the richest families in the nearby riparian forest inventoried by Damasceno-Junior (1997), except for Sapindaceae. Pott *et al.* (2000), based on collections of the Herbarium CPAP and the checklist compiled by Dubs (1998), reported 937 species across the entire hilly area, and the richest families are similar to those in our records. The main difference is

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that these authors included the Cerrado rupestre vegetation at the higher part of the Urucum residual plateau. On the Urucum tops, Poaceae predominate, and the richest family was Convolvulaceae rather than Bignoniaceae, as found in our records.

Regarding the total number of species, independent of altitude, the proportions of species per growth habit differ slightly from those found in other seasonal forests in the region. Damasceno-Junior *et al.* (1999) reported proportions of 72% for trees, 20% for lianas, and 7.4% for epiphytes, parasites, and herbs, excluding herbs from the edges of forest islets in the subregion of Abobral in the Pantanal. In nearby riparian forests, Damasceno-Junior (1997) found 59.7% trees and 38.9% lianas, and the proportion of lianas dropped to 25% when including the aquatic and herbaceous species. Killeen *et al.* (1998) found 434 species in a floristic study of a seasonal forest in Las Trancas, Bolivia, where trees and shrubs accounted for ca. 44% of the species, lianas for 29%, herbs for 23%, epiphytes and hemi-epiphytes for 3.5%, and parasites for 0.5%. Our distinct results, compared with those reported proportions, can be attributed to the floristic heterogeneity of our study area, which is likely related to different edaphic conditions, such as the shallow soils of the Urucum region.

When we consider the low-altitude SDF separately from the SSF at higher altitudes, the differences are mainly observed in lianas, epiphytes, and parasites (Figure 2). The proportions of climbing species for the SDF on the lower altitudinal gradient are similar to those found by Damasceno-Junior (1999) and Araújo (2001) in seasonal forest islets in the Pantanal, whereas for higher areas, such proportions (13%) are closer to those reported by Ratter *et al.* (1978) on Serra do Roncador, Amazon *terra firme* forest.

The differences in the proportions of lianas and epiphytes reflect moisture variation along the studied gradient, as rainfall increased logarithmically with altitude on the Urucum hills (Damasceno-Junior, unpublished data, Fig. S1), and air humidity (dew) was more condensed due to the orographic effect. Many of the epiphytes we cited had been recorded by Rodriguez *et al.* (2009) and Fernandez (1999), who found more species of Orchidaceae and Bromeliaceae at higher altitudes (>400 m) of the Urucum hills. Epiphytes are not abundant in local lowland SDFs, but herbs and subshrubs are more numerous than under closer canopy SSFs. A trend of decreasing liana richness with increasing altitude was also observed in SDFs in Mexico (Vásquez & Givnish, 1998) and in India (Parthasarathy *et al.*, 2004). The reasons for this phenomenon are unclear

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and may be related to the fact that most lianas are wind-dispersed and tend to have fewer species per available area in insular habitats or functional isles (McArthur & Wilson, 1967; Gentry, 1988), as in the studied hills. An additional factor is that lianas benefit from better light availability (Gentry, 1991), as seen in low-altitude SDF, which can lose almost 90% of its leaves during the dry season, providing more open environments (GADJ Pers observation). The increase in humidity along the altitudinal gradient favors zoochorous trees, and most of our climbing species were anemochorous.

Similarly, Vásquez & Givnish (1998) also found a trend toward increased epiphyte richness, particularly at intermediate altitudes along the gradient (the transition zone between vegetation types), and a constant increase in epiphyte richness due to a reduced number of arboreal species. A similar pattern was found by Hietz & Hietz-Seifert (1995) in SDF in Mexico, characterized by a great richness of Orchidaceae and Bromeliaceae at approximately 1400 m a.s.l. In our work, we failed to assess quantitative data to evaluate this pattern; however, in the field, we observed a zonation that is partly similar to that described by Hietz & Hietz-Seifert (1995). We found that most epiphytic Bromeliaceae species in SDF were located in the lower portion of the gradient, whereas Orchidaceae species were found in the upper portions (see Rodriguez *et al.,* 2009). Such differences are primarily associated with increased humidity at higher altitudes, as epiphytes, such as Bromeliaceae and Orchidaceae, are adapted to capture airborne moisture through various strategies (Smith & Downs, 1974). The Bromeliaceae, especially Tillandsioideae, are more efficient at getting humidity from drier environments. In the study area, Bromeliaceae diversity in SDF is mainly represented by *Tillandsia* spp., with the small *Tillandsia loliacea* Mart. ex Schult. & Schult.f. (5 cm) as the most common. This group occurred in habitats with more species, where air humidity was probably higher, such as those close to the Paraguay River or near the large lakes of the Pantanal, and on slopes where the cool fronts reach first and tend to stay longer, with more clouds and even mist (pers. obs.). The diversity of bromeliads is higher in SDF because they may need more light than Orchidaceae.

The floristic differences observed between the surveyed habitats and the nearby riparian forest of the Paraguay River are likely related to flooding, which exerts a strong filter on vegetation (Damasceno-Junior *et al.*, 2005) and fertility gradients. The riparian forest is under a very specific flooding regime: the rainy period coincides with the lowest levels of the Paraguay River's annual hydrological cycle, and the dry period

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(without rain) coincides with the annual flood, delayed by the very low north-south declivity (Damasceno-Junior *et al.*, 2021). This lagged flooding creates a peculiar condition of water deficit in the riparian forests, or, when it occurs, only for a short time. A few meters above the level of flooding influence, an abrupt transition to the SDF occurs, characterized by the lowest number of tree and liana species in common with the riparian forests. The SSF between 400 and 800 m a.s.l., although distant from the riparian forest, had a higher number of shared tree species. That is probably because higher areas of the gradient have better moisture conditions than the low-lying SDF. Most likely, the species common to the riparian forest and the SSF reached higher altitudes via gallery forests along the creeks on the hills. The observation indicates that many SSF species at higher altitudes were also collected in gallery forests along creeks (Table S1), *e.g.*, along the Bandalta Creek. Thus, gallery forests could function as corridors for species that require wetter conditions to reach higher altitudes or cross dry areas. More headwaters, larger creeks, and denser forests occur on the southwest slope (where we mostly worked) because the surface and the underlying rocky strata dip slightly in that direction.

