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Inventory

Checklist of the flora in ironstone outcrops at the Urucum Plateau, Corumbá, Mato Grosso do Sul

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Abstract: "Cangas" are ironstone outcrops occurring at the foot of the Urucum Plateau, on the western edge of Pantanal, Corumbá-MS. In Brazil, the knowledge about flora and ecology of the plant communities associated with these formations is still incipient. These habitats are among the most threatened and less studied in Brazil because of their association with high quality iron ore deposits. We present a cheklist of the flora from these formations, resulting from different authors' collecting efforts in 10 areas of the Plateau. A total of 302 species have been recorded; they were distributed in 53 botanical families and 175 genera. Poaceae (43 species), Fabaceae (41), Euphorbiaceae (22), Cyperaceae (19), Malvaceae (19), Convolvulaceae (15), Malpighiaceae (13) and Apocynaceae (11) accounted for 60.6% of the species richness. Our data add 59 new occurrences of species of angiosperms to the ironstone outcrops flora in the Urucum Plateau. Among these, 27 species had no occurrence record for Mato Grosso do Sul and three species had not yet been recorded for Brazil. The high diversity and presence of endemic, rare, endangered and/or not yet cataloged species for the Urucum Plateau region, reinforces the need for local conservation units that can guarantee the preservation of these species, since the existing environmental protection areas are insufficient to guarantee the maintenance of typical species from this habitat in the region.
Keywords: *biodiversity, ferruginous geosystem, Pantanal.*

Checklist da flora de cangas do Maciço do Urucum, Corumbá, Mato Grosso do Sul

Resumo: As cangas são afloramentos ferruginosos que ocorrem ao sopé do Maciço do Urucum, na Borda Oeste do Pantanal, Corumbá-MS. No Brasil, o conhecimento sobre a florística e ecologia das comunidades vegetais associadas a essas formações ainda é incipiente. Esses habitats estão entre os mais ameaçados e menos estudados do Brasil, devido à sua associação a depósitos de minério de ferro de alta qualidade. Nós apresentamos um cheklist da flora desses ambientes, resultante de diversos esforços de coleta de diferentes autores em 10 áreas do Maciço. Foram registradas 302 espécies distribuídas em 53 famílias botânicas e 175 gêneros. Poaceae (43 espécies), Fabaceae (41), Euphorbiaceae (22), Cyperaceae (19), Malvaceae (19), Convolvulaceae (15), Malpighiaceae (13) e Apocynaceae (11) representaram 60,6% da riqueza específica. Nossos dados adicionam 59 novas ocorrências de espécies de angiospermas para a flora de cangas do Maciço do Urucum. Das espécies apresentadas, 27 ainda não possuíam registro de ocorrência para o Mato Grosso do Sul e três espécies não haviam sido ainda registradas para o Brasil. A alta diversidade e a presença de espécies endêmicas, raras, ameaçadas e/ou ainda não catalogadas para a região do Maciço do Urucum reforça a necessidade de unidades de conservação locais que possam garantir a preservação dessas espécies, uma vez que as áreas de proteção ambiental existentes na região são insuficientes para garantir a manutenção de populações típicas desse habitat.
Palavras-chave: *biodiversidade, geossistema ferruginoso, Pantanal.*

Introduction

Ferruginous geosystems are landscapes of great value due to the uniqueness of their flora and fauna, presence of endemic species and/or provided ecosystem services (Tibbett 2015). Due to the soil porosity and permeability in these formations, they have high water recharge capacity and storage, forming large aquifers that supply springs and cities (Carmo et al. 2012). However, because they are located in regions with large mineral deposits of economic interest, they are among the most endangered landscapes in the world (Jacobi & Carmo 2008a, Tibbett 2015).

These environments, originated in the Archean and Paleoproterozoic period, are usually located in mountain tops, but can also be found in foothills (Souza & Carmo 2015). In addition to presenting high biological value, these environments harbor sites of inestimable archaeological value and important water resource deposits (Jacobi et al. 2015, Souza & Carmo 2015). In Brazil, ferruginous geosystems occur in the states of Bahia, Minas Gerais, Mato Grosso do Sul and Pará, and they are important mineral exploration areas (Carmo et al. 2012). These geosystems, known in Brazil as "cangas", usually occur in higher relief areas, with tabular tops (Souza & Carmo 2015). However, in the Urucum Plateau region, located in the municipalities of Corumbá and Ladário, state of Mato Grosso do Sul, they not only occur on tops but also in low altimetric levels and slopes (Del'arco et al. 1982, Takahasi 2015). These low altimetric ironstone outcrops are called "bancadas lateríticas" (Takahasi & Meirelles 2014).

The Urucum Plateau represents the lithostratigraphic unit of most economic interest in Mato Grosso do Sul, due to the presence of important deposits of iron and manganese (Del'arco et al. 1982). Ironstone outcrops of Urucum plateau are Quaternary deposit formations produced under climatic conditions different from those of the current era. They probably occurred at the time of the Paraguay River Depression and the plio-plestocene plediplain origin, period in which a semi-arid weather subjected to torrential rains and erosive processes prevailed (Del'arco et al. 1982).

In Brazil, the knowledge about floristic and ecology of plant communities associated with ferruginous geosystems is still incipient (Jacobi & Carmo 2011, Jacobi et al. 2015). These habitats are among the most threatened and least studied in Brazil respectively due to their association with iron ore deposits with high quality and the difficulty of access (Jacobi & Carmo 2008a). Studies on ironstone outcrops flora are recent and concentrated largely on the Iron Quadrangle, in the state of Minas Gerais (Mourão & Stehmann 2007, Viana & Lombardi 2007, Pifano et al. 2010, Ataíde et al. 2011, Carmo & Jacobi 2013). The results obtained by those studies indicate that ironstone outcrops harbor a large number of plant species, contributing to the increase of the alpha diversity of the regions where they occur (Jacobi & Carmo 2008a).

In the region of Corumbá, some ironstone outcrops in the Urucum plateau have been studied for their ecological aspects (Takahasi 2010, Takahasi & Meirelles 2014, Oliveira 2016) and flora (Takahasi 2010, Takahasi 2015); but there is no listing that includes all species already collected in the region. In this study we present a checklist of species of Angiosperms from the ironstone outcrops in Urucum Plateau, based on several collecting efforts carried out in region from the 1990s to the present time, in order to fill the information gaps about the flora of these environments and evaluate the similarity between the ferruginous outcrops from Mato Grosso do Sul and those ferruginous outcrops from other regions.

Material and Methods

The studied ironstone outcrops are located at the foot of the Urucum Plateau Residual, a non-floodable region around the municipalities of Corumbá and Ladário (Figure 1), the western border of Pantanal, Mato Grosso do Sul, Midwest region of Brazil. The plateau, also known as Urucum Massif, is a complex of hills called locally as Ururum, Santa Cruz, Grande, Rabichão, São Domingos and Tromba dos Macacos, whose altitudes vary between 80 to 1.065 m, being the highest hill recognized as the highest point of the State (Borges et al. 1997, Damasceno-Junior 2005). The area covers approximately 1.211 km² and is bordered on north by the Paraguay River, on west by the Bolivian border, on south and east by the Pantanal floodplain (Silva et al. 2000). Ironstone outcrops from this region occur along the drainage lines at the foot of the plateau hills (about 100 to 150 m altitude), and due to the predominantly flat terrain, small pools of water may accumulate during the rainy season.

Ten ironstone outcrops were included in this inventory: Pantanal Park Road, Band'alta farm, Monjolinho farm, Figueira farm, São João farm, São Sebastião do Carandá farm, two sites in the Municipal Natural Park Piraputangas, Uruba farm and Rabicho farm (Table 1).

In the Urucum Plateau region, the average annual temperature is 25.1 ºC and the average rainfall is 1.070 mm annually (Soriano 1997). There are two well-defined seasons, a dry season that runs from May to September and a rainy season from October to March, with 45% of rainfall occurring from December to February (Loureiro et al. 1982).

The vegetation surrounding these ironstone outcrops is a Submontane Seasonal Decidual Forest (Damasceno-Junior 2005). We can characterize three habitats in ironstone outcrops at Urucum Plateau: the first one is hardened ferruginous substrate where plants established directly on them or in places with a thin layer of sediment. The second one consists of soil islands, specially mats of monocotyledons, with a deeper layer of soil that allows establishment of phanerophytes. Finally, the third one is constituted by ephemeral flush communities that occurs on runoff-habitats like the slopes of ironstone outcrops allowing the establishment of typical flooded plant species.

The checklist of the ironstone outcrops flora in the Urucum Plateau was elaborated through data collected in Fazenda Band'alta, from January 2017 to July 2018; in researches made by the authors over several years in the outcrops from the region and Herbaria queries at Universidade Federal de Mato Grosso do Sul, Campus Corumbá (COR) and Campo Grande (CGMS); Herbarium of Embrapa Pantanal (CPAP); Herbarium Friburguense of Pontifícia Universidade Católica do Rio de Janeiro (FCAB); Herbarium of Universidade Estadual de Campinas (UEC); Herbarium of Instituto de Biociências at Universidade do Rio Grande do Sul (ICN); Herbarium Maria Eneyda P. K. Fidalgo, at Instituto de Botânica de São Paulo (SP) and Herbarium of Universidade de Brasília (UB). The obtained dataset covers a large part of the ironstone outcrops flora in the region, and was later supplemented with herbaria data available on internet (CRIA 2018, Flora do Brasil 2020,

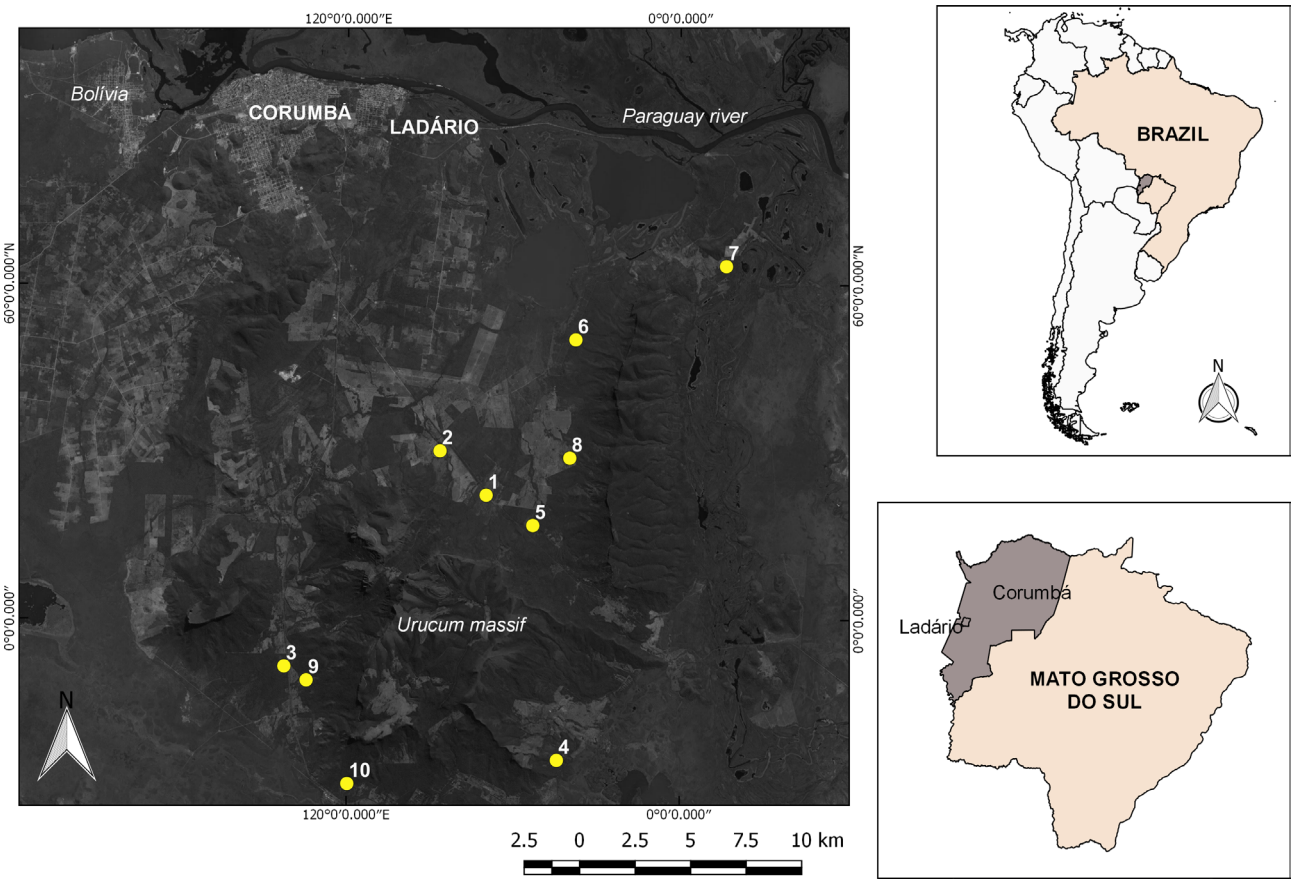

Figure 1. Location of the ten analyzed cangas (yellow dots) at the Urucum Plateau, Western Border of Pantanal, MS.

