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Inventory

Diversity of insect galls from Mato Grosso State, Brazil: North Pantanal

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Abstract: The Pantanal Biome occupies 20% of the Brazilian territory extending its distribution over two Brazilian States, Mato Grosso and Mato Grosso do Sul. This Biome is one of Brazil's poorly known regions concerning insect gall and their interactions with host plants. In this study, we characterized for the first time the gall morphology, identified host plants and the gall makers from an area of Brazilian wetlands from Mato Grosso State, known as Pantanal Matogrossense. We sampled Pantanal Biome areas in Poconé municipality, along the Transpantaneira Road, Mato Grosso State, Brazil, in two expeditions, July 2012 and January 2013, with a total effort of 2 hours. We characterized 91 morphotypes of insect galls in 54 host plant species; 28 gall makers in 24 host plant species; the richest host plant families are Fabaceae, Myrtaceae, and Sapindaceae. Psidium guineense Sw. is the super host species. This area in Pantanal Matogrossense is the second in the richness of gall morphotypes (N=91) and average morphotypes/plant species (1.7), comparing phytophysiognomies. Additionally, 15 plant species are new record as host in galler-host plant interaction in the world. This number represents 30% of the total of host plant species sampled in Poconé. This inventory is new knowledge to the Pantanal Matogrossense and representing a unique testimony of insect-plant interactions consumed by the unprecedented fire that occurred in Pantanal Biome in the dry season of 2020.
Keywords: *Biodiversity; Brazilian wetlands; conservation; gall makers; Neotropical region; insect-plant-interaction.*

Diversidade de galhas de insetos do Estado do Mato Grosso, Brasil: Pantanal Norte

Resumo: O Bioma Pantanal ocupa 20% do território brasileiro estendendo sua distribuição sobre dois Estados brasileiros, Mato Grosso e Mato Grosso do Sul. Esta é uma das regiões menos estudadas do Brasil com relação aos insetos e suas interações. Neste estudo, caracterizamos pela primeira vez a morfologia de galhas, identificamos plantas hospedeiras e galhadores em áreas do Pantanal Norte, conhecido como Pantanal Matogrossense. As amostragens foram feitas em áreas do Bioma Pantanal, no município de Poconé, ao longo da Estrada Transpantaneira, Mato Grosso, Brasil em duas expedições, julho de 2012 e janeiro de 2013. Caracterizamos 91 morfotipos de galhas entomógenas em 54 espécies de plantas hospedeiras; identificamos 28 galhadores em 24 espécies de plantas hospedeiras; as famílias de plantas hospedeiras mais ricas em galhas são Fabaceae, Myrtaceae e Sapindaceae. Psidium guineense Sw. é a espécie superhospedeira. Esta área no Pantanal Matogrossense é a segunda tanto em riqueza de morfotipos de galhas (N=91) quanto na média de morfotipos por espécie de planta hospedeira (1,7), em fitofisionomias comparáveis. Além disso, 15 espécies de plantas são novos registros como hospedeiras para galhas de insetos no mundo. Esse número representa 30% do total de plantas amostradas em Poconé. Todos os dados deste inventário são conhecimentos novos para o Pantanal Mato-grossense e para o estado do Mato Grosso, representando um testemunho único das interações inseto-planta que foram consumidas pelo fogo sem precedentes ocorrido no Bioma Pantanal em sua estação seca de 2020.
Palavras-chave: *Biodiversidade; conservação; galhadores; interação inseto-planta; Pantanal Matogrossense; região Neotropical.*

Introduction

The Pantanal biome occupies 20% of the Brazilian territory (Junk et al. 2013), extending its distribution over two Brazilian States, Mato Grosso and Mato Grosso do Sul. The Brazilian wetlands, called Pantanal popularly, are considered a hyper-seasonal savannah under contrasting stresses due to alternation between periods of drought and prolonged flooding (Eiten 1982, Marengo et al. 2021). Pantanal harbors deciduous or semi-deciduous forests shedding leaves during the dry season, deciduous forest and Cerrado vegetation in inselbergs and evergreen floodplain forests in the lower areas along rivers and channels (Nunes da Cunha et al. 2007). Its vegetation is highly influenced by Chaco Biome (Pott et al. 2011). It is considered a hotspot of biodiversity, with more than 2,000 species of vascular plants (Pott et al. 2011) and more than 2,000 species of animals, except terrestrial invertebrates (Junk et al. 2006), with the seasonal flood-pulsing harboring habitat specialization (*e.g.*, morphological, anatomical and physiological adaptations) (Junk et al. 2013).