Some of the recorded species are on the official Brazilian Red List of Threatened Species (Brasil, 2022): *Begonia perdusenii* Brade, *Cedrela fissilis* Vell., *Neptunia pubescens* Benth., *Trichilia stellato-tomentosa* Kuntze, and *Thryallis laburnum* S.Moore. A total of 16 species are in categories that require attention from authorities due to their demand for deforestation, primarily because their soils are rich. These include endemic plants such as *Aspilia grazielae* J.U.Santos, *Bromelia sylvicola* S.Moore, *Fosterella hatschbachii* L.B.Sm. & Read, *Mimosa sensibilis* var. *urucumensis* Barneby, and *Muellera variabilis* (RR.Silva & AMG.Azevedo) M.J.Silva & AMG.Azevedo (Flora e Funga do Brasil, 2026). Another important aspect of our work is the discovery of new species and the recording of new records for the State of Mato Grosso do Sul. Many new, endemic species were recently described for the vicinity, such as *Dimerostemma pantanalense* D.D.M.Mendes & A.M.Teles (Mendes *et al.*, 2024).

Although botanists have already explored this region, there may still be species unknown to science that can be found if collection programs continue. Moreover, the affinities of this vegetation are of particular interest. The neighboring semideciduous and deciduous vegetation are so different that the deciduous forests here are more similar to Las Trancas and Bodoquena National Park than to the adjacent forests (Figure

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6), even though these two areas are 250 to 300 km away. The combination of intense seasonal drought stress and very fertile soils is very similar to that in Urucum, Las Trancas, and Bodoquena Hills. We believe that these floras, with some regional particularities, form a strong pull of deciduous forests. Their conservation is essential because the soils are under pressure due to the opening of new areas for agriculture and mining. In the region, iron and limestone are extracted in the Bodoquena and Urucum hills. Although the Bodoquena National Park is an important protected area for this vegetation type, the vegetation of the Urucum hills presents particularities that deserve attention, such as endemic species found only there, in Bolivia and/or Paraguay, including *Capparidastrum coimbranum* (Cornejo & Iltis) Cornejo & Iltis, *Opuntia retrorsa* Speg., and *Libidibia paraguariensis* (D.Parodi) G.P.Lewis. Some of the researched areas no longer exist due to agricultural expansion and mining activities. Given that the region contains only one protected area encompassing this forest type and harbors a unique species assemblage, establishing a new protected area should be considered. The region is one of the world's most ancient landscapes (Vasconcelos *et al.*, 2019), has many endangered and unique species, and is under intense pressure from deforestation caused by iron mining at the soil level, which involves vegetation suppression.

Despite being within the Cerrado and Pantanal, the Serra da Bodoquena plateau and the present study area are considered inland Atlantic Forest by Brazilian law, with many species of this domain (Damasceno-Junior *et al.*, 2024), as depicted by Ramos *et al.* (2008). The Brazilian Atlantic Forest law (Brasil, 2006) forbade clearing the Atlantic Forest, which was being converted to cultivated pastures, now being converted to soybean and corn.

The flora presented here, especially the deciduous one, also has many affinities with those floras of Chaco and Caatinga. Some elements found in this study are common to Caatinga, such as *Amburana cearensis* (Allemão) A.C.Sm., *Commiphora leptophloeos* (Mart.) J.B.Gillett, *Anadenanthera colubrina* (Vell.) Brenan, and *Aspidosperma pyrifolium* Mart. & Zucc.. They are important elements that mark the affinities of the Pleistocene arc (Prado & Gibbs, 1993). The Chaco vegetation is also well represented in the study area, with *Copernicia alba* Morong, the most characteristic element of the humid Chaco, as well as other species such as *Microlobius foetidus* ssp. *paraguensis* (Benth.) M.Sousa & G.Andrade, *Reichenbachia hirsuta* Spreng, *Bougainvillea infesta* Griseb, and *Urvillea chacoensis* Hunz. The Chaco species are more easily found in lower areas where the soils

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are clayey and waterlogged during the rainy season (G.A. Damasceno-Junior, pers. obs.). These affinities must be considered in deciding to create protected areas in the region, as they are part of this corridor that connects the two main dry vegetation zones of South America. Besides, the Bolivian Chiquitania SDFs, interconnected via the Amolar range with our study area, experienced one of the most intense and rapid deforestation rates to date (Steininger *et al.,* 2001), which has worsened over time.

Although this study is based on qualitative floristic data rather than quantitative sampling, it provides the most comprehensive inventory currently available for the seasonal forests of the Urucum uplands, compiling records accumulated over decades of botanical exploration. Given the extent of the region and the relatively limited sampling effort in some areas, additional species are likely to be documented in future surveys. Nevertheless, the remarkable floristic richness and heterogeneity observed across geographically close forest types, together with the high number of endemic, threatened, and regionally restricted species, clearly demonstrate the outstanding conservation value of these forests.

The surveyed seasonal forests occur on fertile soils that are increasingly threatened by agricultural expansion and mining, including on steep slopes where vegetation clearing should not occur. Conservation planning for the region should therefore recognize the ecological distinctiveness of these lower-elevation seasonal deciduous forests, rather than assuming that protected areas located at higher elevations can compensate for their loss. This recommendation also applies to the seasonal forests of the Serra da Bodoquena. Moreover, the Bolivian Chiquitano Seasonally Dry Tropical Forests, connected to the Urucum region through the Amolar range, have experienced one of the highest deforestation rates recorded for this ecosystem (Steininger *et al.*, 2001), a trend that has intensified over time. Together, these findings emphasize the urgency of strengthening conservation policies and expanding the network of protected areas to safeguard the unique biodiversity of the seasonal forests in the Central West of Brazil, which are considered part of the Atlantic rainforest complex in the Brazilian context.

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Author's Contributions

GADJ conceived the work and designed it. GADJ collected the data, organized it, and wrote the paper; AP, IMB, RHS, and IHI collected the data and wrote the paper.

Conflict of Interest

The authors declare no conflict of interest.

Data Availability Statement

All data sources and materials analyzed in this work are cited in the text and additonaly files.

AI Usage Statement

The artificial intelligence tool ChatGPT, was used to correct scripts during the analysis in the R program.