Table 1. Locations included in this study with their respective geographical coordinates.

Sampling points	Locality	Geographical coordinates
1	Pantanal Park Road	19° 10'02.0"S, 57° 33'31.0"W
2	Band'Alta farm	19° 08'57.3"S, 57° 34'42.1"W
3	Figueira farm	19° 14'10.7"S, 57° 38'43.1"W
4	Monjolinho farm	19° 16'28.4"S, 57° 31'42.7"W
5	São João farm	19° 10'46.2"S, 57° 32'19.1"W
6	São Sebastião do Carandá farm	19° 06'15.5"S, 57° 31'12.5"W
7	Uruba farm	19° 04'28.8"S, 57° 27'20.2"W
8	Rabicho farm	19° 09'08.0"S, 57° 31'22.0"W
9	Municipal Natural Park Piraputangas	19° 14'31.0"S, 57° 38'08.0"W
10	Municipal Natural Park Piraputangas	19° 17'02.0"S, 57° 37'06.0"W

Jabot 2018). We considered only specimens identified at the taxonomic level of species and excluded those with dubious identification or at the genera-level. The taxa classification followed the APG IV system (2016), and the nomenclature and synonymizations were updated according to Flora do Brasil 2020 (2018). The similarity in species composition among the 10 analyzed ironstone outcrops was calculated using the Sorensen Similarity Index.

Results

A total of 302 species distributed in 53 botanical families and 175 genera were cataloged (Table 2). The richest species families were Poaceae (43 species), Fabaceae (41), Euphorbiaceae (22), Malvaceae (19), Cyperaceae (19), Convolvulaceae (15), Malpighiaceae (13) and Apocynaceae (11) that represented 60.6% of the specific richness found in the ironstone outcropsof the region (Figure 2). Poaceae, Fabaceae, Euphorbiaceae and Malvaceae are also the families with the highest number of genera, being *Cyperus* (9), *Croton* (8), *Mimosa* (7), *Portulaca* (7) and *Evolvulus* (6) the most common genera.

In the soil islands, there are deciduous forest species as *Aspidosperma quirandy* Hassl., *Pseudobombax marginatum* (A.St.-Hil.) A.Robyns and *Myracrodruon urundeuva* Allemão, whereas in areas where there is a thin layer of soil only herbaceous species can be established, in many cases annuals for example, *Gomphrena centrota*

Table 2. List of Angiosperms species from the cangas at the Urucum Plateau, Western Border of Pantanal, MS, with respective growth habits, Vouchers (collector's name, collection number and registration in the herbarium where the specimen is deposited, when possible), place of occurrence and state of conservation of the species according to criteria of the International Union of Conservation and Natural Resources (IUCN 2018) and Livro Vermelho da Flora do Brasil pela CNCFlora (Martinelli & Moraes 2013): CR = critically endangered , EN = endangered, LC = least concern , NT = near threatened, VU = vulnerable, DD = data deficient, "─" = not evaluted. The numbers of localities are shown in Table 1.

Species	Growth habit	Vouchers	Locality	Conservation status
Acanthaceae				
Justicia cf. *harleyi* Wassh.	Shrub	Damasceno-Jr,G.A. 1517 (COR 6090)	1	-
Ruellia ciliatiflora Hook.	Herb	Takahasi, A. 1032	4	-
Ruellia erythropus (Nees) Lindau	Herb	Damasceno-Jr,G.A. 1511 (COR 6085)	1	-
Stenandrium pohllii Nees.	Herb	Takahasi, A.818	4	-
Thyrsacanthus boliviensis (Nees) A.Côrtes&Rapini	Shrub	Takahasi, A. 1396 (COR 15350)	1	-
Amaranthaceae				
Alternanthera flavescens Kunth	Herb	Damasceno-Jr,G.A. 1310 (FCAB 5921)	1	-
Alternanthera pungens Kunth	Herb	Damasceno-Jr,G.A. 1504 (COR 6007)	1	-
Alternanthera rufa (Mart.) D.Dietr.	Shrub	Damasceno-Jr,G.A. 1159 (COR 13039)	2	-
Alternanthera tenella Colla	Herb	Damasceno-Jr,G.A. 1492 (COR 6008)	1	-
Gomphrena celosioides Mart.	Herb	Silva, R.H. 964 (CGMS 38691); Takahasi, A. 745; Takahasi, A. 938 (COR 15113)	1, 3, 4	-
Gomphrena centrota E. Holzh.	Herb	Pott, V.J. 7408 (CGMS 36403); Damasceno-Jr,G.A. 1113 (COR 13043); Takahasi, A. 971 (COR 15136); Takahasi, A. 1040 (COR 15170)	1, 2, 3, 5	EN (CNNFlora)
Gomphrena matogrossensis Suess.	Herb	Damasceno-Jr,G.A. 1335 (COR 13504)	1	-
Gomphrena vaga Mart.	Shrub	Takahasi, A. 701 (COR 14995); Takahasi, A. 1097 (COR 15193); Takahasi, A. 1051 (COR 15175)	1, 2, 3	-
Amaryllidaceae				
Zephyranthes cearensis (Herb.) Baker	Herb	Takahasi, A. 782 (COR 15031); Takahasi, A. 947 (COR 15119)	2, 4	-
Anacardiaceae				
Myracrodruon urundeuva Allemão	Tree	Lima, M.S. 276	2	-
Annonaceae				
Annona nutans (R.E. Fr.) R.E. Fr.	Shrub	Takahasi, A. 964 (COR 15130); Takahasi, A. 991 (COR 15145); Damasceno-Jr,G.A. 2459 (COR 11089); Silva, R.H. 911 (CGMS 38696)	3, 4, 7, 10	-
Apocynaceae				
Araujia stuckertiana (Kurtz ex Heger) Fontella & Goyder	Liana	Damasceno-Jr,G.A. 1514 (COR 6082)	1	-
Aspidosperma cuspa (Kunth) S.F.Blake ex Pittier	Tree	Takahasi, A. 1408	6	-
Aspidosperma pyrifolium Mart.	Tree	Damasceno-Jr,G.A. 5317 (CGMS 41015); Takahasi, A. 721 (COR 15006); Takahasi, A. 1120 (COR 15205)		
	1, 2, 4	-		
Aspidosperma quirandy Hassl.	Tree	Damasceno-Jr,G.A. 1338 (COR 9197); Takahasi,A. 1449; Takahasi, A. 698 (COR 14994); Pott, A. 9285 (CGMS 58890)	1, 4, 5, 7	-
Aspidosperma subincanum Mart. ex A.DC.	Tree	Damasceno-Jr, G.A. 1174		

Continuation Table 2.

Species	Growth habit	Vouchers	Locality	Conservation status
	2	-		
Blepharodon pictum (Vahl) W.D. Stevens	Liana	Dasmasceno 1469 (COR 10924); Takahasi, A. 1177 (COR 15232); Takahasi, A. 1094 (COR 15191); Silva, R.H. 878 (CGMS 38698)	1, 2, 4, 8	-
Forsteronia cf. *pubescens* A. DC.	Liana	André, C.B.D.S. 201 (COR 15817)	9	-
Forsteronia thyrsoidea (Vell.) Müll. Arg.	Liana	Takahasi, A. 1445	6	-
Petalostelma robertii (S. Moore) Liede & Meve	Liana	Takahasi, A. 1317 (COR 15302); Silva, R.H. 909 (CGMS 38697)	6, 8	-
Prestonia tomentosa R.Br.	Liana	Takahasi, A. 1410	6	-
Schubertia grandiflora Mart.	Liana	Damasceno-Jr,G.A. 1386 (COR 9202)	1	-
Arecaceae				
Acrocomia aculeata (Jacq.) Lodd. ex Mart.	Palm	Lima, M.S. 280	2	-
Asteraceae				
Calea rupicola Chodat	Herb	Damasceno-Jr,G.A. 1301 (COR 13499); Damasceno-Jr,G.A. 1116 (COR 13038); Takahasi, A.712; Takahasi, A. 1089 (COR 15187); Takahasi, A. 1039 (COR 15169) Silva, R.H. 880 (CGMS 38704)	1, 2, 3, 4, 5, 8	-
Conyza bonariensis (L.) Cronquist	Herb	Takahasi, A. 978	3	-
Lepidaploa amambaia H.Rob.	Herb	Damasceno-Jr,G.A. 1307 (COR 13498)	1	-
Lepidaploa remotiflora (Rich.) H. Rob.	Herb	Damasceno-Jr,G.A. 1502 (COR 6004); Takahasi, A.974 (COR 12648)	1, 3	-
Lepidaploa salzmannii (DC) H.Rob.	Herb	Takahasi, A. 702; Urquiza, M.V.S. 110 (COR 15860); Takahasi, A. 936 (COR 15111)	1, 2, 4	-
Bignoniaceae				
Dolichandra quadrivalvis (Jacq.) L.G.Lohmann	Liana	Pott, A. 12707 (CGMS 58779)	1	-
Fridericia triplinervia (Mart. ex DC.) L.G. Lohmann	Liana	Damasceno-Jr,G.A. 1414 (COR 9204); Damasceno-Jr,G.A. 1201 (COR 13678)	1, 2	-
Handroanthus impetiginosus (Mart. ex DC.) Mattos	Tree	Lima, M.S. 281	2	NT (CNNFlora)
Jacaranda cuspidifolia Mart.	Tree	Takahasi, A. 1121 (COR 15371)	4	-
Bixaceae				
Cochlospermum regium (Schrank) Pilg.	Shrub	Takahasi, A. 705 (COR 14997); Damasceno-Jr,G.A. 1676 (COR 13148); Takahasi, A. 718 (COR 15004); Pott, A. 9300 (CGMS 52018); André, C.B.D.S. 20 (COR 15824)	1, 2, 3, 7, 9	-
Boraginaceae				
Euploca procumbens (Mill.) Diane & Hilger	Herb	Takahasi, A. 945 (COR 15363)	4	-
Brassicaceae				
Capparidastrum cf. *humile* (Hassl.) Cornejo & Iltis	Shrub	Damasceno-Jr,G.A. 1343 (COR 13500)	1	-
Bromeliaceae				
Bromelia balansae Mez	Succulent	Lima, M.S. 279	2	-

Continuation Table 2.