The interaction between plants and insects is still unexplored in North Pantanal, South-western of the State of Mato Grosso, in the Midwest region of Brazil. About 15% of the insect galls inventories made in Brazil were carried out in the Midwest region (Araújo et al. 2019). Despite that, only two have been carried out in the Pantanal biome (Julião et al. 2002, Urso-Guimarães et al. 2017). Both in the State of Mato Grosso do Sul, which is strongly influenced by the Cerrado biome. Julião et al. (2002) and Urso-Guimarães et al. (2017) found 182 morphotypes of galls in 104 host plants, of which only nine plant species and three morphotypes were common. The richest plant family in Abobral was Bignoniaceae, and the super host species was Hippocratea volubilis L. (Julião et al. 2002). In Corumbá/Porto Murtinho, Fabaceae was the richest plant family and Serjania sp. the super host species (Urso-Guimarães et al. 2017).

In this study, we present the first survey of gall-inducing insects for the North Pantanal, including the characterization of gall morphology and the identification of host plants. Our study represents the first step to understanding the richness of the history of host plants' interaction and gall-inducing insects in this biodiverse and unique biome.

In the last three months of 2020, the region of Pantanal Sul Matogrossense and Matogrossense (including Poconé) was devastated by an unprecedented fire. These months correspond to the Pantanal winter, in which the waters of the Paraguay River Basin should overflow the river channels and flood the plains around them. In this period, leaves fall, fruits, and branches accumulated in the litter, generating a formidable amount of food, all consumed by the primary consumers that occupy the food chain base and sustain the unique Pantanal biodiversity. But, in the winter of 2020, the flooding did not occur. All available dry matter functioned as fuel and burned large extensions of the Pantanal, destroying much this biome's rich fauna and flora due to deforestation, cleaning, and reforming pastures using improper management practice without control techniques endanger the conservation (Marengo et al. 2021). In this terrible scenario, our inventory represents a unique testimony of insect-plant interactions consumed by the fire.

Material and Methods

1. *Study site*

We conducted this study in two areas: Pousada Rio Clarinho and Transpantaneira Road Km 40, in Poconé Municipality (16°36'03.5" S, 56°43'46.1" W), State of Mato Grosso, Brazil (Fig. 1). This region is localized in the North Pantanal, also called Pantanal Matogrossense (Fig. 1). Its vegetation is considered a Pantanal mosaic because it is influenced by distinct biomes, with the Amazonia to the North, the Cerrado to the East, the Meridional Forests to the South, and the Chaco to the West (Pott et al. 2011). The Cerrado vegetation occupies 36% of the study area region, corresponding to 10% in the sub-region of Poconé (South-western of the State of Mato Grosso) (Silva et al. 2000). The region's climate is the Tropical Climate of Savannah (Aw), with two well-defined seasons (hot and rainy in summer and dry and cold in winter). The seasonal flooding process is divided into four phases: flooding, flood, reflux, and dry (Costa et al. 2010).

2. *Sampling*

We performed two expeditions in a North Pantanal area in Poconé, State of Mato Grosso, Brazil, one in July 2012 and the other in January 2013. We selected two points to the collection, a floodable gallery forest along the Clarinho river (16° 36' 15.6" S/ 56° 43' 18.8" W), and a dry forest (Chaco edge) near the Transpantaneira Road (16° 35' 14.7" S/ 56° 44' 04.5" W), 3 kilometers apart from each other. We sampled along the trails' edges, with a 30-minute effort was made at each sampling point on each expedition, totaling 2 hours of effort following Price et al. (1998). We measured each route's length to quantify the sampled area (Urso-Guimarães et al. 2017), covering 52 meters in floodable gallery forest trail and 129 meters in the dry forest trail. All gall sighted was collected, without limitation of habitus, stem diameter, or plant height. The collection method, labeling, processing samples, identification of plants, and insects followed Urso-Guimarães et al. (2017) and Araújo et al. (2021). 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 found 91 morphotypes of insect galls in 54 host plant species from 39 genera and 19 families (Table 1 and Figs. 2–5). On average, 1.7 gall morphotypes per plant species (for comparisons with other inventories in Pantanal areas, see Table 2). Four host plants are identified only at the family level, 16 at the genus level, and five are completely unidentified. We collected 83 gall morphotypes in the gallery forest and eight in the dry forest. The richest families in morphotypes are Fabaceae (N=19, 20.9%), Myrtaceae (N=14, 15.4%), and Sapindaceae (N=11, 12%). The richest plant genera in gall morphotypes were *Bauhinia* (N=11, 12%), *Serjania* (N=8, 8.8%), *Psidium* (N=7, 7.7%), and *Combretum* (N=5, 5.5%). The plant species considered super host were *Psidium guineense* Sw. (N=7, 7.7%), *Combretum laxum* Jacq., and the Unidentified sp. 3 (N=5, 5.5% each).