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Supplementary Material

The following online material is available for this article:

Table S1 - Checklist of plant species recorded in forested areas of the Urucum uplands and surroundings, Baía Negra lake basin, Ladário and Corumbá, MS, Brazil (SDF = Seasonal Deciduous Forest; SSF = Seasonal Semideciduous Forest; GF = gallery forest; DA = Disturbed area; EA = Endangered status; Herb no = Herbarium where the plant is

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deposited with respective herbarium code. Main Collector number: **GADJ** = Geraldo A Damasceno-Junior; **AP** = Arnildo Pott, **VJP** = Vali Joana Pott, **CAC** = Claudio Almeida Conceição; **R** = J.A. Ratter; **RRSilva** = Rosilene Rodrigues Silva; **DPR** = Diogenes Parabá Rodriguez; **IMB** = Ieda Maria Bortolotto. Aditional collectors: **ACA** - Antônio da Costa Allem; **AT** – Adriana Takahasi; **TCA** – Tereza Cristina Assis; **AEB** – Ana Elisa Brina; **FJMC** – Francisco José Machado Caporal; **CCRB** – Cecilia Baracat; **DS** - Arthur Algernon Dorrien-Smith; **EM** – Efigênia de Melo; **EP** – Edmundo Pereira; **F** – Rafaela Campostrini Forza; **FCS** – Francisco das Chagas e Silva; **FILG** – Tarcisio de Souza Filgueiras; **FMAl** – Flávio Macedo Alves; **H** – Hoehne; **Ishii** – Iria Hiromi Ishii; **Jacques** – Eliane de Lima Jacques; **JPC** - Jailton Pessoa Costa; **MSL** – Michele Soares Lima; **MDM** – Marta Dias de Moraes; **MPS** – Marta Pereira da Silva; **N** - Larry R. Noblick; **NCBueno** – Norma Catarina Bueno; **RHSilva** – Rosa Helena da Silva; **Salis** – Suzana Maria de Salis; **SAVianna** – Suelen Alves Vianna; **SGR** – Saulo G. Resende; **SYB Silva** – Simone Yara Benites Silva; **Twendt** – Tânia Wendt; **Valls** – José Francisco Montenegro Valls**; W** - Grady L. Webster.).

Figure S1. Total precipitation along the altitudinal gradient of the Urucum Plateau between June 2002 and May 2003 at five points.

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Figure and Table Captions

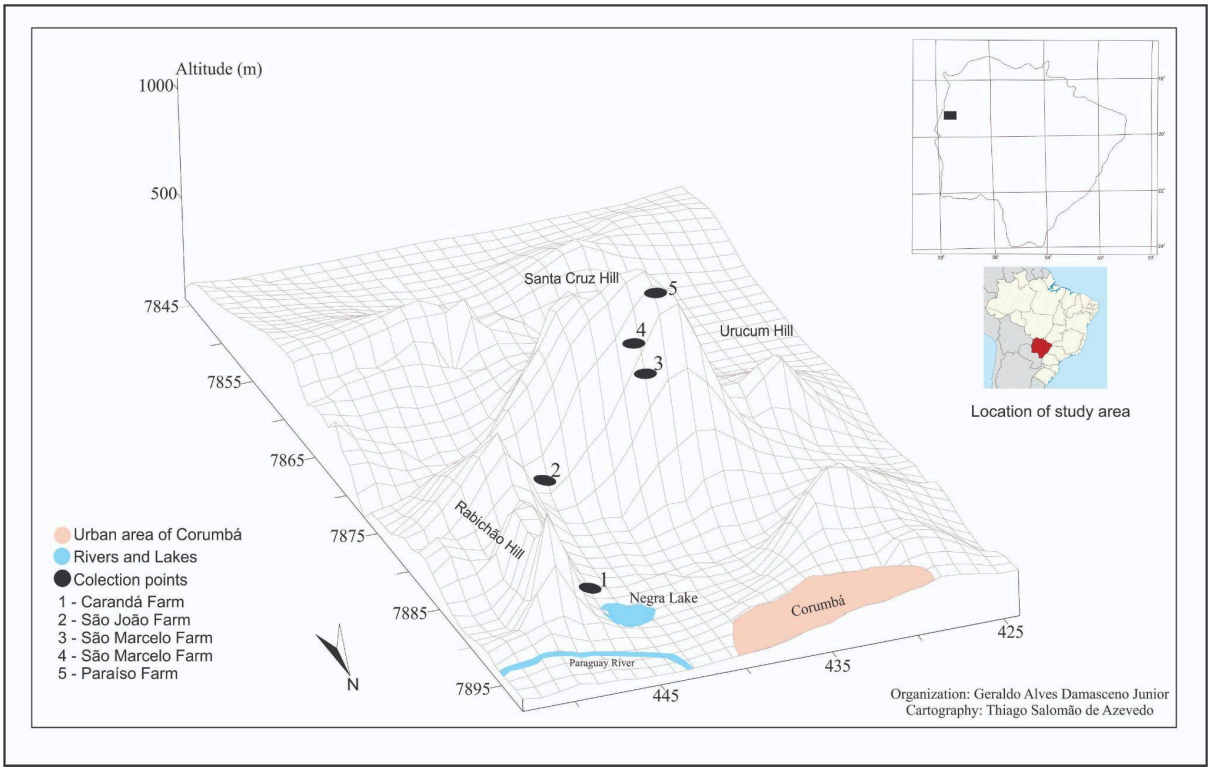

Figure 1. Location of the studied area with the main point of collection at different altitudes of the residual plateau of Urucum in Corumbá and Ladario municipalities. **Point 1** was located in the São Sebastião do Caranda Farm at 100m a.s.l.; **Point 2** in the São João Ranch at 200 m a.s.l.; **Point 3 and 4** in the São Marcelo Ranch at 400 and 600 m a.s.l respectively; **Point 5** in the Paraiso Ranch at 800 m a.s.l.