Species	Growth habit	Vouchers	Locality	Conservation status
Deuterocohnia meziana Kuntze ex Mez	Succulent	Damasceno-Jr, G.A. 5316 (CGMS 41014); Takahasi, A. 722 (COR 15007); Takahasi, A. 751	1, 2, 3	VU (CNNFlora)
Dyckia aff. *gracilis* Mez	Succulent	Damasceno-Jr,G.A. 1404 (COR 10917); Ishii, I.H. 743 (COR 13576)	1, 5	-
Dyckia excelsa Leme	Succulent	Takahasi, A. 1098 (COR 15367)	5	-
Dyckia leptostachya Baker	Succulent	Ishii 746 (COR 15872); Ishii, I.H. 747 (COR 15389); Ishii, I.H.786 (COR 15730)	1, 2, 5	-
Tillandsia loliacea Mart. ex Schult & Schult f.	Epiphyte	Takahasi, A. 1091	4	-
Burseraceae				
Commiphora leptophloeos (Mart.) J.B. Gillett	Tree	Damasceno-Jr, G.A.1329; Lima, M.S. 257; Takahasi, A. 1122 (COR 15206); Takahasi, A. 729; Damasceno-Jr, G.A. 2792	1, 2, 4, 5, 6	-
Cactaceae				
Cereus bicolor Rizzini & A.Mattos	Succulent	Takahasi, A. 1376 (COR 15342)	4	LC (IUCN)
Discocactus ferricola Buining & Brederoo	Succulent	Garcia, J.S. 55 (CGMS17537),		
	1, 2, 3	EN (IUCN), DD (CNNFlora)		
Frailea cataphracta (Dams) Britton & Rose	Succulent	Takahasi, A. 779 (COR 15028)	2	NT (IUCN)
Harrisia balansae (K. Schum.) N.P. Taylor & Zappi	Succulent	Takahasi, A. 755 (COR 15017)	2	LC (IUCN)
Opuntia retrorsa Speg.	Succulent	Takahasi, A. 672 (COR 14895); Lima, M.S. 282	1, 2	-
Praecereus euchlorus (F.A.C. Weber ex K. Schum.) N.P. Taylor	Succulent	Damasceno-Jr,G.A. 1354 (COR 13501); Takahasi, A.1096; Takahasi, A.1171; Damasceno-Jr, G.A. 2805A	1, 2, 4, 6	LC (IUCN)
Cannabaceae				
Celtis iguanaea (Jacq.) Sarg.	Shrub	Takahasi, A. 1461 (COR 15355); Takahasi, A. 1346 (COR 15317); Silva, R.H 915 (CGMS 38725)	3, 4, 9	-
Caryophyllaceae				
Polycarpaea corymbosa (L.) Lam.	Herb	Takahasi, A. 680 (COR 14990); Takahasi, A. 973 (COR 15138); Takahasi, A.875; Silva, R.H. 899 (CGMS 38728)	1, 3, 5, 8	-
Cleomaceae				
Physostemon guianense (Aubl.) Malme	Herb	Damasceno-Jr,G.A. 1434 (COR 13866); Damasceno-Jr,G.A. 1677 (COR 13676); Takahasi, A. 815 (COR 15051); Pott, A. 4784 (CPAP 25125)	1, 2, 4, 7	-
Tarenaya eosina (J.F.Macbr.) Soares Neto & Roalson	Herb	Damasceno-Jr,G.A. 1312 (COR 13865); Takahasi, A. 1002 (COR 15150); Takahasi, A. 915 (COR 15100); Silva, R.H. 882 (CGMS 38729)	1, 2, 3, 8	-
Combretaceae				
Combretum duarteanum Cambess.	Shrub	Damasceno-Jr,G.A. 1304 (COR 13864); Damasceno-Jr,G.A. 1155 (COR 13618); Takahasi, A. 825 (COR 15059)	1, 2, 4	-
Combretum leprosum Mart.	Tree	Takahasi, A. 766 (COR 15021)	2	-
Combretum mellifluum Eichler	Tree	Pott, A. 9271 (CPAP 22949)	7	-

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Continuation Table 2.

Species	Growth habit	Vouchers	Locality	Conservation status
Terminalia argentea Mart.	Tree	Takahasi, A. 1044; Silva, R.H. 941 (CGMS 38733)	4, 9	-
Commelinaceae				
Commelina benghalensis L.	Herb	Damasceno-Jr,G.A. 1424 (COR 13517); Takahasi, A. 1005 (COR 15152)	1, 2	LC (IUCN)
Commelina erecta L.	Herb	Damasceno-Jr,G.A. 1418 (COR 10894); Takahasi, A. 1004; Takahasi, A.732	1, 2, 3	LC (IUCN)
Commelina platyphylla Klotzsch ex Seub.	Herb	Takahasi, A. 1133 (COR 15212)	3	-
Tradescantia boliviana (Hassk.) J.R.Grant	Herb	Takahasi, A. 1175 (COR 15230)	2	-
Tripogandra glandulosa (Seub.) Rohweder	Herb	Takahasi, A. 1186 (COR 15236); Damasceno-Jr,G.A. 2881 (COR 5926); Silva, R.H. 905 (CGMS 38734)	2, 6, 8	-
Convolvulaceae				
Bonamia agrostopolis (Vell.) Hallier f.	Liana	Damasceno-Jr,G.A. 1300 (COR 9189)	1	-
Bonamia balansae Hallier f.	Liana	Damasceno-Jr,G.A. 1350 (COR 13628)	1	-
Bonamia subsessilis Hassl.	Liana	Damasceno-Jr, G.A. 2880A (COR 5927)	6	-
Evolvulus alopecuroides Mart.	Herb	Takahasi, A. 1000 (COR 15149); Takahasi, A. 954 (COR 15122); Silva, R.H. 910 (CGMS 38738)	2, 6, 10	-
Evolvulus cf. *chamaepitys* Mart.	Herb	Silva, R.H. 935 (CGMS 38739)	9	-
Evolvulus cf. *chrysotrichos* Meisn.	Herb	Damasceno-Jr,G.A. 1491 (COR 13860); Damasceno-Jr,G.A. 1680 (COR 13612)	1, 2	EN (CNNFlora)
Evolvulus filipes Mart.	Herb	Takahasi, A. 992 (COR 15146)	4	-
Evolvulus glomeratus Nees & C. Mart.	Herb	Takahasi, A. 1083 (COR 15182)	3	-
Evolvulus lithospermoides Mart.	Herb	Damasceno-Jr,G.A. 1332 (COR 13861); Takahasi, A. 1295 (COR 15283); Takahasi, A. 791 (COR 15038)	1, 2, 3	-
Ipomoea cf. *hieronymi* (Kuntze) O'Donell	Liana	Silva, R.H. 876 (CGMS 38737)	1	-
Ipomoea nil (L.) Roth	Liana	Takahasi, A. 1393 (COR 15348)	2	-
Ipomoea sericophylla Meisn.	Liana	Takahasi, A. 833 (COR 15359); Takahasi, A. 895 (COR 15091)	2, 3	-
Jacquemontia evolvuloides Meisn.	Liana	Damasceno-Jr,G.A. Jr 1423 (COR 13886); Takahasi, A. 763 (COR 15020)	1, 2	-
Jacquemontia fruticulosa Hallier f.	Liana	Takahasi, A. 940 (COR 15115)	4	-
Jacquemontia heterantha (Nees & Mart.) Hallier f.	Liana	Takahasi, A. 708 (UEC 192869); Takahasi, A.1296 (COR 15284)	1, 2	-
Cyperaceae				
Bulbostylis brevifolia Palla	Herb	Takahasi, A. 1030 (COR 12546)	3	-
Bulbostylis conifera (Kunth) C.B.Clarke	Herb	Takahasi, A. 884 (COR 12544)	5	-
Cyperus aff. *meyenianus* Kunth	Herb	Damasceno-Jr,G.A. 1308A (COR 13858)	1	-
Cyperus aggregatus (Willd.) Endl.	Herb	Damasceno-Jr,G.A. Jr 1428 (COR 13714); Takahasi, A. 1010 (COR 12545); Takahasi, A. 905; Takahasi, A. 1275 (COR 12553)	1, 2, 3, 4	-
Cyperus cornelii-ostenii Kük.	Herb	Silva, R.H. 959 (CGMS 38743); Takahasi, A. 1378 (COR 12564); Takahasi, A. 1155 (COR 12548); Takahasi, A. 827 (COR 15060); Takahasi, A. 877 (COR 12543)	1, 2, 3, 4, 5	-
Cyperus cuspidatus Kunth	Herb	Damasceno-Jr,G.A. 1415 (COR 13715); Damasceno-Jr,G.A. 1685 (COR 15914)	1, 2	-

Continuation Table 2.

Species	Growth habit	Vouchers	Locality	Conservation status
Cyperus flavescens L.	Herb	Silva, R.H. 940 (CGMS 38751)	9	-
Cyperus laxus Lam.	Herb	Takahasi, A. 1377 (COR 12563); Takahasi, A. 1263 (COR 12551)	3, 4	-
Cyperus subcastaneus D.A. Simpson	Herb	Takahasi, A. 1379 (COR 12565)	6	-
Cyperus surinamensis Rottb.	Herb	Takahasi, A. 868 (COR 15075); Takahasi, A. 793 (COR 12560)	2, 3	-
Cyperus uncinulatus Schrad. ex Nees	Herb	Takahasi, A. 1129 (COR 12547); Takahasi, A. 835 (COR 15064); Takahasi, A. 880 (COR 15082)	2, 4, 5	-
Eleocharis contracta Maury ex Micheli	Herb	Damasceno-Jr,G.A. 2412 (COR 11069)	1	-
Eleocharis nigrescens (Nees) Kunth	Herb	Takahasi, A. 1239 (COR 12559)	2	-
Eleocharis rugosa D.A.Simpson	Herb	Takahasi, A. 1243 (COR 12550)	2	-
Fimbristylis complanata (Retz.) Link	Herb	Silva, R.H 962 (CGMS 38745)	1	LC (IUCN)
Fimbristylis cf. *dichotoma* (L.) Vahl	Herb	Takahasi, A. 1338 (ICN 156812)	2	LC (IUCN)
Fimbristylis miliacea (L.) Vahl	Herb	Damasceno-Jr, G.A. 2413A	1	-
Kyllinga odorata Vahl	Herb	Takahasi, A. 1182 (COR 15234); Takahasi, A. 1268 (ICN 156813)	2, 4	-
Rhynchospora contracta (Nees) J.Raynal	Herb	Damasceno-Jr, G.A. 2413 (COR 15913); Takahasi, A. 1228 (COR 15256)	1, 2	-
Dioscoreaceae				
Dioscorea acanthogene Rusby	Liana	Damasceno-Jr, G.A. 2880 (11122)	6	-
Dioscorea trifida L.f.	Liana	Silva, R.H. 944 (CGMS 38753)	4	-
Erythroxylaceae				
Erythroxylum deciduum A. St.-Hil.	Shrub	Takahasi, A. 1316 (COR 15301)	6	-
Euphorbiaceae				
Acalypha brasiliensis Müll.Arg.	Shrub	Silva, R.H. 928 (CGMS 38772)	10	-
Acalypha communis Müll. Arg.	Shrub	Takahasi, A. 1235 (COR 15260) Takahasi, A. 1025 (COR 15162) Takahasi, A. 822 (COR 15058)	2, 3, 4	-
Acalypha villosa Jacq.	Shrub	Takahasi, A. 949 (COR 12389)	4	-
Actinostemon klotzschii (Didr.) Pax	Shrub	Takahasi, A. 741 (12395); Takahasi, A. 1119 COR 12392)	3, 6	-
Astraea lobata (L.) Klotzch	Herb	Takahasi, A. 832 COR 12384)	3	-
Cnidoscolus urens (L.) Arthur	Shrub	Takahasi, A. 1304 (COR 15291)	2	-
Cnidoscolus vitifolius var. *cnicodendrum* (Griseb.) Lourteig & O'Donnell	Tree	Damasceno-Jr,G.A. 1397 (COR 13885)	1	-
Croton antisyphiliticus Mart.	Shrub	Takahasi, A. 929 (15107)	3	-
Croton campestris A. St. Hill	Shrub	André, C.B.D.S 12 (COR 15836)	9	-
Croton corumbensis S.Moore	Shrub	Takahasi, A. 801	9	-
Croton didrichsenii G.L.Webster	Shrub	Takahasi, A. 801 (COR 12382)	3	-
Croton glandulosus L.	Herb	Takahasi, A. 1320 (COR 15304)	2	-
Croton pedicellatus Kunth	Herb	Takahasi, A. 1246 (COR 15264)	4	-
Croton sarcopetaloides S.Moore	Shrub	Silva, R.H. 931 (CGMS 38773)	9	-
Croton triqueter Lam.	Shrub	Takahasi, A. 892 (COR 12385)	3	-
Dalechampia brasiliensis Lam.	Liana	Takahasi, A. 1247 (COR 15265)	4	-
Euphorbia thymifolia L.	Herb	Takahasi,A. 1370 (COR 15336)	4	-

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Continuation Table 2.

