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Inventory

Diversity of insect galls from Mato Grosso State, Brazil: Cerrado

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Abstract: The Midwest region of Brazil possesses large areas dominated by the Cerrado that is poorly known concerning insect gall and their interactions. In this study, we inventory the gall morphology, host plants, and the gall makers from Parque Nacional da Chapada dos Guimarães, Mato Grosso State, in areas of natural vegetation from Cerrado, for the first time. Samplings occurred in two expeditions, July 2012 and January 2013. We characterized 295 morphotypes of insect galls in 140 host plant species, with 89 gall makers; the richest family in host plants was Fabaceae (16.7%), and the species was *Protium heptaphyllum* (Aubl.) Marchand (Burseraceae, 3.7%). Parque Nacional da Chapada dos Guimarães is the richest Brazilian cerrado area in gall morphotypes (295) and the second in average morphotypes/host plant species (2.1). Additionally, six genera and 38 species are new records as host plants; two of them, *Bernardia similis* Pax and K.Hoffm and *Ormosia macrophylla* Benth., are new occurrences for Mato Grosso State, and other two, *Vochysia petraea* Warm. and *Talisia subalbens* (Mart.) Radlk. are listed in the Red List of Threatened Species IUCN. This inventory data represents a testimony of insect-plant interactions in a Brazilian Cerrado area that was consumed by an unprecedented fire in the dry season of 2020.
Keywords: *Biodiversity; Brazilian savannah; gall makers; Neotropical region; insect-plant interaction.*

Diversidade de galhas de insetos do Estado do Mato Grosso, Brasil: Cerrado

Resumo: A região Centro-Oeste do Brasil possui grandes áreas dominadas pelo Cerrado nas quais insetos e suas interações são pouco conhecidos. Neste estudo, fizemos o inventário de galhas, plantas hospedeiras e galhadores do Parque Nacional da Chapada dos Guimarães, Mato Grosso, uma área de vegetação natural de Cerrado. As amostragens foram realizadas em duas expedições, em julho de 2012 e janeiro de 2013. Caracterizamos 295 morfotipos de galhas de insetos em 140 espécies de plantas hospedeiras; com identificação de 89 galhadores; a família de plantas com maior número de espécies hospedeiras de galhas foi Fabaceae (16,7%) e a espécie com maior número de galhas, *Protium heptaphyllum* (Aubl.) Marchand (Burseraceae, 3,7%). Esta é a área mais rica em morfotipos de galhas do cerrado brasileiro (295) e a segunda na média de morfotipos/espécie de planta hospedeira (2,1). Além disso, seis gêneros e 38 espécies são registros novos de ocorrência de plantas hospedeiras para galhas de insetos; duas delas, *Bernardia similis* Pax and K.Hoffm and *Ormosia macrophylla* Benth., são registros novos para o Estado do Mato Grosso e outras duas, *Vochysia petraea* Warm. and *Talisia subalbens* (Mart.) Radlk. estão listadas na Lista Vermelha de Espécies Ameaçadas IUCN. Os dados desse inventário representam um testemunho das interações inseto-planta para o Cerrado no Brasil, em uma área que foi consumida por um incêndio sem precedentes na estação seca de 2020.
Palavras-chave: *Biodiversidade; galhadores; interação inseto-planta; região Neotropical; savana brasileira.*

Introduction

Insect–plant interactions are among the most interesting subjects in science, and inventories of the association between host plants and insect gall makers are among the trend topics of studies in the scientific community dedicated to this theme in Brazil. In the last 30 years, more than 50 inventories focusing on insect galls were performed in all Brazilian biomes, with predominance in Atlantic Forest and Cerrado, with 23 and 22 inventories, respectively (Araújo et al. 2019).

The Cerrado from central Brazil harbors the most significant extent of savanna in the Neotropics (Bueno et al. 2018), and it is facing alarming record rates of deforestation (Russo et al. 2018), massively in the Southeast region (~60%), especially in the State of Minas Gerais (~33%). Depending on its geographic distribution, it is affected by innumerous environmental conditions, like soil fertility, water availability, and temperature. Regarding the composition of its phytophysiognomies, Cerrado is severely influenced by adjacent biomes (Bueno et al. 2018). The phytophysiognomies distributed in the states of Minas Gerais, São Paulo, Bahia, Piauí, Maranhão, and the eastern region of Tocantins and Goiás are influenced by the conditions of the Atlantic Forest and Caatinga biome. In contrast, the composition of the vegetation distributed in the States of Mato Grosso do Sul, Mato Grosso, western Goiás, and Tocantins are influenced by the environmental conditions of Amazon, Pantanal, and Chaco biomes. All these complexities make Cerrado the focus of many studies.

Although most of the inventories of the insect galls communities were done in the Cerrado environment, most were restricted to the States of Minas Gerais (41%), Goiás (28%), and Bahia (22%) (Cintra et al. 2020), portraying more the community of active researchers around the sampled areas than the representativeness of the areas in the Cerrado biome. The Midwest region of Brazil possess large areas dominated by the Cerrado, and it is poorly known concerning gall communities, since just about 15% of all studies on insect galls were done in this region (Araújo et al. 2019, Cintra et al. 2020), and none in areas located in the state of Mato Grosso.

Cintra et al. (2020) made an important compilation from insect galls communities sampled in 32 areas of the Cerrado Biome in Minas Gerais, Goiás, Bahia, São Paulo, and Mato Grosso do Sul States. The authorsregistered host plants of 505 species, 222 genera, and 67 families. Nine species threatened of extinction: *Baccharis concinna* G.M.Barroso (Asteraceae), *Lychnophora ramosissima* Gardner (Asteraceae), and *Lychnophora tomentosa* (Mart. ex DC.) Sch.Bip. (Asteraceae). In this study, we characterized gall morphology, identified host plants and the gall makers from Parque Nacional da Chapada dos Guimarães, Mato Grosso State, to contribute to the increase in the knowledge about host plant species and their gall morphotypes associated with gall-inducing insects in areas of natural vegetation from Cerrado. This inventory is the first record of insect-plant interactions in a region threatened by an unprecedented fire in the dry season of 2020 (Marengo et al. 2021). In this troubling scenario, our inventory represents a testimony of insect-plant interactions consumed by the fire and increases knowledge for the insect galls communities of Cerrado.

Material and Methods

1. *Study site*

The study was conducted during the expeditions of the "Rede Temática para Estudos de Diversidade, Sistemática e Limites Distribucionais de Diptera nos Estados do Mato Grosso, Mato Grosso do Sul e Rondônia (SISBIOTA–Diptera Brazil Program, Proc. Fapesp 10/52314-0; Proc. CNPq 563256/2010-9) in the Parque Nacional da Chapada dos Guimarães (PNCG), State of Mato Grosso, Brazil (Fig. 1), which is recognized internationally as a Biosphere Reserve.

The PNCG is located in the Cerrado Biome. The climate is classified as Tropical Climate of Savana (Aw), with two well-defined seasons (hot and rainy in summer; dry and cold in winter). Two geological regions are found in the PNCG, the Cuiabana Depression, which altitude is 200 – 450 m and the Guimarães Plateau with altitudes 600 – 800 m (MMA, 2009). The sampling areas list, including the sampled phytophysiognomies (classified after Ribeiro & Walter 2008), are presented in Table 1.

2. *Sampling*

We made the samples in two expeditions, in July 2012 and January 2013, with an effort of 30 minutes in each point in both, except for Cachoeira das Andorinhas sampled once in July 2012 and Vale do Rio Claro sampled once in January 2013, following Price et al. (1998). We sampled along the trails' edges, and we measured each route's length to dimension the sampled area following Urso-Guimarães et al. (2017). The total sampling effort in PNCH was 5 hours. Plant branches with galls were collected, labeled, stored in plastic bags and taken to the laboratory to document the galls' morphotypes, following Araújo et al. (2021). We transferred part of the galls to plastic tubes for rearing the inducers. We identified gall makers and plant species using identification keys compared with type material, literature, and experts' help. The voucher specimens were deposited in the Universidade Federal de São Carlos: plants in the Herbarium SORO and the insect material in the Laboratório de Sistemática de Diptera.

Results

We identified in the Parque Nacional da Chapada dos Guimarães 295 morphotypes of insect galls in 140 host plant species from 84 genera and 41 families (Table 2, Figs. 2–9). On average, we found 2.1 gall morphotypes per plant species (for comparisons with other inventories in Cerrado areas, see Table 3). Three host plants are identified only at a family level, and 11 are completely unidentified. The richest plant

Table 1. Sampling localities in Parque Nacional Chapada dos Guimarães - Mato Grosso State informing phytophysiognomy, geographical coordinates of the starting points and route length.

Localities	Phytophysiognomies	Geographical Coordinates	Route length
Vale do Rio Claro	Cerrado *s.l.*	15°19'37.1" S & 55°51'21.0" W	234 m
Cachoeira Véu da Noiva	Cerrado *s.l.*	15° 24' 33.6" S & 055° 49' 58.9" W	190 m
Cachoeira das Andorinhas	Cerrado *s.l.*	15° 24' 47.8" S & 055° 50' 34" W	174 m
Vale do Eco	Campo Cerrado	15° 20' 54.2" S & 055° 47' 59.9" W	149 m
Vale da Benção	Gallery forest	15° 26' 10" S & 055° 47' 23" W	47 m
Cidade de Pedra	Cerrado rupestre	15° 18' 00.4" S & 055° 50' 26.2" W	37.5 m

Table 2. Characterization of insect galls recorded in Parque Nacional da Chapada dos Guimarães, MT, Brazil, by host plant. Figures refer to the picture of the gall morphotype.

Host plat family	Host plant species	Host plant organ	Gall shape	Gall color	Trichomes	Collection site	Phytophysiognomy	Figures
Anacardiaceae	*Anacardium nannum* A.St.-Hil.*	Leaf	Globoid	Green/Brown	No	Vale do Eco, Cidade de Pedra	Campo Cerrado, Cerrado rupestre	2a
Anacardiaceae	*Tapirira guianensis* Aubl.	Leaf	Globoid	Green	No	Vale do Eco, Cidade de Pedra	Campo Cerrado, Cerrado rupestre	2b
Annonaceae	*Annona dioica* A.St.-Hil.	Leaf	Lenticular	Green	No	Vale do Eco	Campo Cerrado	2c
Annonaceae	*Annona tomentosa* L.*	Leaf	Globoid	Green/red	No	Vale do Eco	Campo Cerrado	2d, 2e
Annonaceae	*Duguetia flagellaris* Huber*	Leaf	Globoid	Green/brown	No	Vale da Benção	Gallery forest	2f
Annonaceae	*Duguetia flagellaris* Huber*	Leaf	Globoid	Green	No	Vale da Benção	Gallery forest	2g
Annonaceae	*Duguetia furfuracea* (A.St.-Hil.) Saff.	Leaf	Globoid	Green/brown	No	Cachoeira Véu da Noiva	Cerrado s.l.	2h
Annonaceae	*Duguetia furfuracea* (A.St.-Hil.) Saff.	Leaf vein	Pocket shaped	Yellow	No	Vale do Eco	Campo Cerrado	2i
Annonaceae	*Duguetia furfuracea* (A.St.-Hil.) Saff.	Leaf	Cylindrical	Red	No	Vale do Eco	Campo Cerrado	2j
Annonaceae	*Duguetia furfuracea* (A.St.-Hil.) Saff.	Leaf	Globoid	Pink	No	Vale do Eco	Campo Cerrado	2k
Annonaceae	*Guatteria ferruginea* A.St.-Hil.*	Leaf	Lenticular	Black	No	Vale da Benção	Gallery forest	2l
Annonaceae	*Guatteria ferruginea* A.St.-Hil.*	Leaf	Globoid	Brown	No	Vale da Benção	Gallery forest	2m
Annonaceae	*Unonopsis guatterioides* (A.DC.) R.E.Fr.*	Leaf	Lenticular	Brown	No	Vale da Benção	Gallery forest	2n
Apocynaceae	*Aspidosperma subincanum* Mart.	Leaf	Lenticular	Green/grey	No	Vale do Eco	Campo Cerrado	2o
Apocynaceae	*Aspidosperma tomentosum* Mart.	Leaf	Globoid	Green	No	Cachoeira das Andorinhas	Cerrado s.l.	2p
Apocynaceae	*Aspidosperma tomentosum* Mart.	Leaf	Lenticular	Green/yellow	No	Cachoeira Véu da Noiva	Cerrado s.l.	2q
Apocynaceae	*Aspidosperma verbascifolium* Müll. Arg.*	Leaf	Lenticular	Green	No	Cachoeira Véu da Noiva	Cerrado s.l.	2r
Apocynaceae	*Aspidosperma verbascifolium* Müll. Arg.*	Leaf	Globoid	Green	No	Cachoeira Véu da Noiva	Cerrado s.l.	2s
Apocynaceae	*Odontadenia lutea* (Vell.) Markgr.*	Leaf	Fusiform	Green	Yes	Cidade de Pedra	Cerrado rupestre	2t
Araceae	*Philodendron* sp.	Leaf	Lenticular	Yellow/red	No	Cachoeira Véu da Noiva	Cerrado s.l.	2u
Araceae	*Philodendron* sp.	Leaf	Lenticular	Red/yellow	No	Cachoeira das Andorinhas	Cerrado s.l.	2v