The galls were induced mostly in leaves (N=67, 74%) and stem (N=19, 24%); the globoid (N=32, 35%) and lenticular (N=31, 34%) gall shapes are predominant. The colors green and brown were found in equal proportion (N=43; 47% each) and the glabrous galls are dominant (N=70; 77%).

In this inventory, fifteen plant species are new records as a host plant for insect galls in the world: *Amaioua intermedia* Mart. ex Schult. & Schult.f., *Annona cornifolia* A.St.-Hil., *Bauhinia mollis* (Bong.) D.Dietr., *B. pentandra* (Bong.) D.Dietr., *B. platypetala* Burch. ex Benth., *Byrsonima cydoniifolia* A.Juss., *Coccoloba cujabensis* Wedd,

Table 1. Characterization of insect galls recorded in North Pantanal in Poconé, Mato Grosso State, Brazil organized by host plant. Figures refer to the picture of the gall morphotype. All galls are uni-chambered. New records of plants species as host of galls in the world are marked with asterisk.

Host plat family	Host plant species	Host plant organ	Gall shape	Gall color	Trichome	Collection site	Figures
Anacardiaceae	*Astronium graveolens* Jacq.	Leaf, stem	Cylindrical	Green/brown	Yes	Gallery forest	2A
Annonaceae	*Annona cornifolia* A.St.-Hil.*	Leaf	Cylindrical	Green	No	Gallery forest	2B
Bignoniaceae	*Dolichandra quadrivalvis* (Jacq.) L.G.Lohmann*	Stem	Globoid	Green/brown	No	Dry forest	2C
Bignoniaceae	*Dolichandra quadrivalvis* *	Stem	Fusiform	Green/brown	No	Dry forest	2C
Bignoniaceae	Bignoniaceae sp.1	Stem	Globoid	Green	No	Gallery forest	2D
Bignoniaceae	Bignoniaceae sp.1	Stem	Fusiform	Green	No	Gallery forest	2D
Bignoniaceae	Bignoniaceae sp.2	Stem	Globoid	Brown	No	Gallery forest	2E
Bignoniaceae	Bignoniaceae sp.2	Tendril	Fusiform	Brown	No	Gallery forest	2E
Chrysobalanaceae	*Couepia* sp.	Leaf	Lenticular	Green/brown	No	Gallery forest	2F, 2G
Chrysobalanaceae	*Leptobalanus gardneri* (Hook.f.) Sothers & Prance *	Leaf	Lenticular	Brown	No	Gallery forest	2H
Chrysobalanaceae	*Leptobalanus humilis* (Cham. & Schltdl.) Sothers & Prance	Leaf	Lenticular	Brown	No	Gallery forest	2I
Chrysobalanaceae	*Licania* sp.	Leaf	Lenticular	Brown	No	Gallery forest	2J
Combretaceae	*Combretum laxum* Jacq.	Leaf	Cylindrical	Green	Yes	Gallery forest	2K
Combretaceae	*Combretum laxum*	Leaf	Globoid	Brown	Yes	Gallery forest	2L