Species	Growth habit	Vouchers	Locality	Conservation status
Jatropha ribifolia (Pohl) Baill.	Shrub	Takahasi, A. 706 (COR 14998); Takahasi, A. 759(COR 15018); Takahasi, A. 710 (COR 15001)	1, 2, 3	-
Jatropha weddeliana Baill.	Shrub	Damasceno-Jr,G.A. Jr 1316 (COR 13883)	1	-
Manihot anomala Pohl	Shrub	Takahasi, A. 806 (COR 12383); Silva, R.H. 919 (CGMS 38771)	3, 10	-
Manihot guaranitica Chodat & Hassl.	Shrub	Takahasi, A. 767 (COR 15022)	2	-
Microstachys hispida (Mart.) Govaerts	Herb	Takahasi, A. 1028 (COR 15165); Silva, R.H. 937 (CGMS 38774)	3, 9	-
Fabaceae				
Aeschynomene histrix Poir.	Shrub	Damasceno-Jr,G.A. 1318; Takahasi, A. 997 (COR 15148); Takahasi, A. 821 (COR 15057); Takahasi, A. 955 (COR 15123); Pott, V.J. 4781 (CGMS 53934); Silva, R.H. 877 (CGMS 38777)	1, 3, 4, 6, 7, 8	-
Alysicarpus vaginalis (L.) DC.	Herb	Takahasi, A. 1019 (COR 15159)	2	-
Amburana cearensis (Allemão) A.C. Sm.	Tree	Lima, M.S. 283; Damasceno-Jr, G.A. 2882; Silva, R.R 864 (COR 14763)	2, 6, 7	EN (IUCN), NT (CNNFlora)
Anadenanthera colubrina (Vell.) Brenan	Tree	Lima, M.S. 277	2	-
Bauhinia leptantha Malme	Shrub	Silva, R.R 462 (UEC 141018)	7	VU (CNNFlora)
Bauhinia pentandra (Bong.) Vogel ex Steud.	Shrub	Damasceno-Jr,G.A. 1303 (COR 11173); Takahasi, A. 961 (COR 15128); Silva, R.R. 634 (UEC 141026); Silva, R.H. 913 (CGMS 38796)	1, 3, 7, 10	-
Camptosema ellipticum (Desv.) Burkart	Liana	Takahasi, A. 1041 (COR 15171); Takahasi, A. 1093 (COR 15190); Takahasi, A. 1435	2, 4, 6	-
Canavalia brasiliensis Benth.	Liana	Takahasi, A. 1374 (COR 15340)	2	-
Centrosema pascuorum Benth.	Liana	Takahasi, A. 1373 (COR 15339)	2	-
Chamaecrista flexuosa (L.) Greene	Shrub	Damasceno-Jr,G.A. 1431 (COR 13878); Takahasi, A. 1107 (COR 15197); Silva, R.R 544 (UEC 140836); Silva, R.H 881 (CGMS 38778); Souza, N. 8 (COR 15792)	1, 6, 7, 8, 9	-
Chamaecrista nictitans (L.) Moench	Shrub	Takahasi, A. 960 (COR 15127); André, C.B.D.S. 81 (COR 15840)	3, 9	LC (IUCN)
Chamaecrista serpens (L.)Greene	Shrub	Damasceno-Jr,G.A. 1302 (COR 12616); Takahasi, A. 1006 (COR 15153); Silva, R.R 546 (COR 14633); Silva, R.H. 930 (CGMS 38798)	1, 2, 7, 9	-
Chamaecrista supplex (Benth.) Britton & Killip	Herb	Takahasi, A. 885 (COR 15084)	5	-
Crotalaria pallida Aiton	Shrub	Damasceno-Jr,G.A. 2409 (COR 6462)	1	-
Dipteryx alata Vogel	Tree	Takahasi, A. 1319 (COR 15303); Takahasi, A. 684 (COR 14992); Almeida, L.W. 18 (COR 16107)	2, 5, 9	VU (IUCN)
Guibourtia hymenaefolia (Moric.) J. Léonard	Tree	Damasceno-Jr,G.A. 1340 (COR13881); Takahasi, A. 1314 (COR 15299)	1, 6	-
Hymenaea stigonocarpa Hayne	Tree	Almeida, L.W. 17 (COR 16106)	9	-
Macroptilium bracteatum (Nees & C.Mart.) Marechal & Bau	Shrub	Takahasi, A. 996 (COR 15147)	3	LC (IUCN)
Macroptilium lathyroides (L.) Urb.	Liana	Takahasi, A. 1372 (COR 15338)	2	-

Continuation Table 2.

Species	Growth habit	Vouchers	Locality	Conservation status
Mimosa bimucronata (DC.) Kuntze	Shrub	Silva, R.H. 965 (CGMS 38784); Takahasi, A. 1009 (COR 15154)	1, 2	LC (IUCN)
Mimosa candollei R.Grether	Shrub	Silva, R.R 339 (COR 14654)	7	-
Mimosa craspedisetosa Fortunato & Palese	Shrub	Silva, R.R 750 (UEC 143340)	7	-
Mimosa debilis Humb. & Bonpl. ex Willd. var. debilis	Herb	Lima, M.S. 284; Takahasi, A. 803 (COR 15043); Takahasi, A. 1140 (COR 15217); Silva, R.R 1339 (COR 14798); Silva, R.H 894 (CGMS 38780)	2, 3, 6, 7, 8	LC (IUCN)
Mimosa polycarpa Kunth	Shrub	Silva, R.R. 874 (UEC 142402)	7	-
Mimosa sensibilis var. *urucumensis* Barneby	Shrub	Takahasi, A. 1080 (COR 15179); Takahasi, A. 1087 (COR 15186); Silva, R.R 1096 (COR 14687)	3, 4, 7	-
Mimosa xanthocentra Mart.	Shrub	Takahasi, A. 1020 (COR 15160); Takahasi, A. 921 (COR 15104); Takahasi, A. 1092 (COR 15189); Takahasi, A. 958 (COR 15125); Silva, R.R. 646 (UEC 140958)	2, 3, 4, 6, 7	LC (IUCN)
Muellera variabilis (RR.Silva & AMG. Azevedo) MJ.Silva & AMG.Azevedo	Tree	Takahasi, A. 726 (COR 15010); Takahasi, A. 1137 (COR 15215)	2, 3	-
Senegalia cf. *martii* (Benth.) Seigler & Ebinger	Shrub	Damasceno-Jr,G.A. 1342 (COR 13709)	1	-
Senegalia polyphylla (DC.) Britton & Rose	Tree	Damasceno-Jr,G.A. 1346 (COR 13708)	1	-
Senegalia cf. *riparia* (Kunth) Britton & Rose ex Britton & Killip	Shrub	Damasceno-Jr,G.A. 1341 (COR 13711)	1	LC (IUCN)
Senegalia tenuifolia (L.) Britton & Rose	Shrub	Damasceno-Jr,G.A. 1351 (COR 13706); Takahasi, A, 1112 (COR 15200)	1, 2	-
Senna obtusifolia (L.) H.S.Irwin & Barneby	Shrub	Silva, R.H. 901 (CGMS 38781)	8	-
Senna occidentalis (L.) Link	Shrub	Damasceno-Jr, G.A. 1177	2	-
Senna pilifera (Vogel) H.S. Irwin & Barneby	Shrub	Takahasi, A. 707; Takahasi, A. 831 (COR 15062); Takahasi, A. 927 (COR 15106); Takahasi,A. 841 (COR 15066); Silva, R.H. 924 (CGMS 38797)	1, 2, 3, 4, 10	-
Stylosanthes acuminata M.B.Ferreira & Sousa Costa	Herb	Takahasi, A. 795 (COR 15040); Takahasi, A. 844 (15067); Takahasi, A. 956 (COR 15124); Souza, N. 10 (COR 15808)	3, 4, 6, 9	-
Stylosanthes capitata Vogel	Herb	Takahasi, A. 1108 (COR 15158)	6	-
Stylosanthes guianensis (Aubl.) Sw.	Herb	Silva, R.R. 405 (UEC 141003)	7	-
Stylosanthes montevidensis Vogel	Herb	Damasceno-Jr, G.A. 1319 (UEC 140180)	1	-
Zornia cf. *crinita* (Mohlenbr.) Vanni	Herb	Damasceno-Jr, G.A. 4785 (CGMS 52405)	1	-
Zornia latifolia Sm.	Herb	Silva, R.R 364 (COR 14650)	7	-
Zornia reticulata Sm.	Herb	Culau, R. 16 (UEC 140174); Takahasi, A. 802 (COR 15042); Silva, R.R 549 (COR 14651); Silva, R.H. 908 (CGMS 38782)	1, 3, 7, 8	-
Iridaceae				
Cipura formosa Ravenna	Herb	Silva, R.H. 949 (CGMS 38805); Takahasi, A. 1181 (COR 15233); Takahasi, A. 1261	1, 2, 4	-
Krameriaceae				
Krameria grandiflora A. St. Hill	Herb	Takahasi, A. 784; Takahasi, A. 808; Pott, V.J. 4780 (CGMS 52708); Almeida, F.L.R. 38 (COR 15848)	2, 3, 7, 9	-

Continuation Table 2.

Species	Growth habit	Vouchers	Locality	Conservation status
Lamiaceae				
Hyptis brevipes Poit.	Herb	Takahasi, A. 1012 (COR 15156); Takahasi, A. 966	2, 3	-
Mesosphaerum pectinatum (L.) Kuntze	Herb	Takahasi, A. 1267 (COR 15275)	4	-
Lythraceae				
Cuphea micrantha Kunth	Herb	Damasceno-Jr,G.A. 2408 (COR 10890); Takahasi, A. 785 (COR 15033); Takahasi, A. 994	1, 2, 4	-
Malpighiaceae				
Aspicarpa pulchella (Griseb.) O'Donell & Lourteig	Herb	Damasceno-Jr, G.A. 1306 (SP 365739); Takahasi, A. 1124 (COR 15208); Takahasi, A. 737 (COR 15014)	1, 2, 3	-
Banisteriopsis muricata (Cav.) Cuatrec	Liana	Takahasi, A. 896 (COR 15092)	3	-
Callaeum psilophyllum (A.Juss.) D.M.Johnson	Liana	Takahasi, A. 762 (COR 15019)	2	-
Dicella macroptera A.Juss.	Liana	Damasceno-Jr,G.A. 1328 (COR 9196)	1	-
Diplopterys lutea (Griseb.) W.R.Anderson & C.Davis	Liana	Damasceno-Jr,G.A. 1156 (COR 13882)	2	-
Diplopterys pubipetala (A. Juss) W.R. Anderson & C. Davis	Liana	André, C.B.D.S. 78 (COR 15839)	9	-
Heteropterys cf. *amplexicaulis* Morong	Liana	Takahasi, A. 1109 (COR 15199)	2	-
Heteropterys cochleosperma A.Juss.	Liana	André, C.B.D.S. 21 (COR 15837)	9	-
Heteropterys hypericifolia A.Juss.	Shrub	André, C.B.D.S. 80 (COR 15849)	9	-
Heteropterys cf. *tomentosa* A.Juss.	Liana	Souza, N. 9 (COR 15799)	9	-
Janusia guaranitica (A. St.-Hil.) A. Juss.	Liana	Takahasi, A. 819 (COR 15055); Pott, A. 9303 (CGMS 51180)	4, 7	-
Ptilochaeta densiflora Nied.	Tree	Damasceno-Jr,G.A. 1200 (COR 13614)	2	-
Thryallis laburnum S. Moore	Shrub	Damasceno-Jr,G.A. 1345 (COR 9408); Takahasi, A. 1358 (COR 15326)	1, 3	VU (CNNFlora)
Malvaceae				
Abutilon ramiflorum A.St.-Hil.	Shrub	Silva, R.H. 952 (CGMS 38823)	1	-
Ayenia tomentosa L.	Herb	Takahasi, A. 1081 (COR 15180); Takahasi, A. 1350 (COR 15320); André, C.B.D.S. 7 (COR 15798)	3, 4, 9	-
Corchorus hirtus L.	Herb	Damasceno-Jr,G.A. 1409 (COR 6434); Takahasi, A. 946 (COR 15118); Takahasi, A. 876 (COR 15079); Silva, R.H. 883 (CGMS 38815)	1, 4, 5, 8	-
Gaya pilosa K.Schum.	Shrub	Silva, R.H. 886 (CGMS 38816)	8	-
Helicteres lhotzkyana K.Schum.	Shrub	Matos-Alves, F. 222 (CGMS 18874); Damasceno-Jr,G.A. 1160 (COR 13677)	1, 2	-
Luehea candicans Mart.	Tree	Takahasi, A. 847 (COR 15069); Takahasi, A. 1306 (COR 15293); Silva, R.H. 890 (CGMS 38817)	1, 2, 8	-
Melochia parvifolia Kunth	Shrub	Takahasi, A. 977 (COR 15140); Silva, R.H. 892 (CGMS 38818)	3, 8	-
Melochia pyramidata L.	Shrub	Takahasi, A. 1085 (COR 15184)	3	-

Continuation Table 2.