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Araliaceae	*Schefflera morototoni* (Aubl.) Maguire *et al.*	Leaf vein	Swelling	Yellow	Yes	Cachoeira Véu da Noiva	Cerrado s.l.	2w
Aristolochiaceae	*Aristolochia* sp.	Tendril	Fusiform	Green/brown	No	Vale da Benção	Gallery forest	2x
Aristolochiaceae	*Aristolochia* sp.	Stem	Globoid	Green	No	Vale da Benção	Gallery forest	2y
Asteraceae	*Mikania* sp.	Leaf, stem	Fusiform	Brown	Yes	Cachoeira Véu da Noiva	Cerrado s.l.	2z
Asteraceae	*Mikania* cf. *micrantha* Kunth	Leaf	Globoid	Green	No	Vale da Benção	Gallery forest	2za
Asteraceae	*Mikania* cf. *micrantha* Kunth	Leaf vein	Fusiform	Green	No	Vale da Benção	Gallery forest	2zb
Asteraceae	*Mikania* cf. *micrantha* Kunth	Leaf vein	Globoid	Green	No	Vale da Benção	Gallery forest	2zc
Asteraceae	*Piptocarpha rotundifolia* (Less.) Baker	Leaf	Lenticular	Grey	No	Cachoeira Véu da Noiva	Cerrado s.l.	2zd
Asteraceae	*Piptocarpha rotundifolia* (Less.) Baker	Leaf	Globoid	Yellow	Yes	Cachoeira Véu da Noiva	Cerrado s.l.	2ze
Asteraceae	*Piptocarpha rotundifolia* (Less.) Baker	Leaf	Globoid	Brown	Yes	Cachoeira Véu da Noiva	Cerrado s.l.	2zf
Bignoniaceae	*Anemopaegma glaucum* Mart. ex DC.*	Stem	Amorphous	Green	No	Vale da Benção	Campo Cerrado	2zg
Bignoniaceae	*Anemopaegma glaucum* Mart. ex DC.*	Leaf bud	Amorphous	Yellow	No	Cachoeira Véu da Noiva	Cerrado rupestre	2zh
Bignoniaceae	*Anemopaegma glaucum* Mart. ex DC.*	Stem	Fusiform	Green/brown	No	Cachoeira Véu da Noiva	Cerrado rupestre	2zi
Bignoniaceae	*Anemopaegma glaucum* Mart. ex DC.*	Leaf vein	Fusiform	Green	No	Vale da Benção	Campo Cerrado	2zj
Bignoniaceae	*Anemopaegma glaucum* Mart. ex DC.*	Leaf	Lenticular	Yellow/red	No	Vale da Benção	Campo Cerrado	3a
Bignoniaceae	*Pleonotoma* sp.	Stem	Fusiform	Brown	No	Vale da Benção	Gallery forest	3b
Bignoniaceae	*Pleonotoma* sp.	Stem	Fusiform	Green	No	Vale da Benção	Cerrado s.l.	3c
Bignoniaceae	*Pleonotoma* sp.	Stem	Globoid	Green	No	Vale da Benção	Cerrado s.l.	3c
Bignoniaceae	Bignoniaceae sp. 1	Tendril	Fusiform	Green	No	Cachoeira Véu da Noiva	Gallery forest	3d
Bignoniaceae	Bignoniaceae sp. 2	Stem	Globoid	Brown	No	Vale do Eco	Gallery forest	3e
Bignoniaceae	Bignoniaceae sp. 2	Leaf	Globoid	Brown	No	Vale do Rio Claro	Gallery forest	3f
Bignoniaceae	Bignoniaceae sp. 2	Leaf	Conical	Green	Yes	Vale da Benção	Gallery forest	3g
Bignoniaceae	Bignoniaceae sp. 3	Leaf vein	Globoid	Brown	No	Vale da Benção	Gallery forest	3h

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Bignoniaceae	Bignoniaceae sp. 3	Stem	Globoid	Green/brown	No	Vale da Benção	Cerrado s.l.	3i
Bignoniaceae	Bignoniaceae sp. 4	Leaf vein	Globoid	Green/Red	No	Vale da Benção	Campo Cerrado	3j
Bignoniaceae	Bignoniaceae sp. 4	Leaf	Fusiform	Brown	No	Cachoeira Véu da Noiva	Cerrado s.s.	3k
Boraginaceae	*Cordia sellowiana* Cham.	Stem	Globoid	Grey	No	Cachoeira Véu da Noiva	Gallery forest	3l
Boraginaceae	*Cordia sellowiana* Cham.	Stem	Fusiform	Grey	No	Vale da Benção	Gallery forest	3l
Boraginaceae	*Cordia sellowiana* Cham.	Leaf	Globoid	Brown	No	Vale da Benção	Gallery forest	3m
Boraginaceae	*Cordia sellowiana* Cham.	Leaf	Globoid	Brown	Yes	Vale da Benção	Gallery forest	3n
Boraginaceae	*Cordia sellowiana* Cham.	Leaf	Globoid	Green	Yes	Vale da Benção	Gallery forest	3n
Boraginaceae	*Cordia sellowiana* Cham.	Leaf	Globoid	Grey	Yes	Vale da Benção	Gallery forest	3o
Burseraceae	cf. *Tetragastris altissima* (Aubl.) Swart	Leaf	Lenticular	Yellow	No	Cachoeira Véu da Noiva	Cerrado s.l.	3p
Burseraceae	*Protium heptaphyllum* (Aubl.) Marchand	Leaf	Globoid	Brown	No	Cidade de Pedra	Cerrado rupestre	3q
Burseraceae	*Protium heptaphyllum* (Aubl.) Marchand	Leaf margin	Swelling	Green	No	Vale do Eco	Campo Cerrado	3r
Burseraceae	*Protium heptaphyllum* (Aubl.) Marchand	Leaf	Lenticular (adax), globoid (abax)	Green	No	Vale do Eco	Campo Cerrado	3s
Burseraceae	*Protium heptaphyllum* (Aubl.) Marchand	Leaf	Conical	Green	No	Vale do Eco	Campo Cerrado	3t
Burseraceae	*Protium heptaphyllum* (Aubl.) Marchand	Stem	Fusiform	Brown	No	Vale do Eco	Campo Cerrado	3u
Burseraceae	*Protium heptaphyllum* (Aubl.) Marchand	Leaf	Globoid	Green/brown	No	Cidade de Pedra	Cerrado rupestre	3v
Burseraceae	*Protium heptaphyllum* (Aubl.) Marchand	Leaf	Lenticular	Green	No	Vale do Eco	Campo Cerrado	3w
Burseraceae	*Protium heptaphyllum* (Aubl.) Marchand	Leaf	Globoid	Brown	No	Vale da Benção	Gallery forest	3x
Burseraceae	*Protium heptaphyllum* (Aubl.) Marchand	Leaf	Globoid	Green/red	Yes	Vale da Benção	Gallery forest	3y
Burseraceae	*Protium heptaphyllum* (Aubl.) Marchand	Leaf	Globoid	Green/red	Yes	Cachoeira Véu da Noiva	Cerrado s.l.	3y
Burseraceae	*Protium heptaphyllum* (Aubl.) Marchand	Leaf, stem	Globoid	Green	No	Vale do Eco	Campo Cerrado	3z

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Callophylaceae	*Kielmeyera grandiflora* (Wawra) Saddi	Leaf	Lenticular	Brown	No	Cachoeira Véu da Noiva	Cerrado s.l.	3za
Callophylaceae	*Kielmeyera grandiflora* (Wawra) Saddi	Leaf vein	Fusiform	Green/Brown	No	Cachoeira Véu da Noiva	Cerrado s.l.	3zb
Caryocaraceae	*Caryocar brasiliense* Camb.	Leaf	Lenticular	Green	Yes	Vale do Eco	Campo Cerrado	3zc
Celastraceae	*Peritassa* sp.	Leaf	Globoid	Red	Yes	Vale da Benção	Gallery forest	3zd
Celastraceae	*Peritassa* sp.	Leaf	Cylindrical	Brown	No	Vale da Benção	Gallery forest	3ze
Celastraceae	*Peritassa* sp.	Leaf	Lenticular	Brown	No	Vale da Benção	Gallery forest	3ze
Celastraceae	*Peritassa* sp.	Leaf	Globoid	Yellow/ brown	No	Vale da Benção	Gallery forest	3zf
Celastraceae	*Peritassa* sp.	Leaf	Globoid	Brown	Yes	Vale da Benção	Gallery forest	3zg
Celastraceae	*Pristimera celastroides* (Kunth) A.C.Sm.*	Leaf vein	Fusiform	Brown	No	Vale da Benção	Gallery forest	3zh
Chrysobalanaceae	Chrysobalanaceae sp.	Leaf	Lenticular	Brown/black	No	Cidade de Pedra	Cerrado rupestre	3zi
Chrysobalanaceae	*Parinari obtusifolia* Hook.f.*	Leaf	Lenticular	Green	No	Vale do Eco	Campo Cerrado	4a
Chrysobalanaceae	*Parinari obtusifolia* Hook.f.*	Leaf	Globoid	Brown	Yes	Cidade de Pedra	Cerrado rupestre	4b
Chrysobalanaceae	*Parinari obtusifolia* Hook.f.*	Leaf	Globoid	Brown	Yes	Cidade de Pedra	Cerrado rupestre	4b
Chrysobalanaceae	*Parinari obtusifolia* Hook.f.*	Leaf	Globoid	Brown	Yes	Vale do Eco	Campo Cerrado	4b
Combretaceae	*Combretum mellifluum* Eichler*	Leaf	Lenticular	Brown	No	Cidade de Pedra	Cerrado rupestre	4c
Combretaceae	*Combretum mellifluum* Eichler*	Leaf	Globoid	Green	No	Cidade de Pedra	Cerrado rupestre	4d
Combretaceae	*Combretum mellifluum* Eichler*	Leaf	Globoid	Yellow	No	Cidade de Pedra	Cerrado rupestre	4e
Combretaceae	*Combretum mellifluum* Eichler*	Leaf	lenticular	Yellow	No	Cidade de Pedra	Cerrado rupestre	4e
Combretaceae	*Terminalia fagifolia* Mart.	Leaf	Lenticular	Green	No	Cidade de Pedra	Cerrado rupestre	4f
Combretaceae	*Terminalia fagifolia* Mart.	Leaf	Cylindrical	Brown	No	Cidade de Pedra	Cerrado rupestre	4g
Combretaceae	*Terminalia fagifolia* Mart.	Leaf	Conical	Brown	No	Cidade de Pedra	Cerrado rupestre	4h
Combretaceae	*Terminalia glabrescens* Mart.*	Leaf	Lenticular	Green	No	Cidade de Pedra	Cerrado rupestre	4i
Combretaceae	*Terminalia glabrescens* Mart.*	Leaf	Globoid	Green	Yes	Vale do Eco	Campo Cerrado	4i
Connaraceae	*Connarus suberosus* Planch.	Leaf	Globoid	Yellow/ brown	No	Vale do Eco	Campo Cerrado	4j
Connaraceae	*Rourea induta* Planch.	Leaf	Lenticular	Green/brown	No	Cachoeira Véu da Noiva	Cerrado s.l.	4k
Connaraceae	*Rourea induta* Planch.	Leaf	Lenticular	Brown	No	Cidade de Pedra	Cerrado rupestre	4l
Connaraceae	*Rourea induta* Planch.	Leaf	Amorphous	Green	No	Cachoeira Véu da Noiva	Cerrado s.l.	4m
Dilleniaceae	*Davilla grandiflora* A.St.-Hil.*	Leaf	Lenticular	Brown	No	Cachoeira Véu da Noiva	Cerrado s.l.	4n

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Dilleniaceae	*Davilla grandiflora* A.St.-Hil.*	Leaf	Lenticular	Brown	No	Cachoeira Véu da Noiva	Cerrado s.l.	4o
Dilleniaceae	*Davilla grandiflora* A.St.-Hil.*	Leaf	Lenticular	Grey	No	Cidade de Pedra	Cerrado rupestre	4p
Dilleniaceae	*Davilla grandiflora* A.St.-Hil.*	Fruit	Amorphous	Green	No	Cidade de Pedra	Cerrado rupestre	4q
Dilleniaceae	*Davilla grandiflora* A.St.-Hil.*	Leaf	Lenticular	Grey	No	Vale do Eco	Campo Cerrado	4r
Dilleniaceae	*Davilla grandiflora* A.St.-Hil.*	Leaf	Rosette	Brown	No	Cidade de Pedra	Cerrado rupestre	4s
Dilleniaceae	*Davilla grandiflora* A.St.-Hil.*	Leaf bud	Rosette	Green	No	Vale do Rio Claro	Cerrado s.s.	4t
Dilleniaceae	*Davilla grandiflora* A.St.-Hil.*	Stem	Swelling	Brown	No	Cachoeira Véu da Noiva	Cerrado s.l.	4u
Dilleniaceae	*Davilla lacunosa* Mart.*	Leaf	Lenticular	Grey/brown	No	Cachoeira Véu da Noiva	Cerrado s.l.	4v
Dilleniaceae	*Davilla lacunosa* Mart.*	Leaf	Lenticular	Grey	No	Cachoeira Véu da Noiva	Cerrado s.l.	4w
Dilleniaceae	*Davilla lacunosa* Mart.*	Leaf	Lenticular	Yellow	No	Cachoeira das Andorinhas	Cerrado s.l.	4x
Elaeocarpaceae	*Sloanea* sp.	Leaf	Cylindrical	Green	No	Vale da Benção	Gallery forest	4y
Elaeocarpaceae	*Sloanea* sp.	Leaf	Cylindrical	Brown	No	Vale da Benção	Gallery forest	4z
Erythroxylaceae	*Erythroxylum* cf. *pruinosum* O.E.Schulz*	Fruit	Amorphous	Green	No	Cachoeira Véu da Noiva	Cerrado s.l.	4za
Erythroxylaceae	*Erythroxylum campestre* A.St.-Hil.	Leaf	Lenticular	Green/brown	No	Cachoeira Véu da Noiva	Cerrado s.l.	4zb
Erythroxylaceae	*Erythroxylum citrifolium* A.St.-Hil.	Leaf	Lenticular	Brown	No	Cachoeira das Andorinhas	Cerrado s.l.	4zc
Erythroxylaceae	*Erythroxylum citrifolium* A.St.-Hil.	Leaf	Lenticular	Yellow	No	Cachoeira das Andorinhas	Cerrado s.l.	4zc
Erythroxylaceae	*Erythroxylum daphnites* Mart.	Leaf	Star shaped	Brown	Yes	Cachoeira Véu da Noiva	Cerrado s.l.	4zd
Erythroxylaceae	*Erythroxylum daphnites* Mart.	Stem	Piriformis	Brown	No	Cachoeira Véu da Noiva	Cerrado s.l.	4ze
Erythroxylaceae	*Erythroxylum daphnites* Mart.	Leaf	Lenticular	Grey	No	Cachoeira Véu da Noiva	Cerrado s.l.	4ze
Erythroxylaceae	*Erythroxylum daphnites* Mart.	Leaf	Globoid	Yellow	Yes	Cachoeira Véu da Noiva	Cerrado s.l.	4zf
Erythroxylaceae	*Erythroxylum daphnites* Mart.	Leaf	Lenticular	Brown	No	Cidade de Pedra	Cerrado rupestre	4zg
Euphorbiaceae	*Bernardia similis* Pax & K.Hoffm.*	Leaf	Lenticular	Black	No	Cidade de Pedra	Cerrado rupestre	4zh
Euphorbiaceae	*Mabea* sp.	Leaf	Conical	Yellow	No	Vale da Benção	Gallery forest	4zi