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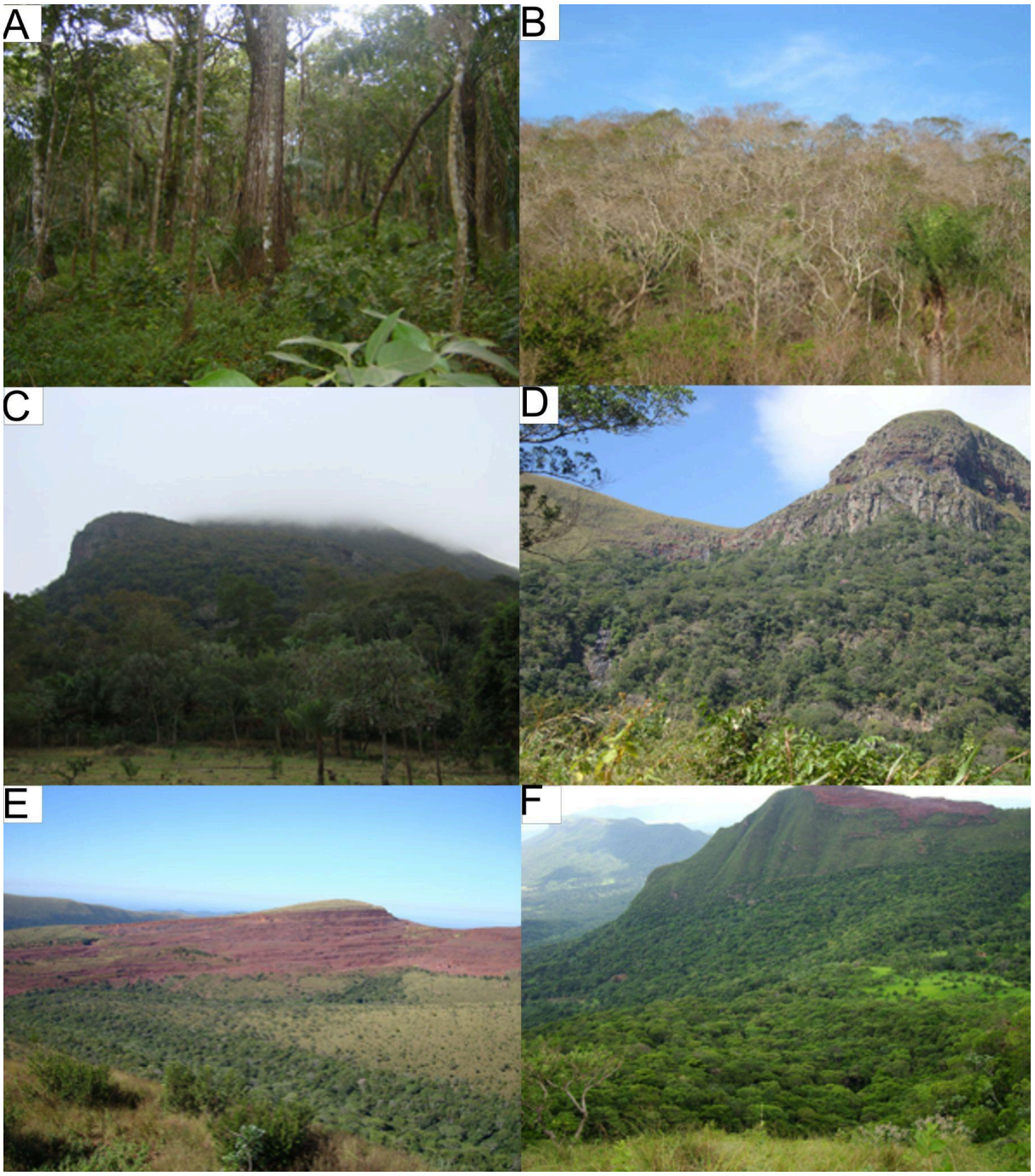

Figure 2. Vegetation of the Urucum residual plateau. **A** Semideciduous forest at 600 m a.s.l; **B** Deciduous forest at 100 m a.s.l.; **C** The entire gradient showing the clouds that promote the orographic rain; **D** Semideciduous forest at Paraiso Ranch; **E** Mining activity in the Cerrado vegetation at the top; **F** Mining activity and the semideciduous forest.

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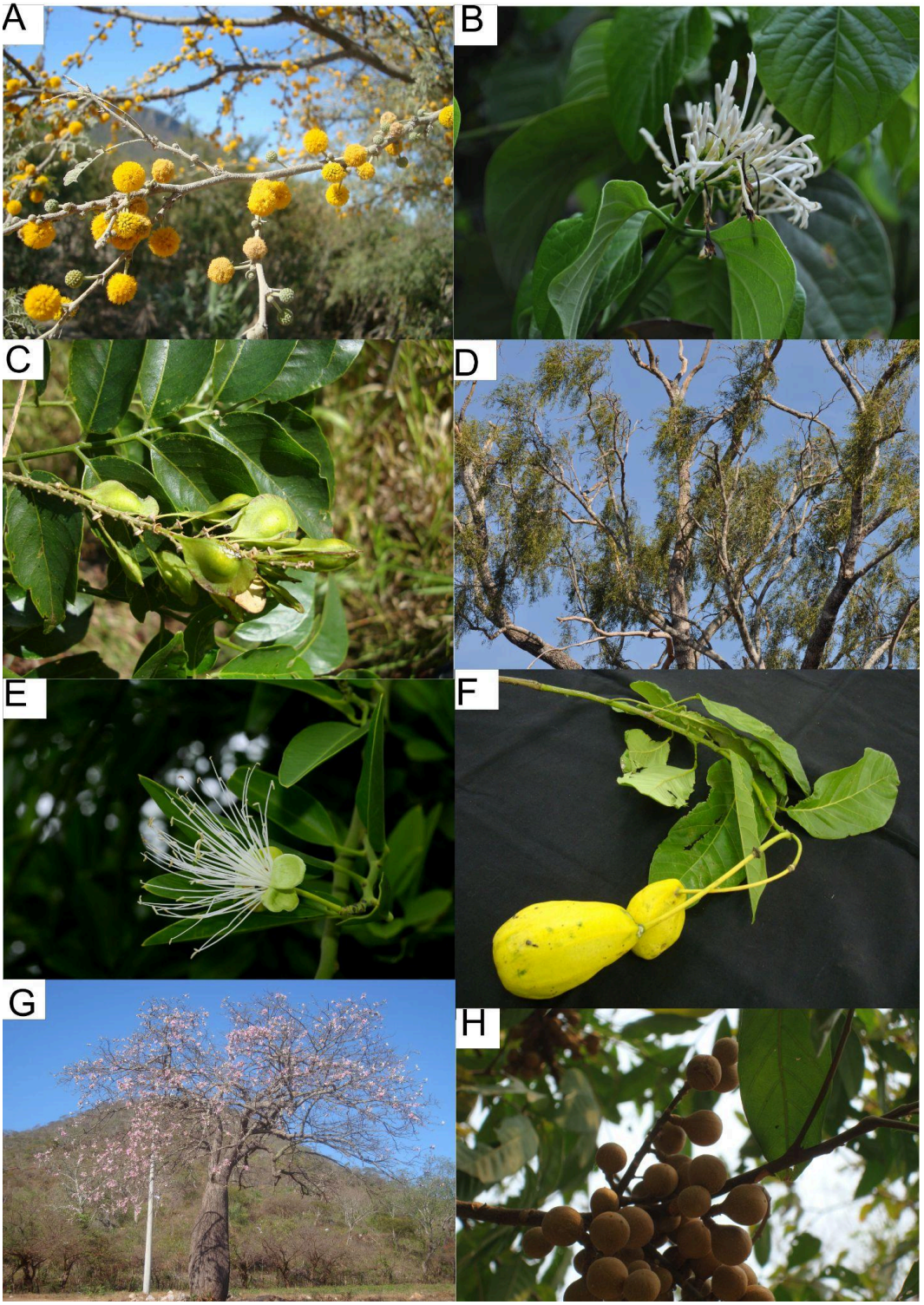