Species	Growth habit	Vouchers	Locality	Conservation status
Pavonia sidifolia Kunth	Herb	Takahasi, A. 919 (COR 15102); Takahasi, A. 828 (COR 15061); Silva, R.H. 896 (CGMS 38819); Oliveira, P.P 329(COR 15844)	3, 4, 8, 9	-
Pseudobombax marginatum (A.St.-Hil.) A.Robyns	Tree	Takahasi, A. 1033	4	-
Sida coradinii Krapov.	Herb	Damasceno-Jr, G.A 1509 (COR 6015)	1	-
Sida cordifolia L.	Herb	Takahasi, A. 1375 (COR 15341)	4	-
Sida glomerata Cav.	Herb	Takahasi, A. 1281 (COR 15280)	4	-
Sida linifolia Juss. ex Cav.	Herb	Damasceno-Jr,G.A. 1417 (COR 2340); Takahasi, A. 1034 (COR 15166); Takahasi, A. 1090 (COR 15188); Oliveira, P.P 205 (COR 15819); Silva, R.H. 925 (CGMS 38826)	1, 3, 4, 9, 10	-
Sida rupicola Hassl. (Sida glabra Mill.)	Herb	Damasceno-Jr,G.A. 1311 (COR 13853); Takahasi, A. 1024 (COR 15161)	1, 2	-
Waltheria indica L.	Herb	Silva, R.H. 926 (CGMS 38827)	10	-
Waltheria operculata Rose	Herb	Takahasi, A. 771 (COR 15023); Takahasi, A. 711 (COR 15002); Takahasi, A. 944 (COR 15117)	2, 3, 4	-
Waltheria rotundifolia Schrank	Shrub	André, C.B.D.S. 6 (COR 15845)	9	-
Wissadula macrantha R.E.Fr.	Shrub	Damasceno-Jr, G.A. 1510; Takahasi, A. 986 (COR 15143)	1, 4	-
Molluginaceae				
Mollugo verticillata L.	Herb	Damasceno-Jr,G.A. 1322 (COR 13848); Damasceno-Jr,G.A. 1678 (COR 13847); Takahasi, A. 788 (COR 15036); Takahasi, A. 839; Silva, R.H. 895 (CGMS 38833)	1, 2, 3, 4, 8	-
Myrtaceae				
Eugenia aurata O. Berg	Shrub	Takahasi, A. 1115 (COR 5958); Silva, R.H. 934 (CGMS 38845)	3, 9	-
Eugenia punicifolia (Kunth) DC.	Shrub	Oliveira, P.P 204 (COR 15831)	9	-
Eugenia pyriformis Cambess.	Shrub	Takahasi, A. 774 (COR 5956); Takahasi, A. 794 (COR 15039)	2, 3	-
Myrcia laruotteana Cambess.	Shrub	Takahasi, A. 1264 (COR 15274)	4	-
Myrcia pyrifolia (Desv.) Nied.	Shrub	Souza, N. 33 (COR 15287)	9	-
Psidium guineense Sw.	Shrub	Silva, R.H. 922 (CGMS 38844)	10	-
Nyctaginaceae				
Reichenbachia paraguayensis (D.Parodi) Dugand & Daniel	Tree	Damasceno-Jr,G.A. 1348 (COR 9200)	1	-
Ochnaceae				
Ouratea aff. *castaneifolia* (DC.) Engl.	Tree	Takahasi, A. 1301 (COR 15288); Takahasi, A. 731	4, 5	-
Onagraceae				
Ludwigia lagunae (Morong) H. Hara	Shrub	Damasceno-Jr,G.A. 2414 (COR 10828)	1	-
Ludwigia leptocarpa (Nutt.) H. Hara	Shrub	Silva, R.H. 936 (CGMS 38849)	9	-
Orchidaceae				
Cyrtopodium virescens Rchb. f. & Warm.	Herb	Takahasi, A. 1114 (COR 15370); Damasceno-Jr, G.A. 2783 (CGMS 33893)	3, 6	-

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Continuation Table 2.

Species	Growth habit	Vouchers	Locality	Conservation status
Oxalidaceae				
Oxalis barrelieri L.	Herb	Takahasi, A. 893 (COR 15089); Takahasi, A. 816 (COR 15052)	3, 4	-
Oxalis frutescens L.	Herb	Takahasi, A. 1126 (COR 15210); Takahasi, A. 1106	2, 6	-
Passifloraceae				
Passiflora foetida L.	Liana	Takahasi, A. 1402	6	-
Piriqueta corumbensis Moura	Herb	Takahasi, A. 1052 (COR 15176)	3	-
Piriqueta morongii Rolfe	Herb	Culau, R. 18 (COR 13702)	1	-
Turnera cf. *blanchetiana* Urb.	Herb	Damasceno-Jr,G.A. 3299 (COR 13150)	1	-
Turnera grandiflora (Urb.) Arbo	Herb	Takahasi, A. 663; Takahasi, A. 897 (COR 15093); Takahasi, A. 1260 (COR 15272); Damasceno-Jr,G.A. 2791 (COR 10914); André, C.B.D.S. 13 (COR 15809)	1, 3, 4, 6, 9	-
Turnera melochioides A. St.-Hil. & Cambess.	Herb	Oliveira, P.P 206 (COR 15841)	9	-
Turnera pumilea L.	Herb	Takahasi, A. 820 (COR 15056); Takahasi, A. 1381 (COR 15343)	4, 6	-
Turnera weddelliana Urb. & Rolfe	Herb	Damasceno 1419 (COR 13630); Damasceno-Jr,G.A. 1687 (COR 13698)	1, 2	-
Phyllanthaceae				
Phyllanthus orbiculatus Rich.	Herb	Takahasi, A. 1253 (COR 12394); Silva, R.H. 897 (CGMS 38852); Almeida, L.W. 45 (COR 15815)	4, 8, 9	-
Phytolaccaceae				
Microtea scabrida Urb.	Herb	Takahasi, A. 789 (COR 15037); Takahasi, A. 879 (COR 15081)	3, 5	-
Poaceae				
Axonopus compressus (Sw.) P.Beauv.	Herb	Takahasi, A. 969 (COR 15134); Takahasi, A. 1259 (COR 11749)	3, 4	-
Axonopus pressus (Steud.) Parodi	Herb	Oliveira, P.P 324 (COR 15821)	9	-
Axonopus suffultus (J.C.Mikan ex Trin.) Parodi	Herb	Takahasi, A. 952 (COR 11752)	6	-
Chloris elata Desv.	Herb	Takahasi, A. 796 (COR 11716)	3	-
Dactyloctenium aegyptium (L.) Willd.	Herb	Takahasi, A. 1207 (COR 11715)	2	-
Digitaria bicornis (Lam.) Roem. & Schult.	Herb	Takahasi, A. 1293 (COR 11717)	3	-
Digitaria insularis (L.) Mez ex Ekman	Herb	Damasceno-Jr, G.A. 1412; Oliveira, P.P 325 (COR 15796)	1, 9	-
Digitaria sanguinalis (L.) Scop.	Herb	Silva, R.H. 884 (CGMS 38855)	8	-
Eragrostis articulata (Schrank) Nees	Herb	Silva, R.H. 885 (CGMS 38856)	8	-
Eragrostis orthoclada Hack.	Herb	Takahasi, A. 1290 (CGMS 20374)	3	LC (IUCN)
Eragrostis pilosa (L.) P.Beauv.	Herb	Silva, R.H. 933 (CGMS 38875)	9	-
Eustachys distichophylla (Lag.) Nees	Herb	Takahasi, A. 1272 (COR 11721)	4	-
Gouinia latifolia (Griseb.) Vasey	Herb	Damasceno-Jr, G.A. 1416; Takahasi, A. 1021 (COR 11739)	1, 3	-
Leptochloa virgata (L.) P.Beauv.	Herb	Silva, R.H. 889 (CGMS 38867)	8	-

Continuation Table 2.

Species	Growth habit	Vouchers	Locality	Conservation status
Megathyrsus maximus (Jacq.) B.K.Simon & S.W.L.Jacobs	Herb	Silva, R.H. 967 (CGMS 38863); Takahasi, A. 1211 (COR 11733); Takahasi, A. 981 (COR 15142); André, C.B.D.S. 18 (COR 15803)	1, 2, 3, 9	-
Melinis minutiflora P.Beauv.	Herb	Takahasi, A. 1029 (COR 11740)	3	-
Melinis repens (Willd.) Zizka	Herb	Damasceno-Jr,G.A. 1324 (COR 9194); Takahasi, A. 747 (COR 11735); Silva, R.H. 891 (CGMS 38858)	1, 3, 8	-
Mesosetum cayennense Steud.	Herb	Diamante, M. 292 (COR 15820)	9	-
Mesosetum chaseae Luces	Herb	Takahasi, A. 1204 (COR 11747); Takahasi, A. 957 (COR 11725)	4, 6	-
Microchloa indica (L.f.) P.Beauv.	Herb	Takahasi, A. 1172 (COR 11730); Takahasi, A. 898; Takahasi, A. 1351 (COR 15321); Silva, R.H. 920 (CGMS 38873)	2, 3, 4, 10	-
Oplismenus hirtellus (L.) P.Beauv.	Herb	Takahasi, A. 1274 (COR 11722)	4	-
Panicum exiguum Mez	Herb	Takahasi, A. 1183 (COR 15235); Takahasi, A. 1150 (COR 11741); Takahasi, A. 1276 (COR 11751)	2, 3, 4	-
Panicum millegrana Poir.	Herb	Takahasi, A. 1292 (COR 11727)	6	LC (IUCN)
Panicum sellowii Nees	Herb	Silva, R.H 938 (CGMS 38876)	9	-
Panicum stramineum Hitchc. & Chase	Herb	Silva, R.H. 968 (CGMS 38864)	1	-
Panicum trichoides Sw.	Herb	Takahasi, A. 883	5	-
Pappophorum pappiferum (Lam.) Kuntze	Herb	Takahasi, A. 855 (COR 11714)	2	-
Paspalum malacophyllum Trin.	Herb	Takahasi, A. 1273 (COR 11750); Takahasi, A. 1162 (COR 15226)	4, 6	-
Paspalum plicatulum Michx.	Herb	Takahasi, A. 1157 (COR 11743); Takahasi, A. 1249 (COR 11748); Silva, R.H. 921 (CGMS 38874)	3, 4, 10	-
Rugoloa polygonata (Schrad.) Zuloaga	Herb	Takahasi, A. 1234 (COR 11734)	2	-
Schizachyrium condensatum (Kunth) Nees	Herb	Takahasi, A. 999 (COR 11719)	4	-
Schizachyrium cf. *sanguineum* (Retz.) Alston	Herb	Damasceno-Jr,G.A. 1429 (COR 6410)	1	-
Setaria parviflora (Poir.) Kerguélen	Herb	Damasceno-Jr,G.A. 1495 (COR 6012); Takahasi, A. 870 (COR 11728); Takahasi, A. 1294 (COR 11718); Oliveira, P.P. 328 (15822)	1, 2, 3, 9	LC (IUCN), CR (CNNFlora)
Setaria vulpiseta (Lam.) Roem. & Schult.	Herb	Silva, R.H. 902 (CGMS 38859)	8	-
Sporobolus aeneus (Trin.) Kunth var. aeneus	Herb	Damasceno-Jr,G.A. 1323 (COR 6413)	1	-
Sporobolus indicus (L.) R.Br.	Herb	Damasceno-Jr,G.A. 2410 (COR 10930); Takahasi, A. 968 (COR 15133); Takahasi, A. 1255 (COR 15271); Oliveira, P.P 207 (COR 15832)	1, 3, 4, 9	-
Sporobolus monandrus Roseng., B.R.Arrill. & Izag.	Herb	Takahasi, A. 1016 (COR 15157); Takahasi, A. 787 (COR 15035); Takahasi, A. 982 (COR 11745); Takahasi, A. 1289 (CGMS 20378); Silva, R.H. 903 (CGMS 38860)	2, 3, 4, 6, 8	-
Sporobolus tenuissimus (Schrank.) Kuntze	Herb	Culau, R. 51 (COR 6424)	2	-
Steinchisma cf. *laxum* (Sw.) Zuloaga	Herb	André, C.B.D.S. 35 (COR 15813)	9	-