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Euphorbiaceae	*Manihot tripartita* (Spreng.) Müll. Arg.	Leaf	Globoid	Green/red	No	Cidade de Pedra	Cerrado rupestre	5a
Euphorbiaceae	*Manihot tripartita* (Spreng.) Müll. Arg.	Leaf	Cylindrical	Green	No	Cidade de Pedra	Cerrado rupestre	5b
Euphorbiaceae	*Manihot tripartita* (Spreng.) Müll. Arg.	Leaf	Lenticular	Brown	No	Cidade de Pedra	Cerrado rupestre	5b
Euphorbiaceae	*Manihot tripartita* (Spreng.) Müll. Arg.	Leaf	Lenticular	Black	No	Cidade de Pedra	Cerrado rupestre	5b
Euphorbiaceae	*Manihot tripartita* (Spreng.) Müll. Arg.	Leaf	Cylindrical	Green/red	No	Vale do Rio Claro	Cerrado s.s.	5c
Euphorbiaceae	*Jatropha* sp.	Leaf	Cylindrical	Green	No	Vale do Eco	Campo Cerrado	5d
Euphorbiaceae	*Jatropha* sp.	Leaf	Cylindrical	Green/red	No	Vale do Eco	Campo Cerrado	5e
Euphorbiaceae	*Maprounea guianensis* Aubl.	Stem	Globoid	Green/brown	No	Vale da Benção	Gallery forest	5f
Euphorbiaceae	*Maprounea guianensis* Aubl.	Stem	Fusiform	Green/brown	No	Cachoeira Véu da Noiva	Cerrado s.l.	5g
Fabaceae	*Ancistrotropis firmula* (Mart. ex Benth.) A. Delgado*	Leaf	Lenticular	Yellow	No	Cidade de Pedra	Cerrado rupestre	5h
Fabaceae	*Andira cujabensis* Benth.	Leaf	Amorphous	Yellow	No	Vale do Eco	Campo Cerrado	5i
Fabaceae	*Andira cujabensis* Benth.	Leaf	Lenticular	Yellow	Yes	Cachoeira das Andorinhas	Cerrado s.l.	5j
Fabaceae	*Andira cujabensis* Benth.	Leaf	Lenticular	Yellow/red	No	Cachoeira Véu da Noiva	Cerrado s.l.	5k
Fabaceae	*Andira cujabensis* Benth.	Leaf	Lenticular	Yellow	No	Cachoeira Véu da Noiva	Cerrado s.l.	5l
Fabaceae	*Andira cujabensis* Benth.	Leaf	Lenticular	Green	No	Cachoeira Véu da Noiva	Cerrado s.l.	5m
Fabaceae	*Andira cujabensis* Benth.	Leaf	Lenticular	Yellow	No	Vale do Rio Claro	Cerrado s.s.	5n
Fabaceae	*Andira humilis* Mart. ex Benth.	Leaf	Globoid	Green	No	Vale do Eco	Campo Cerrado	5o
Fabaceae	*Andira surinamensis* (Bondt) Splitg. ex Amshoff	Leaf	Globoid	Brown	No	Cidade de Pedra	Cerrado rupestre	5p
Fabaceae	*Andira surinamensis* (Bondt) Splitg. ex Amshoff	Leaf vein	Fusiform	Yellow/red	No	Cidade de Pedra	Cerrado rupestre	5q
Fabaceae	*Andira surinamensis* (Bondt) Splitg. ex Amshoff	Leaf	Globoid	Yellow	No	Cidade de Pedra	Cerrado rupestre	5q
Fabaceae	*Andira surinamensis* (Bondt) Splitg. ex Amshoff	Leaf	Globoid	Green/red	No	Vale do Eco	Campo Cerrado	5r
Fabaceae	*Andira surinamensis* (Bondt) Splitg. ex Amshoff	Leaf	Lenticular	Brown	No	Vale do Eco	Campo Cerrado	5r

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Fabaceae	*Andira surinamensis* (Bondt) Splitg. ex Amshoff	Leaf	Globoid	Yellow	No	Vale do Rio Claro	Cerrado s.s.	5s
Fabaceae	*Andira surinamensis* (Bondt) Splitg. ex Amshoff	Leaf	Kidney shape	Green	No	Vale do Eco	Campo Cerrado	5t
Fabaceae	*Andira vermifuga* (Mart.) Benth.	Leaf	Globoid	Green	No	Vale do Eco	Campo Cerrado	5u
Fabaceae	*Andira vermifuga* (Mart.) Benth.	Leaf	Conical	Green	No	Vale do Rio Claro	Cerrado s.s.	5v
Fabaceae	*Andira vermifuga* (Mart.) Benth.	Leaf	Kidney shape	Green	No	Vale do Rio Claro	Cerrado s.s.	5w
Fabaceae	*Bauhinia* sp. 1	Leaf	Lenticular	Brown	No	Vale da Benção	Gallery forest	5x
Fabaceae	*Bauhinia* sp. 1	Leaf vein	Triangular	Green	No	Vale da Benção	Gallery forest	5x
Fabaceae	*Bauhinia* sp. 2	Leaf vein	Fusiform	Green	No	Vale do Eco	Campo Cerrado	5y
Fabaceae	*Bauhinia* sp. 3	Leaf	Lenticular	Grey	No	Cachoeira Véu da Noiva	Cerrado s.l.	5z
Fabaceae	*Bauhinia* sp. 4	Leaf	Globoid	Green	No	Vale do Eco	Campo Cerrado	5za
Fabaceae	*Calliandra* sp.	Stem	Fusiform	Brown	No	Vale do Eco	Campo Cerrado	5zb
Fabaceae	*Chamaecrista* sp.	Leaf	Lenticular	Brown	No	Cachoeira Véu da Noiva	Cerrado s.l.	5zc
Fabaceae	*Copaifera depilis* Dwyer	Leaf	Lenticular	Brown	No	Vale do Eco	Campo Cerrado	5zd
Fabaceae	*Copaifera depilis* Dwyer	Leaf	Lenticular	Green	No	Vale do Eco	Campo Cerrado	5ze
Fabaceae	*Copaifera depilis* Dwyer	Leaf	Globoid	Yellow	No	Vale do Eco	Campo Cerrado	5ze
Fabaceae	*Copaifera depilis* Dwyer	Leaf	Globoid	Brown	Yes	Vale do Eco	Campo Cerrado	5zf
Fabaceae	*Copaifera depilis* Dwyer	Leaf, stem	Globoid	Yellow	No	Vale do Eco	Campo Cerrado	5zg
Fabaceae	*Copaifera depilis* Dwyer	Leaf	Lenticular convex	Brown/pink	No	Vale do Eco	Campo Cerrado	5zh
Fabaceae	*Copaifera depilis* Dwyer	Leaf	Globoid	Brown	Yes	Vale do Eco	Campo Cerrado	5zi
Fabaceae	*Copaifera depilis* Dwyer	Leaf bud	Globoid	Brown	Yes	Vale do Eco	Campo Cerrado	6a
Fabaceae	*Hymenaea courbaril* L.	Leaf	Lenticular	Yellow	No	Vale da Benção	Gallery forest	6b
Fabaceae	*Hymenaea courbaril* L.	Leaf	Lenticular	Yellow	No	Vale da Benção	Gallery forest	6c
Fabaceae	*Hymenaea courbaril* L.	Leaf	Lenticular	Green	No	Vale da Benção	Gallery forest	6d
Fabaceae	*Inga disticha* Benth.	Leaf	Globoid	Yellow	Yes	Cachoeira Véu da Noiva	Cerrado s.l.	6e
Fabaceae	*Inga disticha* Benth.	Leaf	Globoid	Yellow	No	Cachoeira Véu da Noiva	Cerrado s.l.	6e
Fabaceae	*Inga leiocalycina* Benth.*	Leaf	Marginal roll	Green	No	Vale da Benção	Gallery forest	6f

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Fabaceae	*Inga vera* Willd.	Leaf vein	Fusiform	Yellow	No	Cachoeira Véu da Noiva	Cerrado s.l.	6g
Fabaceae	*Machaerium* sp.	Leaf	Cylindrical	Green	No	Vale da Benção	Gallery forest	6h
Fabaceae	*Ormosia macrophylla* Benth.*	Leaf	Lenticular	Grey	No	Vale da Benção	Gallery forest	6i
Fabaceae	*Senegalia* sp.	Leaf	Globoid	Brown	No	Vale da Benção	Gallery forest	6j
Fabaceae	*Stryphnodendron adstringens* (Mart.) Coville	Leaf	Lenticular	Brown	No	Cidade de Pedra	Cerrado rupestre	6k
Fabaceae	*Stryphnodendron adstringens* (Mart.) Coville	Stem	Globoid	Brown	No	Cidade de Pedra	Cerrado rupestre	6l
Fabaceae	*Stryphnodendron adstringens* (Mart.) Coville	Stem	Fusiform	Brown	No	Vale do Eco	Campo Cerrado	6m
Fabaceae	*Tachigali rubiginosa* (Mart. ex Tul.) Oliveira-Filho*	Leaf	Lenticular	Green /brown	Yes	Cachoeira Véu da Noiva	Cerrado s.l.	6n
Fabaceae	*Tachigali rubiginosa* (Mart. ex Tul.) Oliveira-Filho*	Leaf	Globoid (adax), lenticular (abax)	Green/brown	Yes	Cachoeira Véu da Noiva	Cerrado s.l.	6o, 6p
Fabaceae	*Tachigali subvelutina* (Benth.) Oliveira-Filho*	Leaf, stem	Cylindrical	Green	Yes	Vale do Eco	Campo Cerrado	6q
Lauraceae	*Aiouea saligna* Meisn.*	Leaf	Globoid	Green/brown	No	Vale do Eco	Campo Cerrado	6r
Lauraceae	*Aiouea saligna* Meisn.*	Ovary	Swelling	Green/red	No	Vale do Eco	Campo Cerrado	6s
Malpighiaceae	*Alicia macrodisca* (Triana & Planch.) W.R.Anderson*	Stem	Fusiform	Green/brown	Yes	Vale da Benção	Gallery forest	6t
Malpighiaceae	*Byrsonima coccolobifolia* Kunth.	Leaf vein	Swelling	Brown	No	Cachoeira Véu da Noiva	Cerrado s.l.	6u
Malpighiaceae	*Byrsonima sericea* DC.	Stem	Fusiform	Brown	No	Cachoeira Véu da Noiva	Cerrado s.l.	6v
Malpighiaceae	*Byrsonima sericea* DC.	Leaf	Lenticular	Green	No	Cidade de Pedra	Cerrado rupestre	6w
Malpighiaceae	*Diplopterys pubipetala* (A.Juss.) W.R.Anderson & C.C.Davis	Leaf	Conical	Green	No	Vale do Eco	Campo Cerrado	6x
Malpighiaceae	*Heteropterys* cf. *coriacea* A. Juss.*	Leaf bud	Amorphous	Green	No	Cidade de Pedra	Cerrado rupestre	6y
Malpighiaceae	*Heteropterys* cf. *coriacea* A. Juss.*	Leaf	Lenticular	Brown	No	Cidade de Pedra	Cerrado rupestre	6z
Malpighiaceae	*Heteropterys* cf. *coriacea* A. Juss.*	Leaf	Lenticular	Green /brown	No	Cidade de Pedra	Cerrado rupestre	6za
Malpighiaceae	*Heteropterys* cf. *coriacea* A. Juss.*	Leaf	Lenticular	Brown	No	Cachoeira das Andorinhas	Cerrado s.l.	6zb
Malpighiaceae	*Heteropterys* cf. *coriacea* A. Juss.*	Leaf	Lenticular	Green /brown	No	Cachoeira das Andorinhas	Cerrado s.l.	6zc

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Malpighiaceae	*Heteropterys* cf. *coriacea* A. Juss.*	Leaf	Lenticular	Green /brown	No	Cidade de Pedra	Cerrado rupestre	6zd
Malpighiaceae	*Heteropterys* cf. *coriacea* A. Juss.*	Leaf	Lenticular	Yellow	No	Vale do Rio Claro	Cerrado s.s.	6ze
Melastomataceae	*Macairea radula* (Bonpl.) DC.	Stem	Globoid	Green	Yes	Cachoeira Véu da Noiva	Cerrado s.l.	6zf
Melastomataceae	*Miconia albicans* (Sw.) Triana	Leaf	Globoid	Brown	Yes	Cachoeira Véu da Noiva	Cerrado s.l.	6zg
Melastomataceae	*Miconia albicans* (Sw.) Triana	Leaf	Amorphous	Yellow	No	Cachoeira das Andorinhas	Cerrado s.l.	6zh
Melastomataceae	*Miconia rubiginosa* (Bonpl.) DC.*	Leaf	Lenticular	Brown	No	Cachoeira Véu da Noiva	Cerrado s.l.	6zi
Melastomataceae	*Miconia* sp. 1	Leaf	Lenticular	Yellow	No	Cachoeira Véu da Noiva	Cerrado s.l.	7a
Melastomataceae	*Miconia* sp. 1	Leaf	Globoid	Yellow/pink	Yes	Cachoeira Véu da Noiva	Cerrado s.l.	7b
Melastomataceae	*Miconia* sp. 1	Leaf	Globoid	Yellow	Yes	Cachoeira Véu da Noiva	Cerrado s.l.	7c
Melastomataceae	*Miconia* sp. 1	Leaf bud	Amorphous	Green	Yes	Cachoeira Véu da Noiva	Cerrado s.l.	7d
Melastomataceae	*Miconia* sp. 2	Leaf	Globoid	Green	Yes	Cachoeira das Andorinhas	Cerrado s.l.	7e, 7f
Melastomataceae	*Mouriri elliptica* Mart.*	Leaf	Lenticular	Brown	No	Cidade de Pedra	Cerrado rupestre	7g
Melastomataceae	*Tibouchina* sp.	Stem	Fusiform	Brown	No	Cidade de Pedra	Cerrado rupestre	7h
Melastomataceae	*Tibouchina* sp.	Stem	Globoid	Brown	No	Cidade de Pedra	Cerrado rupestre	7i
Melastomataceae	*Tococa* sp	Leaf	Lenticular	Brown	No	Cachoeira Véu da Noiva	Cerrado s.l.	7j
Melastomataceae	*Tococa* sp	Leaf vein	Fusiform	Brown	No	Cachoeira Véu da Noiva	Cerrado s.l.	7j
Meliaceae	*Guarea guidonia* (L.) Sleumer	Leaf vein	Fusiform	Brown	No	Vale da Benção	Gallery forest	7k
Meliaceae	*Guarea guidonia* (L.) Sleumer	Leaf	Globoid	Yellow	No	Vale da Benção	Gallery forest	7l
Meliaceae	*Guarea guidonia* (L.) Sleumer	Leaf	Globoid	Yellow	No	Vale da Benção	Gallery forest	7m
Meliaceae	*Guarea macrophylla* subsp. *spiciflora* (A.Juss.) T.D.Penn.*	Leaf	Globoid	Yellow	Yes	Cachoeira Véu da Noiva	Cerrado s.l.	7n
Monimiaceae	*Mollinedia* sp.	Leaf	Lenticular	Green/yellow	No	Cachoeira Véu da Noiva	Cerrado s.l.	7o
Moraceae	*Brosimum lactescens* (S.Moore) C.C.Berg	Leaf	Cylindrical	Green/brown	No	Cachoeira Véu da Noiva	Cerrado s.l.	7p