Combretaceae	*Combretum laxum*	Leaf	Lenticular	Green	Yes	Gallery forest	2M
Combretaceae	*Combretum laxum*	Leaf	Conical	Green	Yes	Gallery forest	2M, 2N
Combretaceae	*Combretum laxum*	Leaf	Globoid	Green/brown	No	Gallery forest	2O, 2P
Combretaceae	*Terminalia argentea* Mart. & Zucc.	Leaf	Lenticular	Brown	Yes	Dry forest	2Q
Dilleniaceae	*Davilla elliptica* A.St.-Hil.	Leaf	Lenticular	Brown	No	Gallery forest	2R
Euphorbiaceae	*Maprounea guianensis* Aubl.	Leaf	Lenticular	Light yellow	No	Gallery forest	2S
Fabaceae	*Andira vermifuga* (Mart.) Benth.*	Leaf	Lenticular	Brown	No	Dry forest	2T
Fabaceae	*Bauhinia* cf. *pulchella* Benth.	Stem	Globoid	Brown	No	Gallery forest	2U, 2V
Fabaceae	*Bauhinia* cf. *pulchella*	Leaf	Globoid	Brown	No	Gallery forest	2X
Fabaceae	*Bauhinia* cf. *pulchella*	Stem	Globoid	Brown	No	Gallery forest	2Z
Fabaceae	*Bauhinia* cf. *pulchella*	Stem	Fusiform	Brown	No	Gallery forest	2Z
Fabaceae	*Bauhinia mollis* (Bong.) D. Dietr.*	Leaf	Globoid	Brown	Yes	Dry forest	3A
Fabaceae	*Bauhinia mollis* *	Leaf	Lenticular	Brown	No	Gallery forest	3B
Fabaceae	*Bauhinia pentandra* (Bong.) D. Dietr.*	Leaf	Globoid	Brown	Yes	Gallery forest	3C
Fabaceae	*Bauhinia pentandra**	Stem	Fusiform	Brown	No	Gallery forest	3D
Fabaceae	*Bauhinia pentandra**	Stem	Globoid	Brown	No	Gallery forest	3D
Fabaceae	*Bauhinia pentandra**	Stem	Globoid	Brown	No	Gallery forest	3E
Fabaceae	*Bauhinia platypetala* Burch. ex Benth. *	Leaf	Globoid	Brown	Yes	Gallery forest	3F, 3G
Fabaceae	Fabaceae sp.	Leaf	Globoid	Brown	No	Gallery forest	3H, 3I
Fabaceae	Fabaceae sp.	Leaf	Lenticular	Brown	No	Gallery forest	3H, 3I
Fabaceae	Fabaceae sp.	Leaf	Lenticular	Brown	No	Gallery forest	3J
Fabaceae	*Galactia glaucescens* Kunth*	Leaf	Globoid	Brown	No	Gallery forest	3K
Fabaceae	*Galactia glaucescens* *	Stem	Globoid	Brown	No	Dry forest	3L
Fabaceae	*Hymenaea courbaril* L.	Leaf	Lenticular	Brown	No	Gallery forest	3M, 3N
Fabaceae	*Senegalia* sp.	Leaf	Amorphous	Green	No	Gallery forest	3O
Lamiaceae	*Aegiphila* sp. 1	Leaf	Amorphous	Green	No	Gallery forest	3P
Lamiaceae	*Aegiphila* sp. 2	Leaf bud	Globoid	Brown	No	Gallery forest	3Q
Malpighiaceae	*Byrsonima crassifolia* (L.) Kunth	Leaf	Conical	Green/red	No	Gallery forest	3R, 3S
Malpighiaceae	*Byrsonima crassifolia* (L.)	Leaf	Conical	Light yellow	Yes	Gallery forest	3T, 3U