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Continuation Table 2.

Species	Growth habit	Vouchers	Locality	Conservation status
Tripogon spicatus (Nees) Ekman	Herb	Damasceno-Jr, G.A. 1522; Takahasi, A. 1131 (COR 11729); Takahasi, A. 1154 (COR 11742); Takahasi, A. 1168 (COR 11746); Takahasi, A. 873 (COR 15078)	1, 2, 3, 4, 5	-
Urochloa adspersa (Trin.) R.D.Webster	Herb	Takahasi, A. 1277 (COR 11755)	4	-
Urochloa brizantha (Hochst. ex A. Rich.) R.D.Webster	Herb	Damasceno-Jr, G.A. 1394 (COR 6414); Takahasi, A. 1184 (COR 11732)	1, 2	-
Urochloa plantaginea (Link) R.D.Webster	Herb	Silva, R.H. 906 (CGMS 38861)	8	-
Polygalaceae				
Asemeia monninoides (Kunth) J.F.B.Pastore & J.R.Abbott	Herb	Culau, R. 30 (COR 13622)	1	-
Bredemeyera floribunda Willd.	Liana	Takahasi, A. 1101 (COR 15195); Takahasi, A. 1037 (COR 15168); Takahasi, A. 1038; Souza, N. 26 (COR 15826)	2, 3, 4, 9	-
Portulacaceae				
Portulaca amilis Speg.	Succulent	Silva, R.H. 969 (CGMS 38883); Takahasi, A. 1128 (COR 15211)	1, 2	-
Portulaca halimoides L.	Succulent	Takahasi, A. 1371 (COR 15337)	2	-
Portulaca hoehnei D. Legrand	Succulent	Pott, V.J. 7407 (CGMS 55952)	1	-
Portulaca mucronata Link	Succulent	Takahasi, A. 1218 (COR 15250); Takahasi, A. 809 (COR 15047); Takahasi, A. 1254 (COR 15270); Takahasi, A. 882 (COR 15083)	2, 3, 4, 5	-
Portulaca mucronulata D. Legrand	Succulent	Takahasi, A. 1193 (COR 15242); Takahasi, A. 970 (COR 15135); Takahasi, A. 1139 (COR 15216); Takahasi, A. 888 (Cor 15087)	2, 3, 4, 5	-
Portulaca pilosa L.	Succulent	Takahasi, A. 800 (COR 15041); Takahasi, A. 1305 (COR 15292)	3, 4	-
Portulaca umbraticola Kunth	Succulent	Takahasi, A. 1367 (COR 15333); Takahasi, A. 1361 (COR 15329)	3, 4	-
Talinum fruticosum (L.) Juss.	Succulent	Takahasi, A. 909 (COR 15099)	3	-
Rhamnaceae				
Gouania lupuloides (L.) Urb.	Liana	Damasceno-Jr,G.A.-Jr 1305 (COR 9190); Damasceno-Jr, G.A. 1176; Takahasi, A. 881	1, 2, 5	-
Ziziphus oblongifolia S. Moore	Tree	Damasceno-Jr, G.A. 5320 (CGMS 41018)	1	-
Rubiaceae				
Borreria capitata (Ruiz & Pav.) DC.	Herb	Damasceno-Jr,G.A. 1313 (COR 5320)	1	-
Borreria verticillata (L.) G.Mey.	Herb	Takahasi, A. 1190 (COR 15240); Takahasi, A. 1138 (COR 12405); Silva, R.H. 879 (CGMS 38885)	2, 4, 8	-
Cordiera concolor (Cham.) Kuntze	Tree	Takahasi, A.1407	6	-
Coutarea hexandra (Jacq.) K.Schum.	Shrub	Damasceno-Jr, G.A. 1405 (UB 30281); Takahasi, A. 906 (COR 12401); Souza, N. 32 (COR 15851); Silva, R.H. 916 (CGMS 38894)	1, 3, 9, 10	-
Randia armata (Sw.) DC.	Shrub	Takahasi, A. 743 (COR 12400); Silva, R.H. 923 (CGMS 38895)	3, 10	-
Spermacoce gracillima (DC.) Delprete	Herb	Damasceno-Jr,G.A. 1327 (COR 5321)	1	-

Continuation Table 2.

Species	Growth habit	Vouchers	Locality	Conservation status
Staelia thymoides Cham. & Schltdl.	Herb	Pott, A. 9279 (CGMS 37441); Silva, R.H. 904 (CGMS 38887)	7, 8	-
Tocoyena formosa (Cham. & Schltdl.) K.Schum.	Shrub	Damasceno-Jr,G.A. 1408 (COR 5323); Takahasi, A. 1146 (COR 12399); Takahasi, A. 805 (COR 15045)	1, 2, 3	-
Rutaceae				
Esenbeckia almawillia Kaastra	Shrub	Damasceno-Jr,G.A. 3295 (COR 13166)	1	-
Helietta puberula R.E. Fr.	Tree	Takahasi, A. 1176 (COR 15231); Takahasi, A. 1354 (COR 15323); Takahasi, A. 871 (COR 15077); Silva, R.H. 918 (CGMS 38900)	2, 4, 5, 10	-
Salicaceae				
Casearia gossypiosperma Briq.	Tree	Takahasi,A. 1086 (COR 15185); Takahasi, A. 1415; Oliveira, P.P 203 (COR 15852)	4, 6, 9	-
Casearia sylvestris Sw.	Tree	Takahasi, A. 1057 (COR 15178)	3	-
Xylosma venosa N.E.Br.	Tree	Silva, R.H. 927 (CGMS 38901)	10	-
Sapindaceae				
Serjania caracasana (Jacq.) Willd.	Liana	Takahasi, A. 1188 (COR 15238); Takahasi, A. 1027 (COR 15164)	2, 3	-
Serjania marginata Casar.	Liana	Damasceno-Jr,G.A. 1330 (COR 13705)	1	-
Thinouia paraguayensis (Britton) Radlk.	Liana	Damasceno-Jr,G.A. 1518 (COR 6089)	1	-
Urvillea laevis Radlk.	Liana	Damasceno-Jr,G.A. 1512 (COR 6081)	1	-
Sapotaceae				
Pouteria torta (Mart.) Radlk.	Tree	Takahasi, A. 1166 (COR 15228)	4	-
Smilacaceae				
Smilax cf. *fluminensis* Steud.	Liana	Takahasi, A. 1045 (COR 15173)	4	-
Verbenaceae				
Stachytarpheta matogrossensis Moldenke	Herb	Takahasi, A. 703; Takahasi, A. 1231 (COR 15258); Takahasi, A. 744; Takahasi, A. 886 (COR 15085); Takahasi, A. 1164	1, 2, 3, 5, 6	-

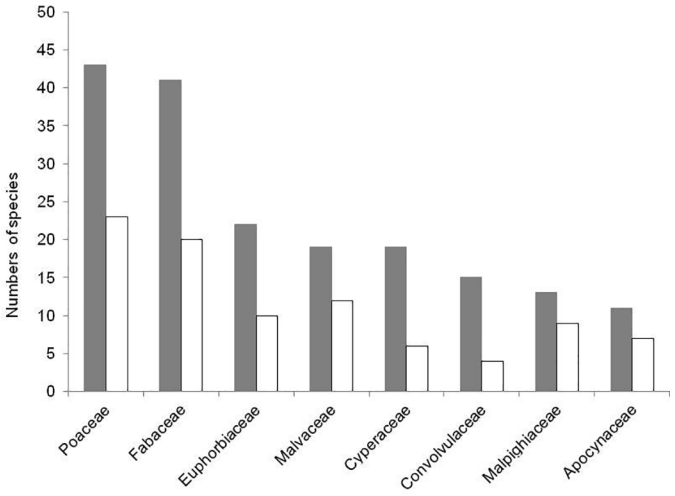

Figure 2. Number of species (gray bar) and genera (white bar) of the richest families found on the cangas at the Urucum Plateau, Western Border of Pantanal, MS.

E. Holzh. and *Borreria verticillata* (L.) G.Mey. In the seasonally wet areas we can find species such as *Ludwigia lagunae* (Morong) H. Hara, *Crotalaria pallida* Aiton, *Sporobolus indicus* (L.) R.Br. and *Eleocharis contracta* Maury ex Micheli.

Based on the species list of Flora do Brasil 2020, among the total number of recorded species, 177 (58.61%) are of wide distribution, occurring in almost all regions in Brazil, such as *Acrocomia aculeata* (Jacq.) Lodd. ex Mart., *Anadenanthera colubrina* (Vell.) Brenan, *Bromelia balansae* Mez, *Conyza bonariensis* (L.) Cronquist, *Handroanthus impetiginosus* (Mart. ex DC.) Mattos, *Myracrodruon urundeuva* Allemão, *Ludwigia leptocarpa* (Nutt.) H. Hara and *Urochloa brizantha* (Hochst. ex A. Rich.) R.D.Webster. Other species are recorded as common in other biomes, such as *Myrcia pyrifolia* (Desv.) Nied. (Amazon Rainforest), *Sida coradinii* Krapov. and *Zephyranthes cearensis* (Herb.) Baker (Caatinga), *Aspidosperma quirandy* Hassl. (Atlantic Forest), *Frailea cataphracta* (Dams) Britton & Rose, *Digitaria sanguinalis* (L.) Scop. and *Staelia thymoides* Cham. & Schltdl. (Pampas).

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Twenty species are listed in the International Union Conservation of Nature and Natural Resources (IUCN 2018) as endangered species, and nine species in the Red Book of Brazilian flora (Martinelli & Moraes 2013), (Table 2). The species *Muellera variabilis* (RR.Silva & AMG.Azevedo) MJ.Silva & AMG.Azevedo, *Gomphrena centrota* E. Holzh., *Bonamia balansae* Hallier f. and *Bauhinia leptantha* Malme are considered as rare species because of their restricted distribution or the scarcity of information on the size of their populations (Giulietti et al. 2009). Two species are considered endemic to the ironstone outcrops at the Urucum Plateau: *G. centrota* (Tomás et al. 2010) and *Discocactus ferricola* Buining & Brederoo, being the latter also present in Morro do Mutum, Bolivia (Tomás et al. 2010, Takahasi & Meirelles 2014).