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Moraceae	*Ficus* sp. 1	Leaf	Lenticular	Green	No	Cachoeira das Andorinhas	Cerrado s.l.	7q
Moraceae	*Ficus* sp. 2	Leaf	Globoid	Green/red	No	Cachoeira Véu da Noiva	Cerrado s.l.	7r
Moraceae	*Ficus* sp. 2	Leaf	Lenticular	Green /brown	No	Cachoeira Véu da Noiva	Cerrado s.l.	7s
Moraceae	*Ficus* sp. 2	Leaf	Lenticular	Yellow/red	No	Cachoeira Véu da Noiva	Cerrado s.l.	7t
Myrtaceae	*Eugenia punicifolia* (Kunth)	Stem	Globoid	Brown	No	Cachoeira Véu da Noiva	Cerrado s.l.	7u
Myrtaceae	*Eugenia* sp.	Leaf	Lenticular	Yellow/red	No	Vale do Rio Claro	Cerrado s.s.	7v
Myrtaceae	*Myrcia bella* Cambess.	Leaf	Lenticular	Yellow/ brown	No	Vale do Eco	Campo Cerrado	7w
Myrtaceae	*Myrcia bella* Cambess.	Leaf	Globoid	Green/red	No	Vale do Eco	Campo Cerrado	7x
Myrtaceae	*Myrcia bella* Cambess.	Leaf bud	Amorphous	Green	No	Vale do Rio Claro	Cerrado s.s.	7y
Myrtaceae	*Myrcia guianensis* (Aubl.) DC.	Leaf	Lenticular	Green/brown	No	Cachoeira Véu da Noiva	Cerrado s.l.	7z
Myrtaceae	*Myrcia guianensis* (Aubl.) DC.	Leaf	Lenticular	Brown	No	Cachoeira Véu da Noiva	Cerrado s.l.	7za
Myrtaceae	*Myrcia* sp.	Leaf	Lenticular	Brown	No	Cachoeira Véu da Noiva	Cerrado s.l.	7zb
Myrtaceae	*Myrcia splendens* (Sw.) DC.	Leaf	Globoid	Green	No	Vale da Benção	Gallery forest	7zc
Myrtaceae	*Myrcia splendens* (Sw.) DC.	Leaf	Globoid	Green	Yes	Vale da Benção	Gallery forest	7zd
Myrtaceae	*Myrcia splendens* (Sw.) DC.	Leaf	Lenticular	Brown	No	Cachoeira das Andorinhas	Cerrado s.l.	7ze
Myrtaceae	*Myrcia splendens* (Sw.) DC.	Leaf	Globoid	Red	Yes	Cachoeira Véu da Noiva	Cerrado s.l.	7zf
Myrtaceae	*Myrcia variabilis* DC.	Leaf	Lenticular	Brown	No	Cachoeira das Andorinhas	Cerrado s.l.	7zg
Ochnaceae	*Ouratea castaneifolia* (DC.) Engl.	Leaf	Lenticular	Green	No	Vale da Benção	Gallery forest	7zh
Ochnaceae	*Ouratea nana* (A.St.-Hil.) Engl.*	Leaf	Lenticular	Grey	No	Cidade de Pedra	Cerrado rupestre	7zi
Ochnaceae	*Ouratea nana* (A.St.-Hil.) Engl.*	Leaf	Lenticular	Green/brown	No	Cidade de Pedra	Cerrado rupestre	7zi
Ochnaceae	*Ouratea nana* (A.St.-Hil.) Engl.*	Leaf	Lenticular	Green/brown	No	Cachoeira das Andorinhas	Cerrado s.l.	8a
Ochnaceae	*Ouratea riedeliana* Engl.*	Leaf	Lenticular	Green/brown	No	Cidade de Pedra	Cerrado rupestre	8b
Piperaceae	cf. *Piper dilatatum* Rich.	Leaf, stem	Cylindrical	Green	Yes	Vale da Benção	Gallery forest	8c

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Polygonaceae	*Coccoloba cujabensis* Wedd.	Leaf, stem	Lenticular	Brown	No	Cidade de Pedra	Cerrado rupestre	8d
Proteaceae	*Roupala montana* Aubl.	Leaf	Lenticular	Brown	No	Cachoeira das Andorinhas	Cerrado s.l.	8e
Rubiaceae	*Cordiera myrciifolia* (K.Schum.) C.H.Perss. and Delprete*	Leaf	Lenticular	Brown	No	Cachoeira das Andorinhas	Cerrado s.l.	8f
Rubiaceae	*Cordiera myrciifolia* (K.Schum.) C.H.Perss. and Delprete*	Leaf vein	Fusiform	Green	No	Cachoeira das Andorinhas	Cerrado s.l.	8f
Rubiaceae	*Cordiera obtusa* (K.Schum.) Kuntze*	Leaf	Lenticular	Brown	No	Cidade de Pedra	Cerrado rupestre	8g
Rubiaceae	Rubiaceae sp.	Stem	Fusiform	Brown	No	Vale da Benção	Gallery forest	8h
Sapindaceae	*Matayba guianensis* Aubl.	Leaf	Cylindrical	Green	Yes	Cachoeira Véu da Noiva	Cerrado s.l.	8i
Sapindaceae	*Matayba* sp. 1	Leaf vein	Fusiform	Green	No	Vale da Benção	Gallery forest	8j
Sapindaceae	*Matayba* sp. 2	Leaf	Lenticular	Grey	No	Vale do Eco	Campo Cerrado	8k
Sapindaceae	*Serjania caracasana* (Jacq.) Willd.	Leaf	Cylindrical	Green/Red	Yes	Vale da Benção	Gallery forest	8l
Sapindaceae	*Serjania matogrossensis* Ferrucci & Acev.-Rodr.*	Tendril	Fusiform	Green/brown	No	Vale da Benção	Gallery forest	8m
Sapindaceae	*Serjania* sp.	Leaf	Lenticular	Brown	No	Cachoeira Véu da Noiva	Cerrado s.l.	8n
Sapindaceae	*Talisia subalbens* (Mart.) Radlk.*	Leaf	Lenticular	Yellow	No	Cachoeira das Andorinhas	Cerrado s.l.	8o
Sapotaceae	*Ecclinusa ramiflora* Mart.*	Leaf	Wrinkle	Green	No	Vale da Benção	Gallery forest	8p
Sapotaceae	*Pouteria ramiflora* (Mart.) Radlk.	Leaf	Lenticular	Brown	No	Cachoeira Véu da Noiva	Cerrado s.l.	8q
Sapotacae	*Pouteria torta* (Mart.) Radlk.	Leaf	Cylindrical	Green/brown	Yes	Vale do Rio Claro	Cerrado s.s.	8r
Sapotaceae	*Pouteria torta* (Mart.) Radlk.	Stem	Fusiform	Brown	No	Vale do Eco	Campo Cerrado	8s
Sapotaceae	*Pouteria torta* (Mart.) Radlk.	Leaf	Conical	Green	Yes	Vale do Eco	Campo Cerrado	8t
Sapotaceae	*Pouteria torta* (Mart.) Radlk.	Leaf	Lenticular	Green	Yes	Vale do Eco	Campo Cerrado	8u
Sapotaceae	*Pouteria* sp. 1	Leaf	Lenticular	Brown	No	Vale do Eco	Campo Cerrado	8v
Sapotaceae	*Pouteria* sp. 1	Stem	Fusiform	Brown	No	Vale do Eco	Campo Cerrado	8v
Sapotaceae	*Pouteria* sp. 2	Leaf	Globoid	Green	No	Vale do Eco	Campo Cerrado	8w
Simaroubaceae	*Simarouba versicolor* A.St.-Hil.*	Leaf	Globoid	Green/red	No	Cachoeira Véu da Noiva	Cerrado s.l.	8x
Simaroubaceae	*Simarouba versicolor* A.St.-Hil.*	Leaf	Lenticular (adax), conical (abax)	Green	No	Cachoeira Véu da Noiva	Cerrado s.l.	8y, 8z

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Simaroubaceae	*Simarouba versicolor* A.St.-Hil.*	Leaf	Cylindrical	Green	No	Cachoeira das Andorinhas	Cerrado s.l.	8za
Simplocaceae	*Symplocos* cf. *nitens* (Pohl) Benth.*	Stem	Fusiform	Brown	No	Cachoeira Véu da Noiva	Cerrado s.l.	8zb
Siparunaceae	*Siparuna guianensis* Aubl.	Leaf	Cylindrical	Yellow/ brown	Yes	Cachoeira Véu da Noiva	Cerrado s.l.	8zc
Siparunaceae	*Siparuna guianensis* Aubl.	Stem	Globoid	Green	No	Cachoeira Véu da Noiva	Cerrado s.l.	8zd
Siparunaceae	*Siparuna guianensis* Aubl.	Leaf vein	Globoid	Brown	No	Vale da Benção	Gallery forest	8ze
Siparunaceae	*Siparuna guianensis* Aubl.	Leaf	Globoid	Grey	No	Vale da Benção	Gallery forest	8zf
Siparunaceae	*Siparuna guianensis* Aubl.	Leaf	Lenticular	Green	Yes	Cachoeira Véu da Noiva	Cerrado s.l.	8zg, 8zh
Siparunaceae	*Siparuna* sp.	Leaf vein	Fusiform	Green	Yes	Vale da Benção	Gallery forest	8zi
Smilacaceae	*Smilax brasiliensis* Spreng.	Stem	Amorphous	Green	No	Vale do Eco	Campo Cerrado	9a
Smilacaceae	*Smilax brasiliensis* Spreng.	Leaf vein	Globoid	Green/brown	No	Vale do Eco	Campo Cerrado	9b
Smilacaceae	*Smilax fluminensis* Steud.	Leaf vein	Lenticular (addax.), globoid (abax.)	Green	No	Vale da Benção	Gallery forest	9c
Smilacaceae	*Smilax fluminensis* Steud.	Leaf	Lenticular	Green	No	Vale da Benção	Gallery forest	9d
Styracaceae	*Styrax* sp.	Leaf	Lenticular	Black	No	Cachoeira Véu da Noiva	Cerrado s.l.	9e
Styracaceae	*Styrax* sp.	Stem	Fusiform	Brown	No	Cachoeira Véu da Noiva	Cerrado s.l.	9f
Styracaceae	*Styrax* sp.	Stem	Fusiform	Brown	No	Cachoeira Véu da Noiva	Cerrado s.l.	9g
Styracaceae	*Styrax* sp.	Leaf	Lenticular	Brown	No	Cachoeira Véu da Noiva	Cerrado s.l.	9g
Vochysiaceae	*Qualea parviflora* Mart	Leaf	Lenticular	Brown	No	Cidade de Pedra	Cerrado rupestre	9h
Vochysiaceae	*Qualea parviflora* Mart	Leaf	Lenticular	Black	No	Cidade de Pedra	Cerrado rupestre	9i
Vochysiaceae	*Qualea parviflora* Mart	Leaf	Globoid	Yellow	No	Cidade de Pedra	Cerrado rupestre	9j, 9k
Vochysiaceae	*Qualea parviflora* Mart	Leaf	Lenticular	Yellow/ brown	No	Vale do Eco	Campo Cerrado	9l
Vochysiacece	*Qualea parviflora* Mart	Leaf	Globoid (addax.), conical (abax.)	Green/yellow	Yes	Cidade de Pedra	Cerrado rupestre	9m, 9n

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Vochysiacece	*Qualea parviflora* Mart	Leaf	Globoid	Yellow	No	Vale do Rio Claro	Cerrado s.s.	9o
Vochysiacece	*Qualea parviflora* Mart	Leaf	Globoid	Yellow/red	Yes	Vale do Rio Claro	Cerrado s.s.	9p
Vochysiacece	*Qualea parviflora* Mart	Leaf	Fusiform	Green	No	Vale do Rio Claro	Cerrado s.s.	9q
Vochysiacece	*Qualea parviflora* Mart	Stem	Amorphous	Brown	Yes	Cachoeira Véu da Noiva	Cerrado s.l.	9r
Vochysiacece	*Qualea parviflora* Mart	Leaf	Globoid	Yellow/red	Yes	Cachoeira Véu da Noiva	Cerrado s.l.	9s
Vochysiacece	*Vochysia petraea* Warm.*	Leaf	Lenticular	Green	No	Cidade de Pedra	Cerrado rupestre	9t
Vochysiaceae	*Vochysia petraea* Warm.*	Leaf	Globoid	Yellow	Yes	Vale do Eco	Campo Cerrado	9u
Unidentified	Unidentified sp. 1	Leaf	Amorphous	Yellow	No	Cachoeira Véu da Noiva	Cerrado s.l.	9v
Unidentified	Unidentified sp. 2	Leaf	Globoid	Green	No	Cidade de Pedra	Cerrado rupestre	9w
Unidentified	Unidentified sp. 3	Stem	Globoid	Yellow	No	Cidade de Pedra	Cerrado rupestre	9x
Unidentified	Unidentified sp. 4	Leaf vein	Fusiform	Green	No	Cidade de Pedra	Cerrado rupestre	9y
Unidentified	Unidentified sp. 5	Leaf	Cylindrical	Brown	No	Cidade de Pedra	Cerrado rupestre	9z
Unidentified	Unidentified sp. 5	Leaf	Globoid	Yellow	No	Cidade de Pedra	Cerrado rupestre	9z
Unidentified	Unidentified sp. 6	Leaf	Conical	Yellow	Yes	Cidade de Pedra	Cerrado rupestre	9za
Unidentified	Unidentified sp. 7	Stem	Fusiform	Brown	No	Vale do Eco	Campo Cerrado	9zb
Unidentified	Unidentified sp. 7	Leaf	Cylindrical	Green	Yes	Vale do Eco	Campo Cerrado	9zc, 9zd
Unidentified	Unidentified sp. 8	Leaf vein	Fusiform	Green	No	Vale do Eco	Campo Cerrado	9ze
Unidentified	Unidentified sp. 9	Leaf	Globoid	Green	Yes	Vale da Benção	Gallery forest	9zf
Unidentified	Unidentified sp. 10	Stem	Globoid	Red	No	Cachoeira Véu da Noiva	Cerrado s.l.	9zg
Unidentified	Unidentified sp. 11	Stem	Globoid	Brown	No	Cachoeira Véu da Noiva	Cerrado s.l.	9zh