Figure 3. Some species from the altitudinal gradient at Urucum residual plateau, Corumbá and Ladário, MS. **A** *Vachellia farnesiana*, **B** *Coussarea hydrangeifolia*; **C** *Ateleia guaraya*, **D** *Aspidosperma quebracho-blanco*, **E** *Anisocapparis speciosa*, **F** *Capparidastrum coimbranum*, **G** *Ceiba pubiflora*, **H** *Guarea guidonia*.

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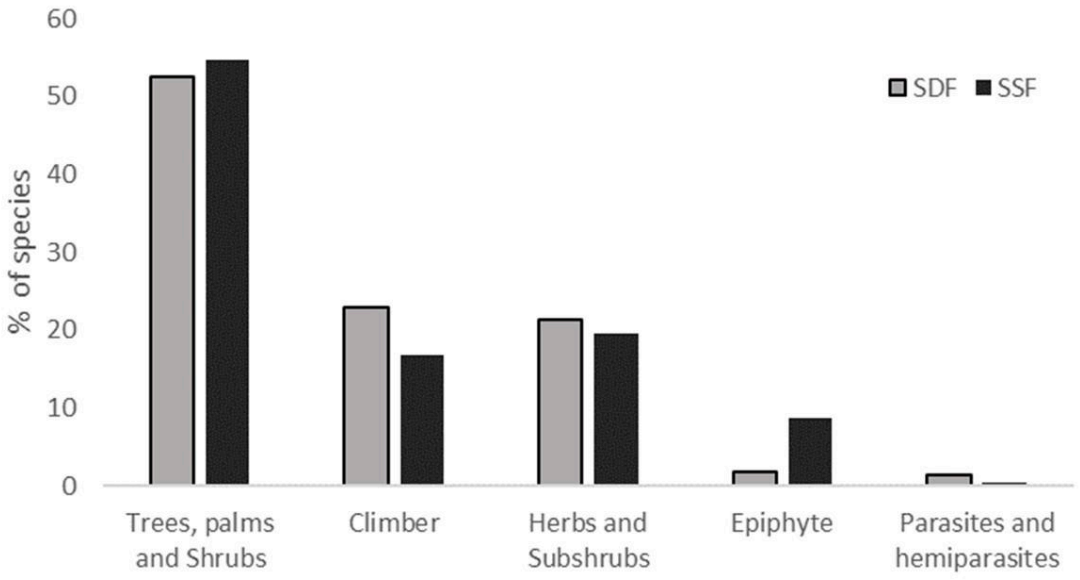

Figure 4. Percentage of the total number of species for each forest of different growth habits in the seasonal deciduous (SDF) and semideciduous forests (SSF) of Urucum hills, basin of the lake Lagoa Negra, and surroundings, Ladário and Corumbá, MS.

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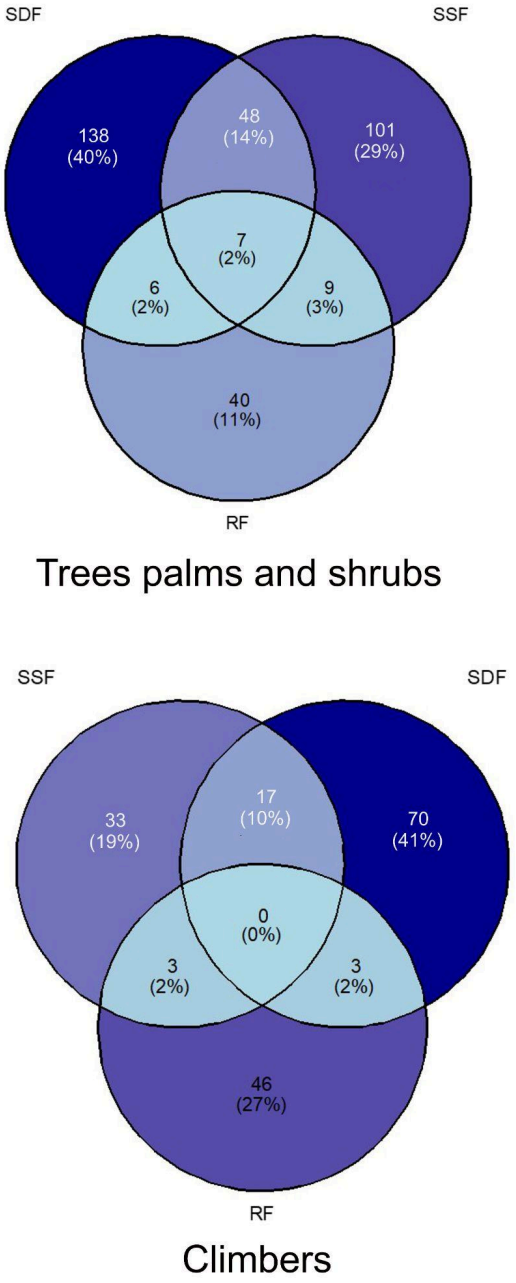

Figure 5. Number of trees and shrubs (upper) and climbers (down) shared by three vegetation types situated in the basin of Baía Negra lake, between the floodable riparian forest of the Paraguay river (Damasceno-Junior, 1997) and the upper limit of the forest vegetation (deciduous and semideciduous forest) along the altitudinal gradient of the Urucum hills surroundings, Ladário and Corumbá, MS. [Seasonal Deciduous Forest, Seasonal Semideciduous Forest, Riparian Forest]