The herbaceous habit was the predominant growth form on ironstone outcrops in the Urucum Plateau (47.02%), probably due to the high species richness in the families Poaceae and Cyperaceae, and the high frequency of herbaceous species in Malvaceae, Fabaceae and Passifloraceae (Figure 3). Shrub (21.85%) and arboreal species (10.26%) were also common in these areas, with great contribution of Fabaceae, Euphorbiaceae, Malvaceae, Myrtaceae and Apocynaceae.

Lianas (13,91%) were represented by the families Convolvulaceae, Malpighiaceae and Apocynaceae mainly (Figure 3). Although succulent species represent only 6.29% of the richness of the local flora, they are quite conspicuous in the landscape, forming dense mats of vegetation composed of *Bromelia balansae* Mez, *Deuterochnonia meziana* Kuntze ex Mez, *Opuntia retrorsa* Speg. and rupicolous vegetation of *Portulaca* sp.

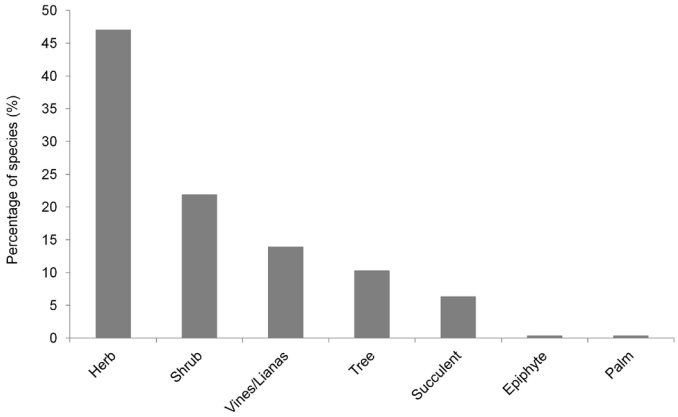

Figure 3. Growth habit of the species found on canga areas at the Urucum Plateau, Western Border of Pantanal, MS.

Considering the floristic associations present on the rocky outcrops at the Urucum plateau, we can distinguish ecological relationships between vegetation and edaphic variables, such as *Gomphrena centrota* E. Holzh., *Discocactus ferricola* Buining & Brederoo and *Polycarpaea corymbosa* (L.) Lam., that lodge directly on the hardened substrate, on slopes or in small cavities and fissures, covering rocky substrates; and soil islands, generally formed by mats of *Bromelia balansae* Mez and *Deuterocohnia meziana* Kuntze ex Mez, containing in their interior trees or shrubs of *Acrocomia aculeata* (Jacq.) Lodd. ex Mart., *Bauhinia pentandra* (Bong.) Vogel ex Steud., *Commiphora leptophloeos* (Mart.) J.B. Gillett, *Myracrodruon urundeuva* Allemão and *Tocoyena formosa* (Cham. & Schltdl.) K.Schum., among others (Takahasi 2010, Takahasi & Meirelles 2014, Takahasi 2015; Figure 4 F). At the edges of soil islands, there are also many herbaceous and annual species, such as *Borreria capitata* (Ruiz & Pav.) DC., *Calea rupicola* Chodat, *Mimosa bimucronata* (DC.) Kuntze, *M. xantocentra* Mart. and *Waltheria operculata* Rose, which desiccate completely during the dry season. Other species such as *Portulaca mucronata* Link, *Cipura formosa* Ravenna and *Zephyranthes cearensis* (Herb.) Baker occur in seasonally flooded sites at topographically lower areas (Takahasi & Meirelles 2014, Takahasi 2015, Figure 4 C).

About 58.28% of the species were found in only one of the ironstone outcrops at the Urucum Plateau, and none of the species was recorded in all 10 analyzed areas. The similarity índex (Table 3) in the composition of the angiosperm flora between the ironstone outcrops was low and ranged from 0 (Rabicho farm, P8 and the Municipal Natural Park Piraputangas, P10) to 41% (Pantanal Park Road, P1 and Band'alta farm, P2).

By crossing data contained in SpeciesLink (CRIA 2018), Flora do Brasil 2020 (2018), Jabot (2018) and checklists of Flora from Mato Grosso do Sul state (Pott & Pott 1996, Schutz 2014, Profice et al. 2015, Machate et al. 2016, Araújo & Trevisan 2018, Barbosa 2018, Bortolotto et al. 2018, Damasceno-Junior et al. 2018, Farinaccio & Simões 2018, Fiaschi 2018, Francener et al. 2018, Groppo et al. 2018, Guglieri-Caporal et al. 2018, Lobão et al. 2018, Loiola & Cordeiro 2018, Panfiglio et al. 2018, Proença et al. 2018, Roque et al. 2018, Sartori et al. 2018, Secco et al. 2018, Versieux et al. 2018, Zappi et al. 2018), it was verified that from the species presented here, 27 were not previously recorded for Mato Grosso do Sul and three species have no information of occurrence in Brazil (Table 4).

Discussion

Previous works on floristics, phytosociology and/or phenology indicated the occurrence of 243 species distributed in 66 botanical families, including pteridophytes (Takahasi 2010, Takahasi & Meirelles 2014, Takahasi 2015, Oliveira 2016), not included in this study. Thus, this study added 59 new occurrences of species of angiosperms to the ironstone outcrops flora in the Urucum Plateau. The high richness of species found, similar to other ferruginous outcrops areas (Jacobi et al. 2007, Mourão & Stehmann 2007, Viana & Lombardi 2007, Pifano et al. 2010, Jacobi & Carmo 2008b, Jacobi & Carmo 2011, Carmo & Jacobi 2013, Skirycz et al. 2014), may be related to the proximity of seasonal forest patches bordering these formations, and related to the existence of cavities that allow the accumulation of soil and water pools, resulting in microhabitats that enable a variety of plant associations (Jacobi & Carmo 2008a, Takahasi & Meirelles 2014).

The high turnover of species between the areas of ironstone outcrops sampled, together with the seasonality, where some species are only perceived during the rainy season, help to explain the high richness found in these environments. Another factor that contributes to species richness is the presence of subspontaneous and ruderal species from adjacent pastures, such as *Megathyrsus maximus* (Jacq.) B.K.Simon & S.W.L.Jacobs and *Melinis minutiflora* P.Beauv.

Overall, species are established according to the topographic characteristics in the environment and the substrate granulometry, so that the structure and spatial-temporal distribution of the species are not homogeneous on ironstone outcrops (Takahasi & Meirelles 2014).

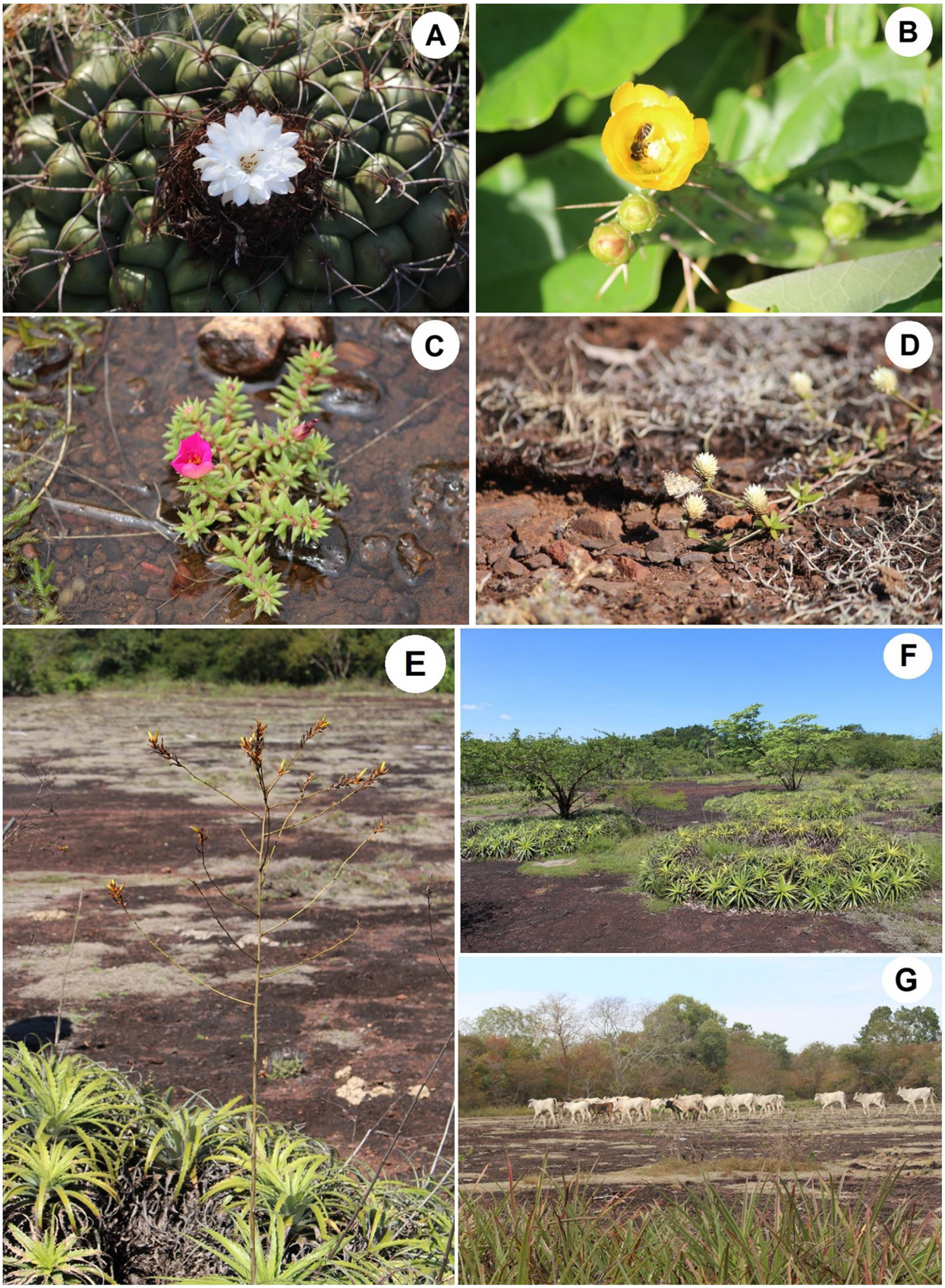

Figure 4. Species from the cangas plant community at the Urucum Plateau. A) *Discocactus ferricola*, B) *Opuntia retrorsa*, C) *Portulaca mucronata* in a flooded rocky substrate área, canga in the Band'alta farm, D) *Gomphrena centrota*, endemic species of the region, E) *Deuterocohnia meziana*. Cangas environments (Band'alta farm): F) Soil islands with densification of *Deuterocohnia meziana* and arboreal-shrub species in the center. In the background, seasonal forests bordering the rocky substrates, G) the vulnerability of the cangas of the region against anthropic pressure, e.g. by grazing livestock.

Table 3. Sorensen index among the cangas (P1-P10) at the Urucum Plateau, Western Border of Pantanal, MS. The numbers of localities are shown in Table 1.

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
P1	1	0.418	0.333	0.236	0.176	0.095	0.118	0.143	0.127	0.063
P2		1	0.384	0.317	0.200	0.155	0.108	0.134	0.093	0.066
P3			1	0.370	0.158	0.143	0.158	0.203	0.237	0.170
P4				1	0.210	0.205	0.133	0.165	0.175	0.124
P5					1	0.069	0.043	0.120	0.030	0.053
P6						1	0.172	0.194	0.101	0.040
P7							1	0.200	0.119	0.105
P8								1	0.085	0
P9									1	0.068
P10										1

Table 4. List of species first mentioned for the state of Mato Grosso do Sul and for Brazil.