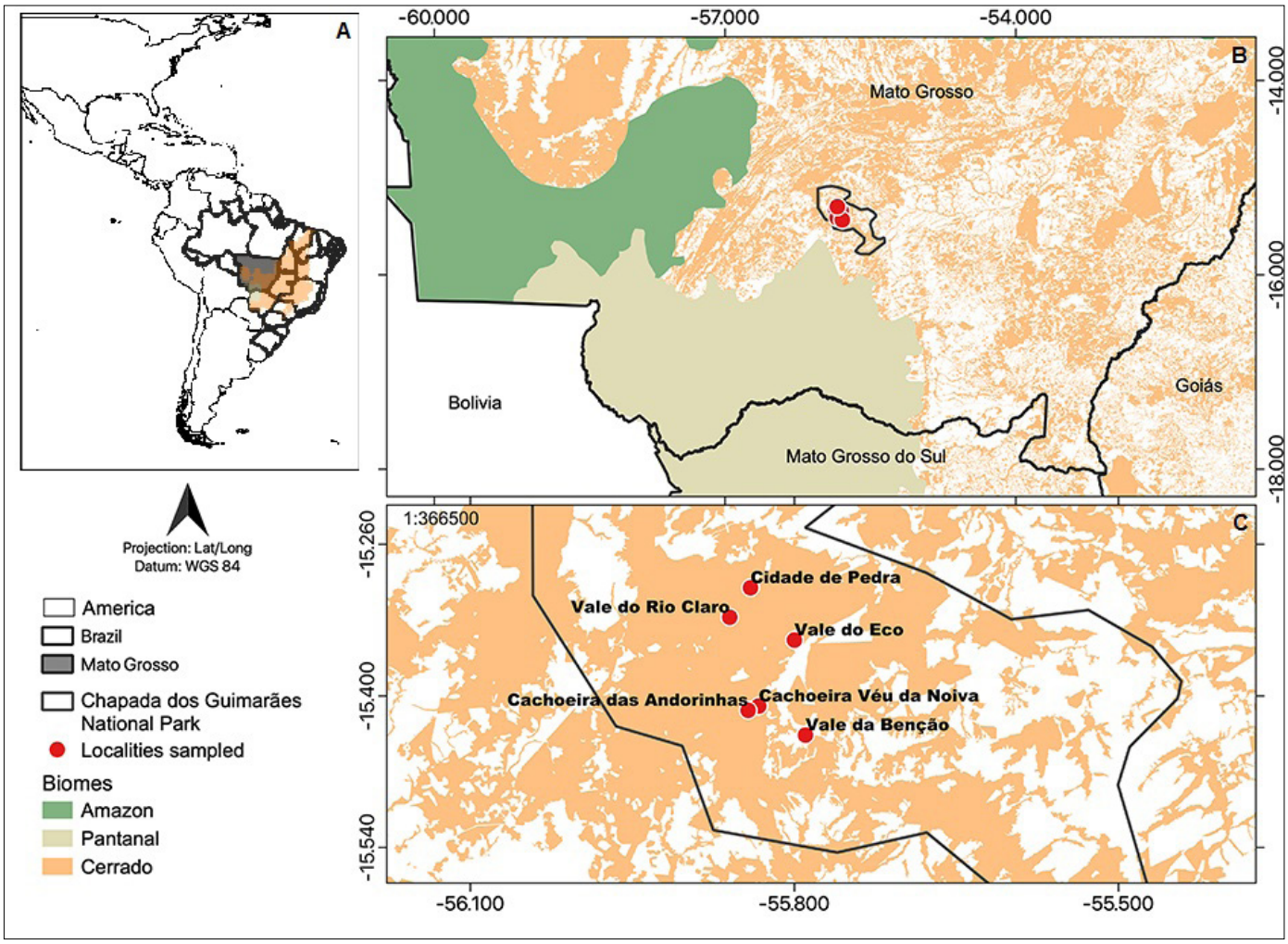

Figure 1. A. Map of South America indicating the Mato Grosso State and Cerrado Biome extension in Brazil. B. Map of the main biomes of Mato Grosso State and the position of Parque Nacional da Chapada dos Guimarães in Mato Grosso State. C. Map of the sampling localities of Parque Nacional da Chapada dos Guimarães, Mato Grosso State, Brazil.

families in morphotypes of insect galls were Fabaceae (N=49, 16.7%), Bignoniaceae (N=16, 5.4%), Melastomataceae, and Myrtaceae (N=13, 4.4% each), Burseraceae, Malpighiaceae, and Vochysiaceae (N=12, 4.1% each). The richest plant genera in gall morphotypes were *Andira* Lam. (N=17; 5.8%), *Myrcia* DC., *Davilla* Vand. and *Protium* Burm.f. (N=11; 3.7%), and *Protium heptaphyllum* (Aubl.) Marchand (N=11, 3.7%), *Qualea parviflora* Mart (N=10, 3.4%), *Davilla grandiflora* A.St.-Hil. and *Copaifera depilis* Dwyer (N=8, 2.7% each) are the studied area's super host species. The organ most affected were the leaves (N=250; 85%); the lenticular (N=104, 35.4%) and globoid gall shapes (N=96, 32.5%) were predominant, as the color green and its variations (N=129; 43.9%) and the glabrous galls (N=239; 81.3%).

From the insect galls, 91 (30%) of the gall inducers were obtained and identified in 66 host plant species. The gall makers of 218 morphotypes are undetermined because the material collected were empty. In 11 cases the specimens obtained were damaged or with insufficient information to the identification. Among the insect gall inducers, 51% belong to Diptera (N=45), 22.5% to Hymenoptera (N=20), followed by far by Coleoptera (N=6, 6.7%), Hemiptera (N=4, 4.5%) and Thysanoptera (N=2, 2.2%) and Lepidoptera (N=1, 1%). We identified eleven species of Cecidomyiidae: nine gall makers – three species of *Lopesia* Rübsaamen, two species of *Asphondylia* Loew and one species of each genus *Bruggmannia* Tavares, *Dasineura* Rondani, *Stephomyia* Tavares and *Youngomyia* Felt, and two species of the inquiline genus *Trotteria* Kieffer. Associated fauna and other details are in Table 4. One supplementary gall in *Miconia albicans* (Sw.) *Triana* (Melastomataceae) (Fig. 9G) was induced by fungus.

Aiouea Aubl., *Alicia* W.R.Anderson, *Ancistrotropis* A. Delgado, *Bernardia* Houst. ex Mill., *Peritassa* Miers, *Pleonotoma* Miers, *Pristimera* Miers are new records as a host plant for insect galls. The same occurs with 38 host plant species (Table 2). Two host plant species are listed in the Red List of Threatened Species of the International Union for Conservation of Nature in the category "Threatened": *Vochysia petraea* Warm. as "Endangered" and *Talisia subalbens* (Mart.) Radlk. as "Vulnerable".

Additionally, *Bernardia similis* Pax and K.Hoffm and *Ormosia macrophylla* Benth. are registered for the first time in Mato Grosso State's flora (Flora do Brasil 2020).

Discussion

Even though comparisons of this study with others are hampered both, by the diversity of sampling methods used and by the presence of

Figure 2. Insect galls of Parque Nacional da Chapada dos Guimarães, Mato Grosso State, Brazil in host plants indicated. Anacardiaceae. a. *Anacardium nannum*, b. *Tapirira guianensis*. Annonaceae. c. *Annona dioica*, d–e. *Annona tomentosa*, f–g. *Duguetia flagellaris*, h–k. *Duguetia furfuracea*, l–m. *Guatteria ferruginea*, n. *Unonopsis guatterioides*. Apocynaceae. o. *Aspidosperma subincanum*, p–q. *Aspidosperma tomentosum*, r–s. *Aspidosperma verbascifolium*, t. *Odontadenia lutea*. Araceae. u–v. *Philodendron* sp. Araliaceae. w. *Schefflera morototoni*. Aristolochiaceae. x–y. *Aristolochia* sp. Asteraceae. z. *Mikania* sp., za–zc. *Mikania* cf. *micrantha*, zd–zf. *Piptocarpha rotundifolia*. Bignoniaceae. zg–zi. *Anemopaegma glaucum*.

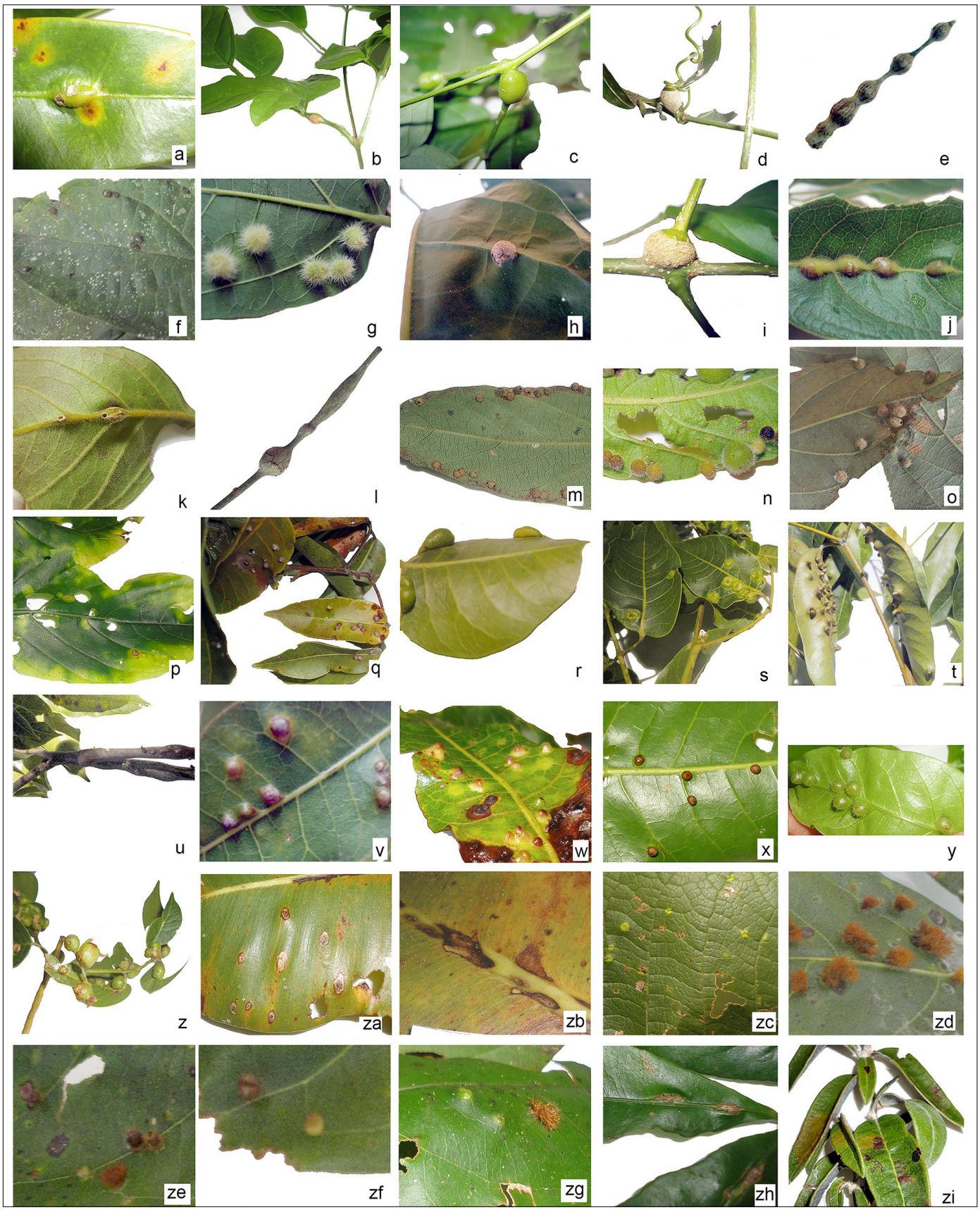

Figure 3. Insect galls of Parque Nacional da Chapada dos Guimarães, Mato Grosso State, Brazil in host plants indicated. Bignoniaceae. a. *Anemopaegma glaucum*. b–c. *Pleonotoma* sp., d. Bignoniaceae sp. 1, e–g. Bignoniaceae sp. 2, h–i. Bignoniaceae sp. 3, j–k. Bignoniaceae sp. 4. Boraginaceae. l–o. *Cordia sellowiana*. Burseraceae. p. cf. *Tetragastris altissima*, q–z. *Protium heptaphyllum*. Callophylaceae. za–zb. *Kielmeyera grandiflora*. Caryocaraceae. zc. *Caryocar brasiliense*. Celastraceae. zd–zg. *Peritassa* sp. zh. *Pristimera celastroides*. Chrysobalanaceae. zi. Chrysobalanaceae sp.