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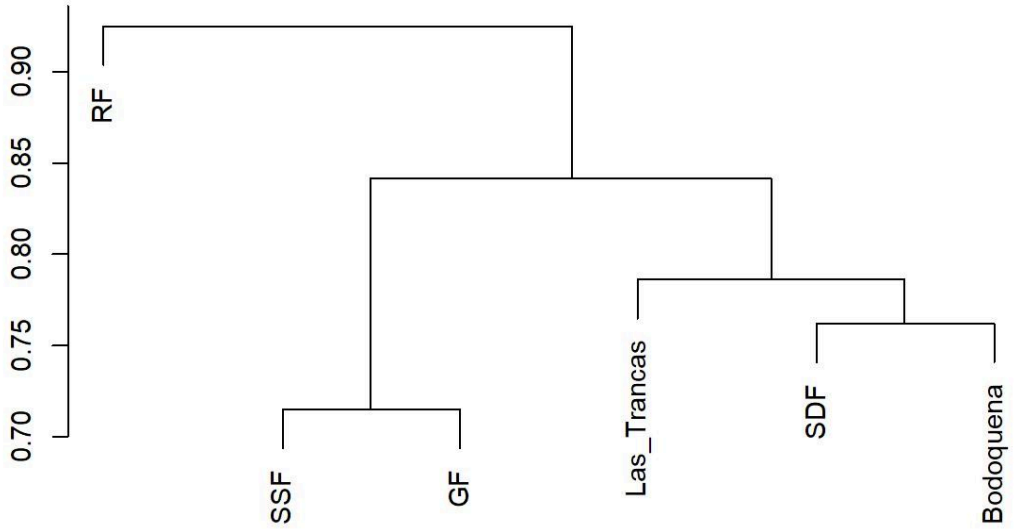

Figure 6. Dendrogram produced using the presence and absence matrix of species, the Jaccard similarity index, and the UPGMA method, showing the affinities among the researched vegetation, the seasonal forests in Chiquitania (Las Trancas), Bolivia, and the forests at Bodoquena National Park (Bonito and Bodoquena), Brazil. GF – Gallery Forest; RF – Riparian forest of the Paraguay River (Corumbá); SDF – Seasonal Deciduous forest at the present study area; SSF – Seasonal semideciduous forest at Urucum Hills (Coffenetic coef = 0.9).

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Table 1 – Species from the altitudinal gradient of Urucum residual plateau, Corumbá and Ladário, MS, Brazil, with restricted distribution to one (MS) or two Brazilian states and/or endangered (ES) according to the information on Flora and Funga of Brazil (2026), Habit, and respective collection number. Detailed vouchers and respective herbaria are available in Table S1. (* = first record for MS; ** = unpublished subspecies).

Family, scientific name	Habit	Collector no.	ES	Distribution
ACANTHACEAE				
Aphelandra longiflora (Lindl.) Profice	Subshrub	GADJ 1890	LC	
Justicia hassleri (Lindau) V.A.W.Graham	Herb	Assis 145	--	MS
Ruellia erythropus (Nees) Lindau.	Herb	Jacques 749	LC	
Ruellia hygrophila Mart.	Herb	GADJ 1915	--	MT e MS
ACHATOCARPACEAE				
Achatocarpus praecox Griseb.	Treelet	GADJ 2752	LC	
AMARANTHACEAE				
Alternanthera kurtzii Schinz ex Pedersen	Herb	VJP 1465	EN	
Alternanthera tenella Colla	Herb	GADJ 2403	LC	
Chamissoa acuminata Mart.	Subshrub	GADJ 2175	LC	
Gomphrena vaga Mart.	Shrub	GADJ 2250	LC	
Hebanthe pulverulenta Mart.	Climber	GADJ 1907	LC	
ANACARDIACEAE				
Astronium fraxinifolium Schott	Tree	GADJ 3243	LC	
Schinopsis brasiliensis Engl.	Tree	VJP 2312	LC	
ANNONACEAE				
Annona emarginata (Schltdl.) H.Rainer	Tree	GADJ 2875	LC	
APOCYNACEAE				
Aspidosperma australe Müll.Arg.	Tree	NCBueno 33	LC	
Aspidosperma cylindrocarpon Müll.Arg.	Tree	GADJ 2554	LC	
Aspidosperma quebracho-blanco Schltdl.	Tree	AP 6960	DD	

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Petalostelma robertii (S.Moore) Lied & Meve	Climber	MD Moraes 554	--	MS
Prestonia quinquangularis (Jacq.) Spreng.	Climber	VJP 138	LC	
Prestonia tomentosa R.Br.	Climber	AP 4900	LC	
Rauvolfia ligustrina Willd. ex Roem. & Schult.	Shrub	VJP 55	LC	
ARACEAE				
Anthurium paraguayense Engl.	Herb	VJP 988	--	MS
ARECACEAE				
Attalea phalerata Mart. ex Spreng.	Palm	Forzza 819	LC	
Copernicia alba Morong ex Morong & Britton	Palm	Noblick 4890	--	MT e MS
ARISTOLOCHIACEAE				
Aristolochia labiata Willd.	Climber	CAC 1100	LC	
ASTERACEAE				
Aldama corumbensis (Malme) Magenta & Pirani.	Subshrub	IMB 712	EN	MT e MS
Aspilia grazielae Santos	Shrub	GADJ 2861	EN	MS
Dimerostemma apense (Chodat) M.D.Moraes	Shrub	Takahasi 894	NT	MS
BEGONIACEAE				
Begonia hirtella Link.	Herb		LC	
Begonia lindmanii Brade.	Herb	Jacques 750	--	MT e MS
Begonia perdusenii Brade	Herb	VJP 943	EN	
BIGNONIACEAE				
Fridericia caudigera (S.Moore) L.G.Lohmann	Climber	GADJ 2000	LC	
Fridericia pubescens (L.) L.G.Lohmann	Climber	GADJ 2160	LC	
Handroanthus impetiginosus (Mart. ex DC.) Mattos	Tree	TCA 35	NT	
Zeyheria tuberculosa (Vell.) Bureau ex Verl.	Tree	R 6512	VU	
BIXACEAE				
Cochlospermum regium (Mart. ex Schrank) Pilg.	Shrub	AP 7173	LC	