Species	Determiner	Geographical distribution	Domain	Reference
Acanthaceae				
Justicia cf. *harleyi* Wassh.	D.T. Azevedo	BA, MG	Cerrado, Caatinga	Cortês & Rapini (2013), Profice et al. (2015)
Amaranthaceae				
Alternanthera flavescens Kunth	L. Senna (VII/2015)	wide distribution	Amazon Rainforest, Cerrado, Atlantic Forest	Senna (2015)
Alternanthera rufa (Mart.) D.Dietr.	L. Senna (VII/2015)	BA, MG, SP, PR	Cerrado Caatinga	Senna (2015)
Amaryllidaceae				
Zephyranthes cearensis (Herb.) Baker	R. Oliveira	Northeast, TO, GO, MT, MG	Caatinga, Cerrado	Dutilh & Oliveira (2015)
Apocynaceae				
Forsteronia thyrsoidea (Vell.) Müll. Arg.	No determiner	wide distribution	Cerrado, Atlantic Forest	Koch et al. (2015)
Convolvulaceae				
Evolvulus cf. *chrysotrichos* Meisn.	R.S.Bianchini X/2003	MG, SP	Cerrado, Atlantic Forest	Simão-Bianchini & Ferreira (2015)
Evolvulus lithospermoides Mart.	R.S.Bianchini V/2009	PA, BA, CE, GO, MT, MG	Amazon Rainforest, Cerrado	Simão-Bianchini & Ferreira (2015)
Ipomoea cf. *hieronymi* (Kuntze) O'Donell	G. Staples V/2016	Bolivia, Argentina	no info	Missouri Botanical Garden (2018)
Cyperaceae				
Cyperus cuspidatus Kunth	A.P.Prata XI/2003	North, Northeast	Amazon Rainforest, Caatinga	Alves et al. (2015)
Cyperus subcastaneus D.A. Simpson	R.Trevisan VI/2008	BA, PE, MG	Caatinga, Cerrado	Alves et al. (2015)
Rhynchospora contracta (Nees) J.Raynal	A.P.Prata XI/2003	Northeast	Caatinga, Cerrado, Atlantic Forest	Alves et al. (2015)
Euphorbiaceae				
Manihot guaranitica Chodat & Hassl.	M. Mendoza I/2016	Argentina, Bolívia, Paraguai	No info	Missouri Botanical Garden (2018)

Continuation Table 4.

Species	Determiner	Geographical distribution	Domain	Reference
Fabaceae				
Chamaecrista supplex (Benth.) Britton & Killip	R.R Silva	wide distribution	Amazon Rainforest, Caatinga, Cerrado, Atlantic Forest	Souza & Bortoluzzi (2015)
Iridaceae				
Cipura formosa Ravenna	No determiner	North, MT, GO, BA	Cerrado	Chukr (2015)
Lamiaceae				
Mesosphaerum cf. *pectinatum* (L.) Kuntze	No determiner	Northeast, Sudeste, PA, PR, SC	Amazon Rainforest, Caatinga, Cerrado, Atlantic Forest	Harley et al. (2015)
Malvaceae				
Gaya pilosa K.Schum.	R.H.Silva III/2013	DF, MG, SP, PR, RS	Cerrado, Atlantic Forest	Esteves & Takeuchi (2015)
Sida coradinii Krapov.	A.Krapovickas X/2003	BA, PI	Caatinga	Bovini (2015)
Waltheria operculata Rose	G.L.Esteves X/2009	MT, GO, BA, PB, PE, RN,MG, RJ	Caatinga, Cerrado, Atlantic Forest, Pantanal	Esteves (2015)
Waltheria rotundifolia Schrank	P.P.Oliveira	BA, PE, PI, RN	Caatinga, Cerrado	Esteves (2015)
Myrtaceae				
Myrcia pyrifolia (Desv.) Nied.	No determiner	PA, AC, AM	Amazon Rainforest	Sobral et al. (2015)
Poaceae				
Digitaria sanguinalis (L.) Scop.	R.H.Silva III/2013	RS	Pampa	Canto-Dorow (2015)
Sporobolus tenuissimus (Schrank.) Kuntze	T.S.Filgueiras X/2001	wide distribution	Amazon Rainforest, Caatinga, Cerrado, Atlantic Forest	Longhi-Wagner (2015)
Polyganaceae				
Asemeia monninoides (Kunth) J.F.B.Pastore & J.R.Abbott	A.C.Aguiar IX/2003	Sudeste, TO, BA, DF, GO	Cerrado, Atlantic Forest	Pastore et al. (2015)
Portulacaceae				
Portulaca halimoides L.	A.O.P.Coelho VI/2010	Northeast, AP, PA, RR, TO, DF, GO, ES, MG, RJ	Amazon Rainforest, Caatinga, Cerrado, Atlantic Forest	Coelho & Zappi (2015)
Portulaca hoehnei D. Legrand	A.O.P.Coelho X/2004	MS	No info	Missouri Botanical Garden (2018)
Portulaca mucronulata D. Legrand	A.O.P.Coelho VI/2010	Argentina	No info	Missouri Botanical Garden (2018)
Rubiaceae				
Spermacoce gracillima (DC.) Delprete	P.Delpetre 1998	GO, TO	Cerrado	Cabral e Salas (2015)

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The topographic development of these formations resulted in unique habitats such as fissures, cavities, small temporary ponds, depressions and exposed rocks, which differ from adjacent landscapes, constituting refuges for species adapted to xeric and mesic conditions (Jacobi et al. 2007, Jacobi & Carmo 2008b).

During the driest season of the year, most of the ironstone outcrops species present intense deciduousity, assuming a similar xeric aspect to that found in other ferruginous geosystems in Brazil (Mota et al. 2015). The difficulty for soil drainage, associated with climatic conditions in the region, gave rise to a prickly vegetation, physiognomically similar to the Caatinga, adapted to extreme conditions of evapotranspiration, thermal amplitude, underdeveloped soil, presence of heavy metals and drought periods in the region (Loureiro et al. 1982, Jacobi & Carmo 2008a, Jacobi et al. 2015). These adaptations may involve partial or total loss of aerial structures in the dry season, succulence, pseudo-bulbs in orchids, clonal reproduction, imbricate leaves, slow growth and CAM photosynthesis in order to resist desiccation cycles and subsequent rehydration (Jacobi et al. 2007, Jacobi & Carmo 2008b, Skirycz et al. 2014, Jacobi et al. 2015).

The predominance of species of wide distribution differs from that expected for ironstone outcrops in other regions of Brazil, where there are occurrences of exclusive species and different species from neighboring ecosystems (Skirycz et al. 2014). The deciduous forests in the Urucum Plateau that border the ironstone outcrops are characterized by the confluence of species from different biomes that surround it, keeping floristic relationships with the Bosque Seco Chiquitano in Bolivia (Jardim et al. 2003), and representatives from Chaco, Cerrado, Amazon Rainforest, Atlantic Forest and Southern Forests in the south and east (Rizzini 1997, Pott & Pott 2003, Tomás et al. 2010). In addition, it presents common species to the Caatinga, a vestige of a vegetative distribution pattern of the Pleistocene period. The period was characterized by a dry climate which resulted in the expansion of the seasonal forests and the retreat of the humid forests, allowing the connection of the previously disjunct vegetation of Northeast and Midwest regions of Brazil and Argentina (Prado & Gibbs 1993, Linares-Palomino et al. 2003).

The high proportion of herbaceous and arboreal-shrub species is explained by the representativeness of the families Fabaceae and Poaceae, similar to the results found for other plant communities in ferruginous outcrops in Brazil (Mourão & Stehmann 2007, Viana & Lombardi 2007, Pifano et al. 2010, Jacobi & Carmo 2011, Carmo & Jacobi 2013, Skirycz et al. 2014). On the other hand, the family Asteraceae, that is well represented in ironstone outcrops of other regions of the country (Mourão & Stehmann 2007, Viana & Lombardi 2007, Pifano et al. 2010, Ataíde et al. 2011), presented low species richness in the studied region. According to Rizzini (1997), the cangas are hardened ferrous formations and therefore have discontinuous vegetation and are typically covered by very specialized herbaceous vegetation, while on its edge woody species remain. The families Poaceae and Fabaceae are not abundant only on ironstone outcrops of the Urucum Plateau, but also among the herbaceous and woody groups, and in general between Angiosperms in Brazil (Forzza et al. 2010, BFG 2015).

Sørensen's similarity estimates found between the areas were low, with values below 0.5, which corroborates other studies indicating high beta diversity for these phytophysiognomies (Mourão & Stehmann 2007, Jacobi & Carmo 2008b, Pifano et al. 2010, Messias et al. 2012). The areas of Pantanal Park Road and Band'alta farm are the closest to each other, which justifies the highest similarity found. However, it should be noted that due to the species surveying method used in this study, sampling effort among the ironstone outcrops was not uniform. Thus, some common and abundant species may not have been listed for some of the ironstone outcrops because they represent species already cataloged for the environment, this way reducing similarity between some areas. In rupestrian grassland on ferruginous outcrops in Iron Quadrangle (Jacobi & Carmo 2008b) low proportion (5%) of common species was found among the analyzed areas, suggesting high beta diversity, probably resulting from the topographic and microclimatic variations in the habitat between areas.

Recent studies have updated the occurrence of some of the species recorded here for Mato Grosso do Sul such as *Tradescantia boliviana* (Hassk.) J.R.Grant (Pellegrini et al. 2017), *Deuterohconia meziana* Kuntze ex Mez (Schutz 2014), *Dyckia excelsa* Leme (Paggi et al. 2015) and *Tarenaya eosina* (J.F.Macbr.) Soares Neto & Roalson, a species considered endemic to Paraguay (Costa-e-Silva 2000, Soares-Neto et al. 2018). *Portulaca hoehnei* D. Legrand is not a species of occurrence for Brazil, although its holotype is from the region of Corumbá (Hoehne R 3565). New occurrences of species in the ironstone outcrops of the Urucum Plateau demonstrate the need for continuous research to update the knowledge about the size and distribution of the species that occur in these formations, and the level of conservation in which they are found.

Although the ironstone outcrops in the Urucum Plateau do not directly undergo mineral extractive activity, due to their location at the foothill and relative distance of the mines of iron and manganese extraction, these environments are under intense anthropic action. Extraction of ornamental species such as orchids, bromeliads and cacti for sale at local fairs, grazing by cattle, fire action and removal of local vegetation by owners are pressures undergone by the flora from these areas (Takahasi & Meirelles 2014, Figure 4 G).

Even in a situation of maximum vulnerability, less than 1% of canga areas in Brazil are included in Full Protected Conservation Units, such as National and State Parks (Carmo et al. 2012). The high diversity and presence of endemic, rare, endangered and/or not yet cataloged species for the Urucum Plateau region, reinforces the need for local conservation units that can guarantee the preservation of these species, since the environmental protection areas in the region are insufficient to guarantee the maintenance of typical populations from this habitat (Tomás et al. 2010). In addition, our data can significantly contribute for changing the conservation status of some species, since only 13% of the rare species present in ferruginous geosystems from Brazil are cited in the List of Endangered Species, in large part due to insufficient data for this type of environment (Giulietti et al. 2009, Jacobi et al. 2015).

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Author Contributions

Michele Soares de Lima: Substantial contribution in the concept and design of the study, contribution to data collection, contribution to data analysis and interpretation, contribution to manuscript preparation, contribution to critical rrevision, adding intelectual content.

Adriana Takahasi: Substantial contribution in the concept and design of the study, contribution to data collection, contribution to data analysis and interpretation, contribution to manuscript preparation, contribution to critical rrevision, adding intelectual content.

Geraldo Alves Damasceno-Junior: Substantial contribution in the concept and design of the study, contribution to data collection, contribution to data analysis and interpretation, contribution to manuscript preparation, contribution to critical rrevision, adding intelectual content.

Andréa Cardoso Araujo: Substantial contribution in the concept and design of the study, contribution to data analysis and interpretation, contribution to manuscript preparation, contribution to critical rrevision, adding intelectual content.

Conflicts of interest

The authors declare that they have no conflict of interest related to the publication of this manuscript.

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