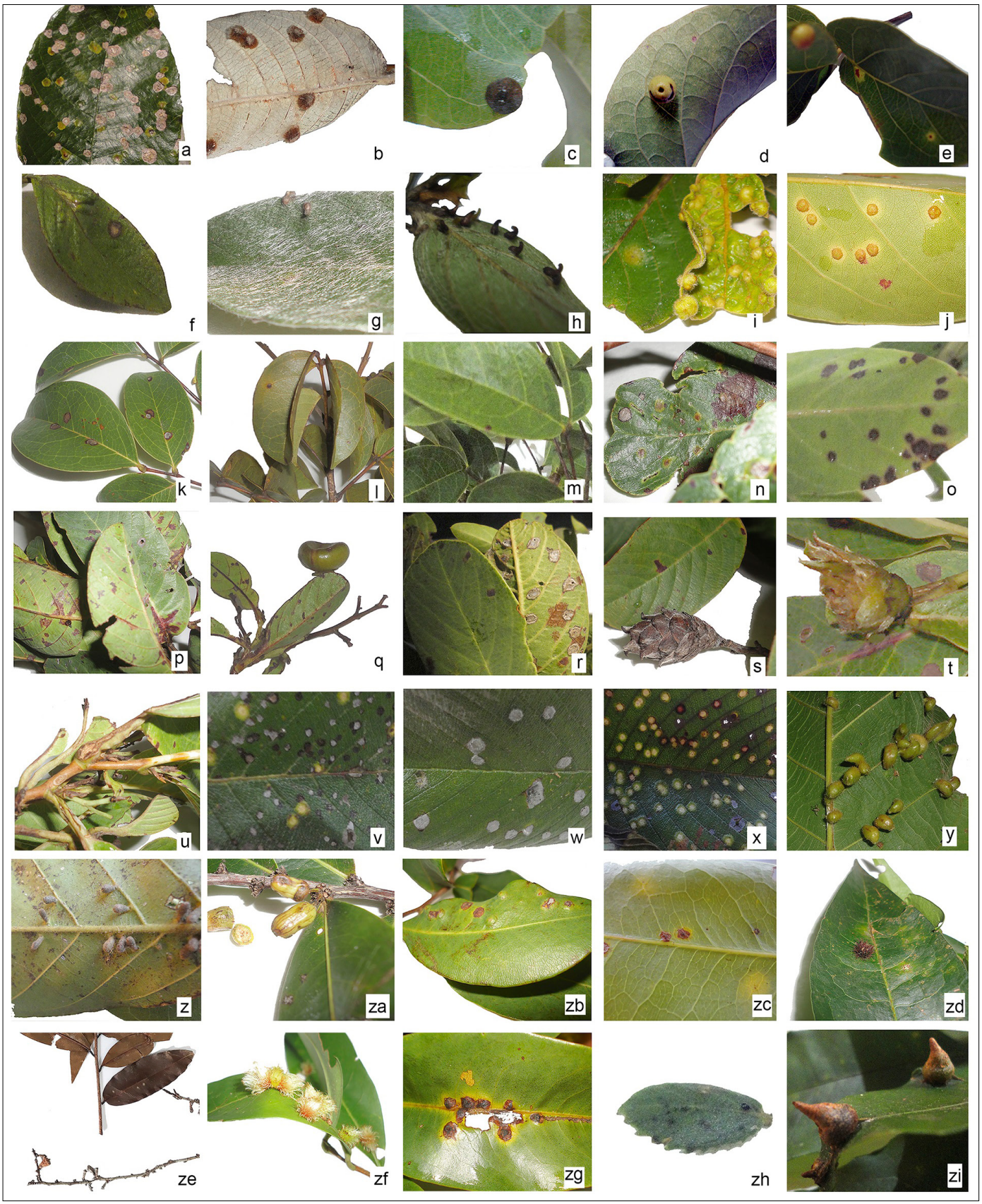

Figure 4. Insect galls of Parque Nacional da Chapada dos Guimarães, Mato Grosso State, Brazil in host plants indicated. Chrysobalanaceae. a–b. *Parinari obtusifolia*. Combretaceae. c–e. *Combretum mellifluum*, f–h. *Terminalia fagifolia*, i. *Terminalia glabrescens*. Connaraceae. j. *Connarus suberosus*, k–m. *Rourea induta*. Dilleniaceae n–u. *Davilla grandiflora*, v–x. *Davilla lacunosa*. Elaeocarpaceae. y–z. *Sloanea* sp. Erythroxylaceae. za. *Erythroxylum* cf. *pruinosum*. zb. *Erythroxylum campestre*, zc. *Erythroxylum citrifolium*, zd–zg. *Erythroxylum daphnites*. Euphorbiaceae. zh. *Bernardia similis*, zi. *Mabea* sp.

Figure 5. Insect galls of Parque Nacional da Chapada dos Guimarães, Mato Grosso State, Brazil in host plants indicated. Euphorbiaceae. a–c. *Manihot tripartita*, d–e. *Jatropha* sp., f–g. *Maprounea guianensis*. Fabaceae. h. *Ancistrotropis formula*, i–n. *Andira cujabensis*, o. *Andira humilis*, p–t. *Andira surinamensis*, u–w. *Andira vermifuga*, x. *Bauhinia* sp. 1, y. *Bauhinia* sp. 2, z. *Bauhinia* sp. 3, za. *Bauhinia* sp. 4, zb. *Calliandra* sp., zc. *Chamaecrista* sp., zd–zi. *Copaifera depilis*.

Figure 6. Insect galls of Parque Nacional da Chapada dos Guimarães, Mato Grosso State, Brazil in host plants indicated. Fabaceae. a. *Copaifera depilis*, b–d. *Hymenaea courbaril*, e. *Inga disticha*, f. *Inga leiocalycina*, g. *Inga vera*, h. *Machaerium* sp., i. *Ormosia macrophylla*, j. *Senegalia* sp., k–m. *Stryphnodendron adstringens*, n–p. *Tachigali rubiginosa*, q. *Tachigali subvelutina*. Lauraceae. r–s. *Aiouea saligna*. Malpighiaceae. t. *Alicia macrodisca*, u. *Byrsonima coccolobifolia*, v–w. *Byrsonima sericea*, x. *Diplopterys pubipetala*, y–ze. *Heteropterys* cf. *coriacea*. Melastomataceae. zf. *Macairea radula*, zg–zh. *Miconia albicans*, zi. *Miconia rubiginosa*.

Figure 7. Insect galls of Parque Nacional da Chapada dos Guimarães, Mato Grosso State, Brazil in host plants indicated. Melastomataceae. a–d. *Miconia* sp. 1, e–f. *Miconia* sp. 2, g. *Mouriri elliptica*, h–i. *Tibouchina* sp. 1, j. *Tococa* sp. Meliaceae. k–m. *Guarea guidonia*, n. *Guarea macrophylla* subsp. *spiciflora*. Monimiaceae. o. *Mollinedia* sp. Moraceae. p. *Brosimum lactescens*, q. *Ficus* sp. 1, r–t. *Ficus* sp. 2. Myrtaceae. u. *Eugenia punicifolia*, v. *Eugenia* sp., w–y. *Myrcia bella*, z–za. *Myrcia guianensis*, zb. *Myrcia* sp., zc–zf. *Myrcia splendens*, zg. *Myrcia variabilis*. Ochnaceae. zh. *Ouratea castaneifolia*, zi. *Ouratea nana*.

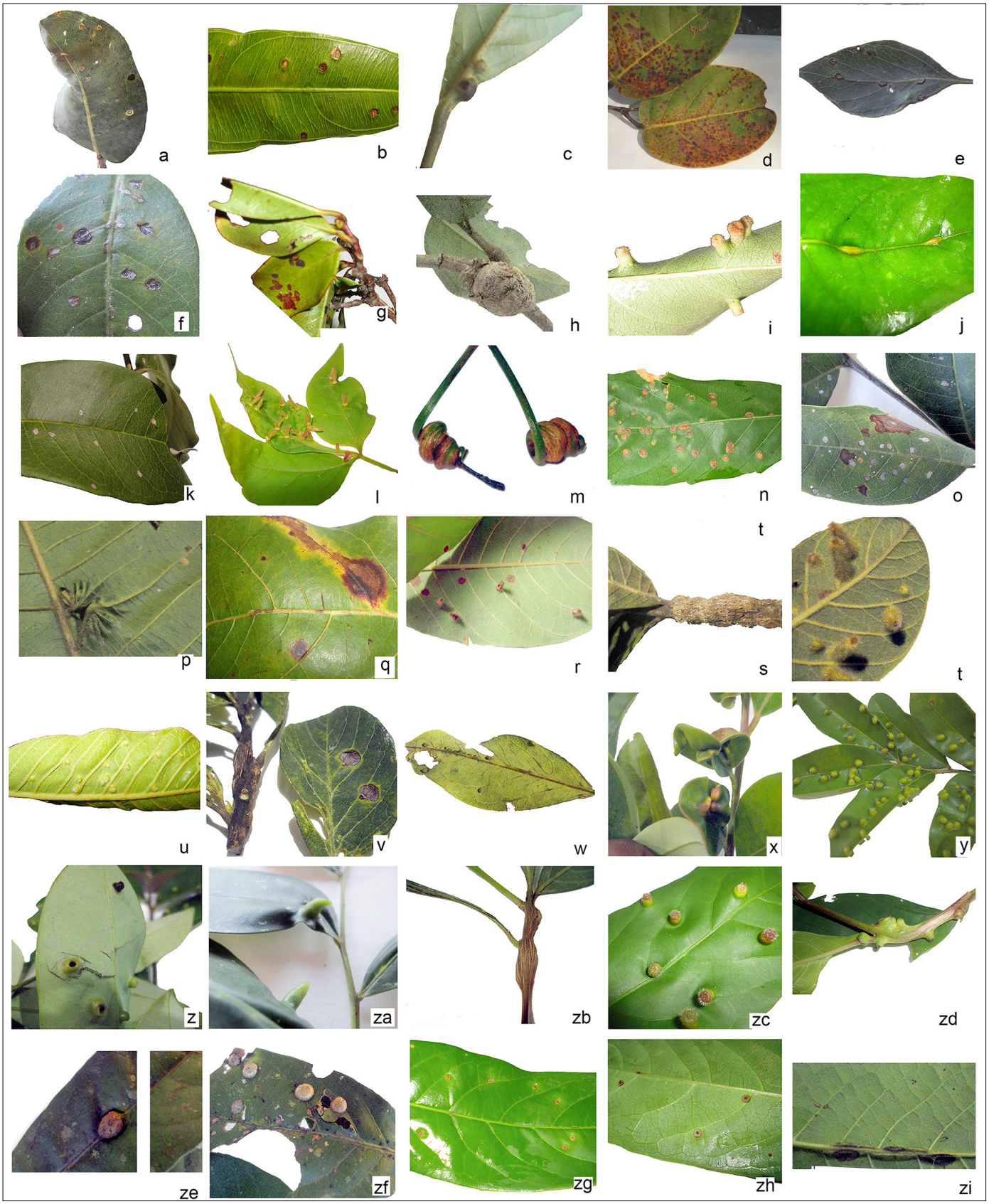

Figure 8. Insect galls of Parque Nacional da Chapada dos Guimarães, Mato Grosso State, Brazil in host plants indicated. Ochnaceae. a. *Ouratea nana*, b. *Ouratea riedeliana*. Piperaceae. c. cf. *Piper dilatatum*. Polygonaceae. d. *Coccoloba cujabensis*. Proteaceae. e. *Roupala montana*. Rubiaceae. f. *Cordiera myrciifolia*, g. *Cordiera obtusa*. h. Rubiaceae sp. Sapindaceae. i. *Matayba guianensis*, j. *Matayba* sp. 1, k. *Matayba* sp. 2, l. *Serjania caracasana*, m. *Serjania matogrossensis*, n. *Serjania* sp., o. *Talisia subalbens*. Sapotaceae. p. *Ecclinusa ramiflora*, q. *Pouteria ramiflora*, r–u. *Pouteria torta*, v. *Pouteria* sp. 1, w. *Pouteria* sp. 2. Simaroubaceae. x–za. *Simarouba versicolor*. Symplocaceae. zb. *Symplocos* cf. *nitens*. Siparunaceae. zc–zh. *Siparuna guianensis*. zi. *Siparuna* sp.

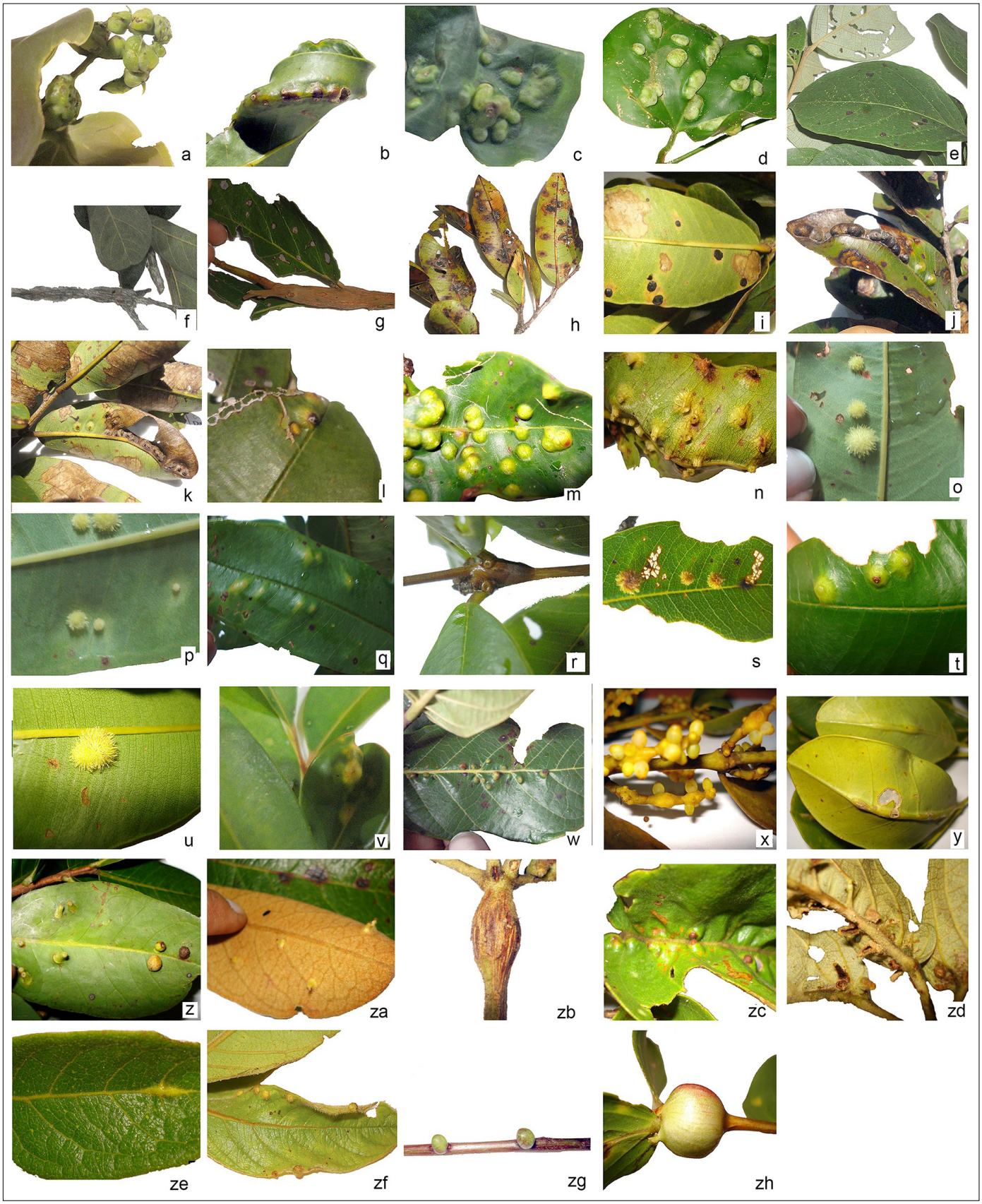

Figure 9. Insect galls of Parque Nacional da Chapada dos Guimarães, Mato Grosso State, Brazil in host plants indicated. Smilacaceae. a–b. *Smilax brasiliensis*, c–d. *Smilax fluminensis*. Styracaceae. e–g. *Styrax* sp. Vochysiaceae. h–s. *Qualea parviflora*, t–u. *Vochysia petraea*. Unidentified. v. Unidentified sp. 1, w. Unidentified sp. 2, x. Unidentified sp. 3, y. Unidentified sp. 4, z. Unidentified sp. 5, za. Unidentified sp. 6, zb–zd. Unidentified sp. 7, ze. Unidentified sp. 8, zf. Unidentified sp. 9, zg. Unidentified sp. 10, zh. Unidentified sp. 11.