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BROMELIACEAE				
Aechmea bromeliifolia (Rudge) Baker	Epiphyte	VJP 1243	LC	
Bromelia balansae Mez	Herb	R 5144	LC	
Fosterella hatschbachii L.B.Smith & R.W.Read	Epiphyte/ rupicolous	GADJ 3294	--	MS
Tillandsia duratii var. *saxatilis* (Hassl.) L.B.Smith	Epiphyte	VJP 829	DD	
Tillandsia streptocarpa Baker	Epiphyte	IMB 412	LC	
Tillandsia tenuifolia var. *vaginata* (Wawra) L.B.Smith	Epiphyte	GADJ 1838	LC	
Tillandsia tricholepis Baker	Epiphyte	GADJ 2002	LC	
CACTACEAE				
Cleistocactus baumannii (Lem.) Lem.	Herb	VJP 393	--	MT e MS
Epiphyllum phyllanthus (L.) Haw.	Epiphyte	GADJ 2847	LC	
Opuntia retrorsa Speg.	Shrub	GADJ 5137	--	MS
Pereskia sacharosa Griseb.	Tree	GADJ 2009	--	MT e MS
CAPPARACEAE				
Anisocapparis speciosa (Griseb.) Cornejo & Iltis	Shrub	GADJ 3297	--	MS
Capparicordis tweediana (Eichler) Iltis & Cornejo	Shrub	GADJ 1928	--	MS
Capparidastrum coimbranum (Cornejo & Iltis) Cornejo & Iltis	Tree	GADJ 2667	--	MS and Bolivia
CARICACEAE				
Vasconcellea glandulosa A.DC.	Subshrub	GADJ 2135	--	MS*
COMBRETACEAE				
Terminalia argentea Mart.	Tree	GADJ 1998	LC	
CONVOLVULACEAE				
Bonamia balansae Hallier f.	Climber	GADJ 1350	--	MS
Evolvulus corumbaensis Hoehne	Herb	AP 1486	--	MS

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Ipomoea cardenasiana O´Donell	Climber	IMB 8	--	MS
Ipomoea sericophylla Meisn.	Climber	VJP229	LC	
CORDIACEAE				
Cordia brasiliensis (I.M.Johnst.) Gottschling & J.S.Mill.	Tree	GADJ 2761	--	MS
DIOSCOREACEAE				
Dioscorea aesculifolia R.Knuth	Climber	VJP 2555	DD	
ERYTHROXYLACEAE				
Erythroxylum anguifugum Mart.	Treelet	RRSilva 176	LC	
Erythroxylum pelleterianum A.St.-Hil.	Shrub	GADJ 1922	LC	
EUPHORBIACEAE				
Astraea lobata (L.) Klotzsch	Climber	GADJ 2756	LC	
Croton micans Sw.	Treelet	AP 12414	--	MT e MS
Tragia hieronymi Pax & K.Hoffm.	Climber	Webster 25370	--	MT e MS
FABACEAE				
Acosmium cardenasii H.S.Irwin & Arroyo	Tree	GADJ 2438	--	MS
Amburana cearensis (Allemão) A.C.Sm.	Tree	GADJ 2457	NT	
Arachis appressipila Krapov. & W.C.Gregory	Herb	GADJ 1730	--	MS
Bauhinia leptantha Malme	Tree	RRSilva 138	VU	MS
Centrosema sagittatum (Kunth ex Willd.) Malme	Climber	GADJ 2885	LC	
Coursetia hassleri Chodat	Shrub	RRSilva 946	--	MS
Dipteryx alata Vogel	Tree	RRSilva 615	LC	
Erythrina similis Krukoff	Treelet	GADJ 3235	--	MT e MS
Galactia striata (Jacq.) Urb.	Climber	GADJ 1729	LC	
Hymenaea courbaril L.	Tree	GADJ 2037	LC	
Hymenaea martiana Hayne	Tree	Brina 1252	LC	
Indigofera guaranitica Hassl.	Subshrub	RRSilva 129	LC	

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Inga laurina (Sw.) Willd.	Tree	GADJ 3265	LC	
Libidibia paraguariensis (D.Parodi) G.P.Lewis	Tree	GADJ 2812	--	MS
Machaerium villosum Vogel	Tree	GADJ 2141	LC	
Microlobius foetidus subsp. *paraguensis* (Benth.) M.Sousa & G.Andrade	Tree	IMB 301	--	MS
Mimosa sensibilis var. *urucumensis* Griseb.	Shrub	GADJ 2198	--	MS
Muellera variabilis (R.R.Silva & A.M.G.Azevedo) M.J.Silva & A.M.G.Azevedo	Treelet	GADJ 2476	--	MS
Neptunia pubescens Benth.	Herb	AP 4745	VU	MS
Piptadenia gonoacantha (Mart.) J.F.Macbr.	Tree	VJP 2257	LC	
Pterogyne nitens Tul.	Tree	RRSilva 326	LC	
LAURACEAE				
Aiouea trinervis Meisn.	Shrub	GADJ 2855	LC	
Nectandra cissiflora Nees	Tree	GADJ 1199	LC	
Nectandra hihua (Ruiz & Pav.) Rower	Tree	GADJ 2468	LC	
Nectandra psammophila Nees	Tree	FMacedo-Alves 56	LC	
LORANTHACEAE				
Psittacanthus acinarius (Mart.) Mart.	Hemiparasite	VJP 3193	LC	
MALPIGHIACEAE				
Carolus chlorocarpus (A.Juss.) W.R.Anderson	Climber	GADJ 1897	LC	
Stigmaphyllon jatrophifolium A.Juss.	Climber	AP 5617		*
Thryallis laburnum S.Moore	Climber	GADJ 2183	VU	MS
MALVACEAE				
Eriotheca roseorum (Cuatrec.) A.Robyns	Tree	GADJ 1905	--	MS
Hochreutinera hasslerana (Hochr.) Krapov.	Subshrub	AP 6999	EN	
Luehea candicans Mart. & Zucc.	Tree	GADJ 2159	LC	
Pavonia hieronymi Gürke	Subshrub	A 4	--	MT e MS
Pavonia immaculata R.E.Fr.	Subshrub	VJP 296	--	MT e MS

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Pavonia platyloba R.E.Fries.	Shrub	AP 7794	--	MS
Pseudabutilon virgatum (Cav.) Fryxell	Subshrub	VJP 293	--	MS
Pseudobombax marginatum (A.St.-Hil.) A.Robyns	Tree	GADJ 3247	LC	
Wissadula indivisa R.E.Fr.	Subshrub	VJP 146	--	MS
Wissadula macrantha R.E.Fr.	Shrub	GADJ 2364	--	MS
MELIACEAE				
Cedrela fissilis Vell.	Tree	GADJ 1919	VU	
Trichilia emarginata (Turcs.) C.DC.	Tree	AP 2587	LC	
Trichilia hirta L.	Shrub	GADJ 1724	LC	
Trichilia stellato-tomentosa Kuntze	Treelet	VJP2508	VU	MT e MS
MORACEAE				
Ficus broadwayi Urban	Tree	GADJ 3308	LC	
Ficus calyptroceras (Miq.) Miq.	Tree	GADJ 3180	LC	
Ficus eximia Schott	Tree	GADJ 3306	LC	
MYRTACEAE				
Blepharocalyx salicifolius (Kunth) O.Berg	Tree	GADJ 2854	LC	
Eugenia aurata O.Berg	Tree	GADJ 3321	LC	
Eugenia florida DC.	Tree	GADJ 3278	LC	
Eugenia paracatuana O.Berg	Treelet	GADJ 3271	LC	
Plinia cauliflora (DC.) Kausel	Shrub	GADJ 2798	LC	
NYCTAGINACEAE				
Bougainvillea infesta Griseb.	Shrub	GADJ 1929	--	MS
Pisonia ambigua Heimerl	Treelet	Salis 1111	LC	
Pisonia zapallo Griseb.	Tree	GADJ 1904	--	MT e MS
Reichenbachia hirsuta Spreng.	Shrub	GADJ 3209	--	MT e MS
ORCHIDACEAE				
Campylocentrum hasslerianum Hoehne	Epiphyte	R 08	--	MS
Cattleya cernua (Lindl.) Van den Berg	Epiphyte	DPR 05	LC	

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Cattleya nobilior Rchb.f.	Epiphyte	DPR 15	NT	
Epidendrum coronatum Ruiz & Pav.	Epiphyte	1986; R 11	LC	
Octomeria warmingii Rchb.f.	Epiphyte	DPR 03	LC	
Trichocentrum jonesianum (Rchb.f.) M.W.Chase & N.H.Williams	Epiphyte	RRSilva 689	LC	
OXALIDACEAE				
Oxalis cratensis Oliv. ex Hook.	Herb	H 60820	LC	
PASSIFLORACEAE				
Passiflora gibertii N.E.Br.	Climber	GADJ 2461	--	MT e MS
Passiflora tricuspis Mast.	Climber	GADJ 2194	LC	
PIPERACEAE				
Peperomia pellucida Kunth	Herb	GADJ 2770	LC	
Piper macedoi Younk.	Shrub	VJP 927	LC	
POACEAE				
Gouinia brasiliensis (S.Moore) Swallen	Herb	VJP 60	--	MT e MS
Gouinia latifolia (Griseb.) Vesey	Herb	FILG.3626	--	MS e Go
Gouinia paraguayensis (Kuntze) Parodi	Herb	Valls 9079	--	MS
POLYGONACEAE				
Coccoloba cujabensis Wedd.	Tree	EPereira 438	--	MT e MS
Coccoloba guaranitica Hassl.	Treelet	AP 5290	--	MS
Coccoloba paraguariensis Lindau	Treelet	AP 2896	--	MS
Ruprechtia exploratricis Sandwith	Treelet	AP 7172	--	MS
Ruprechtia triflora Griseb.	Shrub	GADJ 2813	--	MS
RHAMNACEAE				
Ziziphus oblongifolius S.Moore	Tree	GADJ 761	--	MS
RUBIACEAE				
Calycophyllum multiflorum Griseb.	Tree	GADJ 2270	--	MS
Coussarea hydrangeifolia (Benth.) Müll.Arg.	Shrub	GADJ 3215	LC	
Genipa americana L.	Tree	GADJ 885	LC	

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RUTACEAE				
Helietta puberula R.E.Fr.	Tree	GADJ 2157	--	MS
Zanthoxylum petiolare A.St.-Hil. & Tul.	Tree	GADJ 3217	LC	
SALICACEAE				
Casearia gossypiosperma Briq.	Tree	GADJ 3261	LC	
SAPINDACEAE				
Dilodendron bipinnatum Radlk.	Tree	GADJ 2520	LC	
Diplokeleba floribunda N.E.Br.	Tree	R 6077	--	MS
Magonia pubescens A.St.-Hil.	Tree	RRSilva 697	LC	
Melicoccus lepidopetalus Radlk.	Tree	GADJ 1975	--	MS e MG
Serjania chacoensis Ferrucci & Acev.-Rod.	Climber	GADJ 2452	--	MT e MS
Serjania minutiflora Radlk.	Climber	GADJ 2170	--	MT e MS
Serjania setigera Radlk.	Climber	GADJ 2242	--	MS
Urvillea chacoensis Hunz.	Climber	GADJ 2446	--	MT e MS
Urvillea filipes Radlk.	Climber	AP 7780	--	MT e MS
SAPOTACEAE				
Pouteria torta (Mart.) Radlk.	Tree	GADJ 2489	LC	
Sideroxylon obtusifolium (Roem. & Schult.) T.D.Penn.	Tree	GADJ 2474	LC	
SOLANACEAE				
Cestrum guaraniticum Chodat & Hassl.	Shrub	AP 2725	--	MS
Solanum turneroides Chodat	Herb	GADJ 1959	--	MS e SP
TRIGONIACEAE				
Trigonia boliviana Warm.	Shrub	IMB 62	--	MS e RJ
TURNERACEAE				
Turnera weddelliana Urb. & Rolfe	Shrub	GADJ 2432	--	MT e MS
ULMACEAE				
Phyllostylon rhamnoides (Poiss.) Taub.	Tree	AP 4633	NT	
VOCHYSIACEAE				

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Qualea glaziovii subsp. 1**	Tree	GADJ 3142	--	MS
ZYGOPHYLLACEAE				
Gonopterodendron sarmientoi (Lorentz ex Griseb.) A.C.Godoy-Bürki.	Tree	VJP 2240	--	MS

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