Table 3. Richness of gall morphotypes and plant super-hosts families and species from localities in Brazilian Cerrado areas.

Inventories	Locality, Brazilian State, Brazilian Region	Biome	Richness				Super-host	
			Gall morphotypes	Plant species	Plant family	Average morphotypes/ plant species	Families	Species
Urso-Guimarães, Koch & Castello (present study)	Parque Nacional da Chapada dos Guimarães, MT, Midwest	Gallery Forest, Cerrado	295	139	40	2.1	Fabaceae (49), Bignoniaceae (16), Myrtaceae (13), Malpighiaceae (12), Melastomataceae (11)	*Protium heptaphyllum* (10), *Qualea parviflora* (10), *Davilla grandiflora* (8), *Copaifera depilis* (8)
Carneiro et al. (2009)	Cadeia do Espinhaço, MG, Southeast	Rupestrian fields	241	142	29	1.7	Asteraceae (86), Melastomataceae (22), Malpighiaceae (18)	*Baccharis pseudomyriocephala* (10), *Byrsonima coccolobifolia* (8), *Baccharis platypoda* (7)
Fernandes et al. (1997)	Jequitinhonha Valley, MG, Southeast	Rupestrian fields	236	134	27	1.76	Fabaceae (34), Malpighiaceae (32), Asteraceae (32)	*Sida urens* (6)
Bergamini et al. (2017)	Floresta Nacional de Silvania, GO, Midwest	Gallery Forest, Cerrado	186	61	35	3.05	Fabaceae (18), Asteraceae (17), Sapindaceae (16)	*Protium heptaphyllum* (14), *Siparuna guianensis* (12), *Serjania* sp. (12)
Silva et al. (2018)	Hidrolândia, GO, Midwest	SEF, Cerrado	150	104	39	1.44	Fabaceae (22), Malpighiaceae (13), Sapindaceae (11), Erythroxylaceae (8), Myrtaceae (9)	*Siparuna guianensis* (7), *Bauhinia brevipes* (6), *Erythroxylum* sp. (5)
Maia & Fernandes (2004)	Serra de São José, Tiradentes, MG, Southeast	Rupestrian fields	137	73	30	1.88	Fabaceae (20), Myrtaceae (18), Asteraceae (16)	*Protium heptaphyllum* (7), *Copaifera langsdorffii* (6), *Myrcia* sp. (6)
Luz et al. (2012)	APA Rio Pandeiros, MG, Southeast	Caatinga, Cerrado	98	70	20	1.4	Fabaceae (19), Myrtaceae (6), Sapindaceae (4)	*Copaifera langsdorffii* (11), *Calophyllum brasiliense* (5), *Bauhinia brevipes* (4)
Araújo et al. (2014)	Parque Nacional das Emas, Mineiros, GO, Midwest	Cerrado	97	55	24	1.76	Myrtaceae (17), Fabaceae (14), Vochysiaceae (9)	*Andira cujabensis* (4), *Myrcia guianensis* (4)
Coelho et al. (2013a)	Serra da Mantiqueira, MG, Southeast	Cerrado , Atlantic Forest	93	50	21	1.86	Asteraceae (52), Melastomataceae (17), Euphorbiaceae (5)	*Baccharis platypoda* (8), *Baccharis salzmanii* (6)
Gonçalves-Alvim & Fernandes (2001)	Estação Ecológica de Pirapitinga, Três Marias, MG, Southeast	Cerrado	92	62	28	1.48	Fabaceae (13), Asteraceae (5), Malpighiaceae (5)	*Byrsonima coccolobifolia* (4) *Andira* sp. (4), *Myrcia* sp. (4)

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Saito & Urso-Guimarães (2012)	Estação Ecológica de Jataí, Luiz Antônio, SP, Southeast	Cerrado	69	41	24	1.68	Malpighiaceae (9), Annonaceae (7), Myrtaceae (7)	*Byrsonima intermedia* (6), *Duguetia furfuracea* (5), *Arrabidaea* sp. (4)
Urso-Guimarães et al. (2017)	Morro do Camisão, Aquidauana, MS, Midwest	Cerrado	68	50	23	1.36	Fabaceae (20), Sapindaceae (8), Myrtaceae (7)	*Hymenaea stigonocarpa* (4), *Guibourtia hymenaeifolia* (3), *Amorimia pubiflora* (3)
Araújo et al. (2011)	Parque Estadual da Serra dos Pireneus, Pirenópolis, GO, Midwest	Gallery Forest, SEF, Cerrado, Rocky Savanna	62	51	28	1.22	Fabaceae (8), Styracaceae (6), Malpighiaceae (5)	*Styrax pohlii* (5) &*ira paniculata* (3), *Qualea parviflora* (3), *Davilla elliptica* (2)
Malves & Friero-Costa (2012)	Lavras, MG, Southeast	Rupestrian Fields, Riparian Forest, Cerrado	57	43	18	1.33	Asteraceae (6), Myrtaceae (5), Melastomataceae (3)	*Croton* sp. (4), *Eugenia* sp.2 (3)
Santos et al. (2012)	Caldas Novas, GO, Midwest	Cerrado	56	34	21	1.65	Fabaceae (9), Styracaceae (6), Ulmaceae (4)	*Styrax pohlii* (6), *Inga cylindrica* (3), *Serjania obtusidentata* (3), *Trema micrantha* (3)
Nogueira et al. (2016)	Serra Geral, Caitité, BA, Northeast	Caatinga, Cerrado	49	14	13	3.5	Fabaceae (22), Malpighiaceae (10)	*Copaifera langsdorffii* (10), *Bauhinia acuruana* (5), *Mimosa gemmulata* (4)
Vieira et al. (2018)	Caitité, BA, Northeast	Rupestrian fields, Cerrado	48	37	21	1.3	Fabaceae (10), Malpighiaceae (8), Myrtaceae (4)	Copaifera sabulicola (5)
Coelho et al. (2013b)	Serra do Cabral, MG, Southeast	Rupestrian Fields, Cerrado	47	39	21	1.21	Asteraceae (12), Malpighiaceae (9), Fabaceae (4)	*Byrsonima guilleminiana* (3)
Costa et al. (2014)	Caitité, BA, Northeast	Caatinga, Cerrado	43	33	17	1.3	Fabaceae (15), Myrtaceae (5)	*Bauhinia pulchella* (3)
Silva et al. (2015)	Campus Samambaia - UFG, GO, Midwest	Cerrado	42	22	20	1.91	Styracaceae (7), Burseraceae (7), Fabaceae (5)	*Styrax pohlii* (7), *Protium heptaphyllum* (7), *Siparuna guianensis* (4)
Fernandes et al. (1988)	Campus UFMG, Belo Horizonte, MG, Southeast	Cerrado	37	22	11	1.68	Fabaceae (15), Boraginaceae (5)	*Copaifera langsdorffii* (7), *Cordia sellowiana* (4)
Urso-Guimarães & Scareli-Santos (2006)	Santa Rita do Passa Quatro, SP, Southeast	Cerrado	36	26	15	1.38	Fabaceae (7), Myrtaceae (5), Annonaceae (4)	*Duguetia furfuracea* (3), *Myrcia bella* (3)
Urso-Guimarães et al. (2003)	Delfinópolis, MG, Southeast	Rupestrian fields, Gallery Forest, Cerrado	22	19	16	1.16	Fabaceae (5), Rubiaceae (2),Vochysiaceae (2)	*Bauhinia ungulata* (2), *Chomelia pohliana* (2), *Qualea parviflora* (2)

Table 4. Gall makers and associated fauna in galls of Parque Nacional da Chapada dos Guimarães, Mato Grosso, Brazil.

Host plat family	Host plant species	Gall inducers	Associated Fauna
Anacardiaceae	*Anacardium nannum* A.St.-Hil.*	Diptera, Cecidomyiidae, Asphondyliini, *Bruggmannia* sp.	not observed
Anacardiaceae	*Tapirira guianensis* Aubl.	Diptera, Cecidomyiidae, Cecidomyiinae	not observed
Annonaceae	*Duguetia furfuracea* (A.St.-Hil.) Saff.	Diptera, Cecidomyiidae, Cecidomyiinae	not observed
Annonaceae	*Duguetia furfuracea* (A.St.-Hil.) Saff.	Hemiptera	not observed
Annonaceae	*Duguetia furfuracea* (A.St.-Hil.) Saff.	Hymenoptera, Chalcidoidea	not observed
Apocynaceae	*Aspidosperma tomentosum* Mart.	Unidentified	not observed
Apocynaceae	*Aspidosperma verbascifolium* **Müll.Arg.***	Hemiptera	not observed
Asteraceae	*Mikania* sp.	Coleoptera	not observed
Asteraceae	*Mikania* cf. *micrantha* Kunth	Hymenoptera	not observed
Asteraceae	*Mikania* cf. *micrantha* Kunth	Hymenoptera, Chalcidoidea	not observed
Asteraceae	*Piptocarpha rotundifolia* (Less.) Baker	Diptera, Cecidomyiidae, Cecidomyiinae	Hymenoptera
Asteraceae	*Piptocarpha rotundifolia* (Less.) Baker	Hymenoptera, Chalcidoidea	not observed
Bignoniaceae	*Anemopaegma glaucum* Mart. ex DC.*	Coleoptera	not observed
Bignoniaceae	*Pleonotoma* sp.	not observed	Hymenoptera
Bignoniaceae	*Pleonotoma* sp.	Thysanoptera, Phlaeothripidae	not observed
Bignoniaceae	Bignoniaceae sp. 1	Unidentified	not observed
Bignoniaceae	Bignoniaceae sp. 2	Diptera, Cecidomyiidae, Cecidomyiinae	Hymenoptera
Bignoniaceae	Bignoniaceae sp. 3	Hymenoptera, Chalcidoidea	not observed
Bignoniaceae	Bignoniaceae sp. 3	Coleoptera	Hymenoptera, Chalcidoidea
Bignoniaceae	Bignoniaceae sp. 4	Diptera, Cecidomyiidae, Cecidomyiinae	Hymenoptera
Bignoniaceae	Bignoniaceae sp. 4	Diptera, Cecidomyiidae, Cecidomyiinae	not observed
Boraginaceae	*Cordia sellowiana* Cham.	Diptera, Cecidomyiidae, Asphondyliini, *Asphondylia* sp.2	Hymenoptera, Chalcidoidea
Burseraceae	*Protium heptaphyllum* (Aubl.) Marchand	Diptera, Cecidomyiidae, Cecidomyiinae	Hymenoptera
Burseraceae	*Protium heptaphyllum* (Aubl.) Marchand	Diptera, Cecidomyiidae, Cecidomyiinae	not observed
Burseraceae	*Protium heptaphyllum* (Aubl.) Marchand	Diptera, Cecidomyiidae, Cecidomyiinae	Hymenoptera, Encyrtidae
Burseraceae	*Protium heptaphyllum* (Aubl.) Marchand	Hymenoptera, Chalcididae	not observed
Celastraceae	*Peritassa* sp.	Diptera, Cecidomyiidae, Cecidomyiinae	Diptera, Cecidomyiidae, *Trotteria* sp.1
Celastraceae	*Peritassa* sp.	Hymenoptera, Chalcidoidea	Psocoptera
Celastraceae	*Peritassa* sp.	Hymenoptera, Chalcidoidea	not observed
Celastraceae	*Peritassa* sp.	Hymenoptera, Chalcidoidea	not observed
Chrysobalanaceae	*Parinari obtusifolia* Hook.f.*	Diptera, Cecidomyiidae, Cecidomyiinae	not observed
Chrysobalanaceae	*Parinari obtusifolia* Hook.f.*	Diptera, Cecidomyiidae, Cecidomyiinae, Lasiopteridi	Hymenoptera
Combretaceae	*Terminalia glabrescens* Mart.*	Diptera, Cecidomyiidae, Cecidomyiinae	Hymenoptera
Connaraceae	*Rourea induta* Planch.	Diptera, Cecidomyiidae, Cecidomyiinae	Hemiptera
Dilleniaceae	*Davilla grandiflora* A.St.-Hil.*	Diptera, Cecidomyiidae, Cecidomyiinae	not observed
Dilleniaceae	*Davilla lacunosa* Mart.*	Diptera, Cecidomyiidae, Cecidomyiinae	not observed
Elaeocarpaceae	*Sloanea* sp.	Unidentified	not observed
Erythroxylaceae	*Erythroxylum daphnites* Mart.	Diptera, Cecidomyiidae, Cecidomyiinae	not observed
Euphorbiaceae	*Manihot tripartita* (Spreng.) Müll.Arg.	Diptera, Cecidomyiidae, Cecidomyiinae	not observed
Euphorbiaceae	*Maprounea guianensis* Aubl.	Diptera, Cecidomyiidae, Cecidomyiinae	not observed

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Fabaceae	*Andira cujabensis* Benth.	Hymenoptera	not observed
Fabaceae	*Andira humilis* Mart. ex Benth.	Diptera, Cecidomyiidae, Lopesiini, *Lopesia andira* Garcia et al., 2017	not observed
Fabaceae	*Andira surinamensis* (Bondt) Splitg. ex Amshoff	Unidentified	not observed
Fabaceae	*Andira surinamensis* (Bondt) Splitg. ex Amshoff	Unidentified	not observed
Fabaceae	*Andira vermifuga* (Mart.) Benth.	Diptera, Cecidomyiidae, Cecidomyiinae	Hymenoptera, Chalcidoidea
Fabaceae	*Andira vermifuga* (Mart.) Benth.	Diptera, Cecidomyiidae, Lopesiini, *Lopesia chapadensis* Garcia & Urso-Guimarães, 2018	not observed
Fabaceae	*Bauhinia* sp. 4	Unidentified	not observed
Fabaceae	*Calliandra* sp.	Unidentified	Unidentified
Fabaceae	*Copaifera depilis* Dwyer	Diptera, Cecidomyiidae, Cecidomyiinae	Hymenoptera, Chalcidoidea
Fabaceae	*Copaifera depilis* Dwyer	Diptera, Cecidomyiidae, Cecidomyiinae	not observed
Fabaceae	*Copaifera depilis* Dwyer	Hymenoptera	not observed
Fabaceae	*Copaifera depilis* Dwyer	Unidentified	Unidentified
Fabaceae	*Hymenaea courbaril* L.	Diptera, Cecidomyiidae, Cecidomyiinae	not observed
Fabaceae	*Inga disticha* Benth.	Diptera, Cecidomyiidae, Cecidomyiinae	Hymenoptera, Chalcidoidea
Fabaceae	*Inga leiocalycina* Benth.*	Hemiptera, Cicadelidae	not observed
Fabaceae	*Ormosia macrophylla* Benth.*	Hymenoptera, Chalcidoidea	not observed
Fabaceae	*Tachigali subvelutina* (Benth.) Oliveira-Filho*	Diptera, Cecidomyiidae, Cecidomyiinae	Thysanoptera
Malpighiaceae	*Alicia macrodisca* (Triana & Planch.) W.R.Anderson*	Diptera, Cecidomyiidae, Cecidomyiinae	not observed
Malpighiaceae	*Byrsonima sericea* DC.	Unidentified	not observed
Malpighiaceae	*Diplopterys pubipetala* (A.Juss.) W.R.Anderson & C.C.Davis	Diptera, Cecidomyiidae, Cecidomyiinae	not observed
Malpighiaceae	*Heteropterys* cf. *coriacea* A. Juss.*	Diptera, Cecidomyiidae, Cecidomyiinae	not observed
Malpighiaceae	*Heteropterys* cf. *coriacea* A. Juss.*	Hymenoptera, Pteromalidae	Psocoptera
Melastomataceae	*Miconia* sp. 1	Diptera, Cecidomyiidae, Cecidomyiinae	not observed
Melastomataceae	*Macairea radula* (Bonpl.) DC.	Lepidoptera, Coleophoridae, *Palaeomystella oligophaga* Becker & Adamski, 2008	not observed
Melastomataceae	*Tibouchina* sp.	Unidentified	not observed
Meliaceae	*Guarea guidonia* (L.) Sleumer	Hymenoptera, Chalcidoidea	not observed
Moraceae	*Ficus* sp. 2	Coleoptera	not observed
Myrtaceae	*Myrcia guianensis* (Aubl.) DC.	Hymenoptera, Chalcidoidea	not observed
Myrtaceae	*Myrcia splendens* (Sw.) DC.	Diptera, Cecidomyiidae, Cecidomyiinae	not observed
Piperaceae	cf. *Piper dilatatum* Rich.	Hymenoptera, Chalcidoidea	not observed
Rubiaceae	Rubiaceae sp.	Hymenoptera, Chalcidoidea	not observed
Sapindaceae	*Serjania caracasana* (Jacq.) Willd.	Diptera, Cecidomyiidae, Dasineurini, *Dasineura* sp.	not observed
Sapindaceae	*Serjania matogrossensis* Ferrucci & Acev.-Rodr.*	Diptera, Cecidomyiidae, Cecidomyiinae	not observed
Sapindaceae	*Matayba guianensis* Aubl.	Diptera, Cecidomyiidae,Lopesiini, *Lopesia mataybae* Garcia & Urso-Guimarães, 2018	not observed
Sapotacae	*Pouteria torta* (Mart.) Radlk.	Diptera, Cecidomyiidae, *Youngomyia matogrossensis* Proença & Maia, 2019	not observed

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Sapotaceae	*Pouteria torta* (Mart.) Radlk.	Diptera, Cecidomyiidae, Asphondyliini, *Stephomyia* sp.	Diptera, Cecidomyiidae, *Trotteria* sp.2
Simaroubaceae	*Simarouba versicolor* A.St.-Hil.*	Coleoptera, Curculionidae, Scolytinae	not observed
Simplocaceae	*Symplocos* cf. *nitens* (Pohl) Benth.*	Diptera, Cecidomyiidae, Cecidomyiinae	not observed
Siparunaceae	*Siparuna guianensis* Aubl.	Diptera, Cecidomyiidae, Asphondyliini, *Asphondylia* sp.1	not observed
Siparunaceae	*Siparuna guianensis* Aubl.	Thysanoptera, Phlaeothripidae	Coleoptera, Curculionidae
Smilacaceae	*Smilax brasiliensis* Spreng.	Diptera, Cecidomyiidae, Cecidomyiinae	not observed
Smilacaceae	*Smilax fluminensis* Steud.	Unidentified	Diptera, Phoridae
Styracaceae	*Styrax* sp.	Hymenoptera, Chalcidoidea, Pteromalidae	not observed
Vochysiacece	*Qualea parviflora* Mart	Diptera, Cecidomyiidae, Cecidomyiinae	not observed
Vochysiacece	*Qualea parviflora* Mart	Diptera, Cecidomyiidae, Cecidomyiinae	not observed
Vochysiacece	*Qualea parviflora* Mart	Hymenoptera	not observed
Unidentified	Unidentified sp. 1	Hemiptera	not observed
Unidentified	Unidentified sp. 4	Hymenoptera	not observed
Unidentified	Unidentified sp. 10	Diptera, Cecidomyiidae, Cecidomyiinae	not observed
Unidentified	Unidentified sp. 11	Coleoptera	not observed

other phytophysiognomies than Cerrado *strict sensu*, our results allow us to state that the Parque Nacional da Chapada dos Guimarães harbors the highest number of gall morphotypes and the second-highest gall morphotypes average per plant species found in the Cerrado hitherto (Araújo et al. 2019, Cintra et al. 2020). The number of morphotypes (295) and the average of morphotypes per plant species (2.1) are comparable with those found in the Parque Nacional de Silvania (GO) (Bergamini et al. 2017), with similar phytophysiognomies sampled (Gallery Forest and Cerrado *strict sensu*). These authors found 186 gall morphotypes and an average of 3.0 gall morphotypes per species, representing the highest average recorded in the Cerrado Biome (Bergamini et al. 2017). A similar pattern was found in studies conducted in Campos Rupestres (rupestrian grasslands) in the Cadeia do Espinhaço (Carneiro et al. 2009) and in the Vale do Rio Jequitinhonha (Fernandes et al. 1997) (both in Minas Gerais State), with 241 and 236 gall morphotypes, respectively and an average of 1.7 morphotypes per species each.

Our results corroborate the hypothesis that environmental stress (Fernandes & Price 1988) would justify the high richness of gall morphotypes in these phytophysiognomies. Indeed, considering that gall morphotypes are extended phenotypes of their inducers (Abrahamson & McCrea 1986), it also justifies gall makers' high richness in scleromorphic vegetation. The plants of practically all phytophysiognomies in Cerrado have adaptations to soil poverty and hydric stress, recognized in high concentrations of defense compounds, especially tannins. This higher concentration of chemical compounds provides the galls inducers defense against predators and pathogens (Fernandes & Price 1992). Allied to this, manipulating the nutritional resources in very young vegetable tissue (Fernandes et al. 2011) allows the gallers larvae access to nutrients inaccessible to other herbivores.

Fabaceae, Bignoniaceae, Melastomataceae, Myrtaceae, Burseraceae, Malpighiaceae, and Vochysiaceae are the richer families in species in the Parque Nacional da Chapada dos Guimarães, which corroborates in part the hypothesis of the predominance of gall morphotypes in the families with the most remarkable species richness (Southwood 1960, 1961, Santos-Silva & Araújo 2020). Also confirm the predominance of these families in the data compiled by Cintra et al. (2020). Fabaceae is among the five richest families in gall morphotypes in 20 of the 22 studies in Cerrado phytophysiognomies, Myrtaceae in 11, and Malpighiaceae in 10 (Araújo et al. 2019). On the other hand, Vochysiaceae is a super host family case because, in just two species, we found a high number of morphotypes (12), contributing to increasing the total number of gall morphotypes in the sampled area. This family was also mentioned as a super host in an area of Cerrado in Goiás state (Araújo 2011). Bignoniaceae was referred to as a rich family in gall morphotypes in Pantanal (Julião et al. 2002; Urso-Guimarãeset al. 2017), but it is among the super host families in the Cerrado for the first time. In the compilation of 32 areas of Cerrado, Cintra et al. (2020) found 20 gall morphotypes against 16 morphotypes found in this study. These results may be related to the fact that all Bignoniaceae species sampled in this study are climbing plants, which are not frequently sampled in studies about galling insects. It shows the importance of sampling all vegetation strata to understand the galling insects' distribution in their hosts.

From the richest plant genera in gall morphotypes found in Parque Nacional da Chapada dos Guimarães, *Andira* Lam. and *Myrcia* DC. are richer in species, and *Davilla* Vand. and *Protium* Burm.f. are super host species (Table 3). *Myrcia* appears as one of the richest genera in the Cerrado records in Cintra et al. (2020). But *Andira*, *Davilla*, and *Protium* are referred as morphotype richest genera for the first time to Cerrado biome.

Protium heptaphyllum (Aubl.) Marchand, *Qualea parviflora* Mart, *Davilla grandiflora* A.St.-Hil. and *Copaifera depilis* Dwyer were the richest host species in the studied area (Table 3), being *D. grandiflora* reported as super host of gall morphotypes for the first time.

Leaves are the most abundant resource in any biome. The scleromorphic plants in the Cerrado biome have low leaf abscission rates (Fernandes & Price 1988; Price et al. 1998; Cuevas-Reyes et al. 2004), so it is natural that most galls occurred on leaves. The shapes more common, lenticular and globoid, are predominant because they

favor the reduction of water loss, mainly on leaf galls, compared to more bulky shapes such as cylindrical and conical. Together with the color green and glabrous galls, these predominant characteristics are a pattern also found in precedent surveys in Cerrado phytophysiognomies (Araújo et al. 2019).

The Cecidomyiidae was the predominant family among the gall inducers, as found in surveys worldwide (Espírito-Santo & Fernandes 2007).

All plant species are new as host to insect galls to the state of Mato Grosso, except for *Andira cujabensis* Benth., *A. vermifuga* (Mart.) Benth., *Matayba guianensis* Aubl. (Garcia et al. 2017, Garcia & Urso-Guimarães 2018) and *Pouteria torta* (Mart.) Radlk. (Proença & Maia 2019). Eight percent of the 84 genera found in this inventory are new records as a host plant for insect galls, and 27% of the total host plant species sampled in Parque Nacional da Chapada dos Guimarães are new as host for galls. Among the new registers, *Bernardia similis* Pax & K.Hoffm and *Ormosia macrophylla* Benth., also are registered for the first time in the flora of Mato Grosso State (Flora do Brasil 2020). That reinforces the importance of multidisciplinary studies like this, founding new points of occurrence for plant species and the associated fauna.

The two species classified as threatened, *Vochysia petraea* Warm. and *Talisia subalbens* (Mart.) Radlk., are endemic of Cerrado in Mato Grosso State (Shimizu et al. 2020, Acevedo-Rodríguez 2015). Currently, the state is one of Brazil's agricultural frontiers to soybean plantation areas, meaning that both plant species and their interactions (*e.g.,* galls and associated fauna) are also threatened with extinction.

Studies like this collaborate to increase the knowledge about a rich and undescribed fauna. This fauna begins to be documented from its extended phenotype – the gall – which remains on the host plant even after the emergence of the galler. The taxonomic studies' continuity in the areas registered here is fundamental to identify and describe the inducers and the associated fauna. Before the SISBIOTA – Diptera Brasil Program (2010-2015), this study is part, only two species of Cecidomyiidae, the principal inducer of galls in the world, had the occurrence registered in this Mato Grosso State, *Termitomastus leptoproctus* Silvestri, 1901 and *Asphondylia tuiuiu* Urso-Guimarães & Amorim, 2002. Currently, four new species found in this survey have been described – *Lopesia andirae* Garcia et al., 2017, *L. chapadensis* Garcia & Urso-Guimarães, 2018, *L. mataybae* Garcia & Urso-Guimarães, 2018, and *Youngomyia matogrossensis* Proença & Maia, 2019. Another five are under the description (*Asphondylia* spp., *Bruggmannia* sp., *Dasineura* sp. and *Stephomyia* sp.). Even with the efforts addressed during this period, gall inducers' fauna remains poorly known because they are highly diversified. More investigation focused on finding all stages of the life cycle of gall morphotypes documented in this study is necessary to understand this fauna's richness, including the other insects from the associated guild.

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Author Contributions

Dr. Maria Virginia Urso-Guimarães - Substantial contribution in the concept and design of the study, data collection, data analysis and interpretation, manuscript preparation, critical revision, adding intellectual content; Dr. Ingrid Koch and Dr. Ana Carolina Devides Castello - Substantial contribution in the data analysis and interpretation, manuscript preparation, critical revision, adding intellectual 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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