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Malpighiaceae	*Byrsonima cydoniifolia* A.Juss.*	Leaf	Conical	Green	No	Gallery forest	3V, 3X
Moraceae	*Ficus* sp.	Leaf	Lenticular	Purple	No	Gallery forest	3Z
Myrtaceae	*Campomanesia* sp.	Leaf	Globoid	Green	No	Gallery forest	4A
Myrtaceae	*Campomanesia* sp.	Leaf, stem	Globoid	Green	No	Gallery forest	4B
Myrtaceae	*Eugenia* cf. *florida* DC.	Leaf	Globoid	Green/red	No	Gallery forest	4C
Myrtaceae	*Eugenia* cf. *florida*	Leaf	Lenticular	Green	Yes	Gallery forest	4D
Myrtaceae	*Eugenia* sp.	Leaf	Lenticular	Black	No	Gallery forest	4E
Myrtaceae	*Myrcia neolucida* A.R.Lourenço & E.Lucas*	Leaf	Lenticular	Black	No	Gallery forest	4F
Myrtaceae	*Psidium guineense* Sw.	Leaf	Lenticular	Brown	No	Gallery forest	4G
Myrtaceae	*Psidium guineense*	Leaf	Globoid	Green	Yes	Gallery forest	4H
Myrtaceae	*Psidium guineense*	Stem	Fusiform	Brown	No	Gallery forest	4I
Myrtaceae	*Psidium guineense*	Leaf	Globoid	Green	No	Gallery forest	4J
Myrtaceae	*Psidium guineense*	Stem	Globoid	Brown	No	Gallery forest	4K
Myrtaceae	*Psidium guineense*	Leaf	Lenticular	Brown	No	Gallery forest	4L
Myrtaceae	*Psidium guineense*	Stem	Fusiform	Brown	No	Gallery forest	4L
Myrtaceae	Myrtaceae sp.	Stem	Globoid	Brown	No	Gallery forest	4M
Polygonaceae	*Coccoloba cujabensis* Wedd.*	Leaf	Lenticular	Green	Yes	Gallery forest	4N
Polygonaceae	*Coccoloba cujabensis**	Leaf	Lenticular	Brown	No	Gallery forest	4R
Polygonaceae	*Coccoloba cujabensis**	Stem	Globoid	Brown	No	Gallery forest	4S
Polygonaceae	*Polygonum acuminatum* Kunth*	Leaf	Lenticular	Green/grey	No	Gallery forest	4P
Polygonaceae	*Symmeria paniculata* Benth.*	Leaf	Lenticular	Brown	No	Gallery forest	4N–O
Polygonaceae	*Triplaris gardneriana* Wedd.*	Leaf	Globoid	Green	No	Gallery forest	4Q
Rubiaceae	*Amaioua intermedia* Mart. ex Schult. & Schult.f.*	Leaf, stem	Cylindrical	Green/brown	Yes	Gallery forest	4T
Rubiaceae	*Psychotria* sp.	Leaf bud	Fusiform	Brown	No	Gallery forest	4U
Salicaceae	*Casearia* sp.	Leaf	Globoid	Green	Yes	Gallery forest	4V
Sapindaceae	*Magonia pubescens* A. St.-Hil.	Leaf vein	Globoid	Green	No	Dry forest	4X
Sapindaceae	*Matayba* sp.	Leaf	Globoid	Brown	Yes	Dry forest	4Z
Sapindaceae	*Paullinia* sp.	Leaf	Lenticular	Green	No	Gallery forest	5A
Sapindaceae	*Serjania caracasana* (Jacq.) Willd.*	Leaf	Lenticular	Brown	No	Gallery forest	5B
Sapindaceae	*Serjania caracasana**	Leaf	Lenticular	Green	Yes	Gallery forest	5C
Sapindaceae	*Serjania caracasana**	Leaf	Cylindrical	Light green	Yes	Gallery forest	5D
Sapindaceae	*Serjania erecta* Radlk.	Leaf	Lenticular (Wrinkle)	Green	No	Gallery forest	5E
Sapindaceae	*Serjania erecta*	Leaf	Conical	Green	Yes	Gallery forest	5F
Sapindaceae	*Serjania erecta*	Stem	Globoid	Brown	No	Gallery forest	5G
Sapindaceae	*Serjania erecta*	Leaf	Conical	Green/pink	Yes	Dry forest	5H
Sapindaceae	*Serjania* sp.	Leaf	Lenticular	Brown	No	Gallery forest	5I
Smilacaceae	*Smilax* sp.	Leaf	Amorphous	Green	No	Gallery forest	5J, 5K
Solanaceae	*Cestrum* sp.	Leaf	Conical	Green	Yes	Gallery forest	5L
Symplocaceae	*Symplocos* sp.	Stem	Conical	Green	No	Gallery forest	5M
Unidentified	Unidentified sp. 1	Leaf	Rosette	Brown	No	Gallery forest	5N
Unidentified	Unidentified sp. 2	Leaf	Lenticular	Brown	No	Gallery forest	5O
Unidentified	Unidentified sp. 3	Leaf	Lenticular	Green	No	Gallery forest	5P
Unidentified	Unidentified sp. 3	Leaf	Globoid	Green	No	Gallery forest	5P
Unidentified	Unidentified sp. 3	Leaf	Pineapple	Green	No	Gallery forest	5Q
Unidentified	Unidentified sp. 3	Leaf	Cylindrical	Green/brown	No	Gallery forest	5R
Unidentified	Unidentified sp. 3	Leaf	Globoid	Green	No	Gallery forest	5R
Unidentified	Unidentified sp. 4	Stem, tendril	Fusiform	Green	No	Gallery forest	5S
Unidentified	Unidentified sp. 5	Leaf	Lenticular	Green	No	Gallery forest	5T

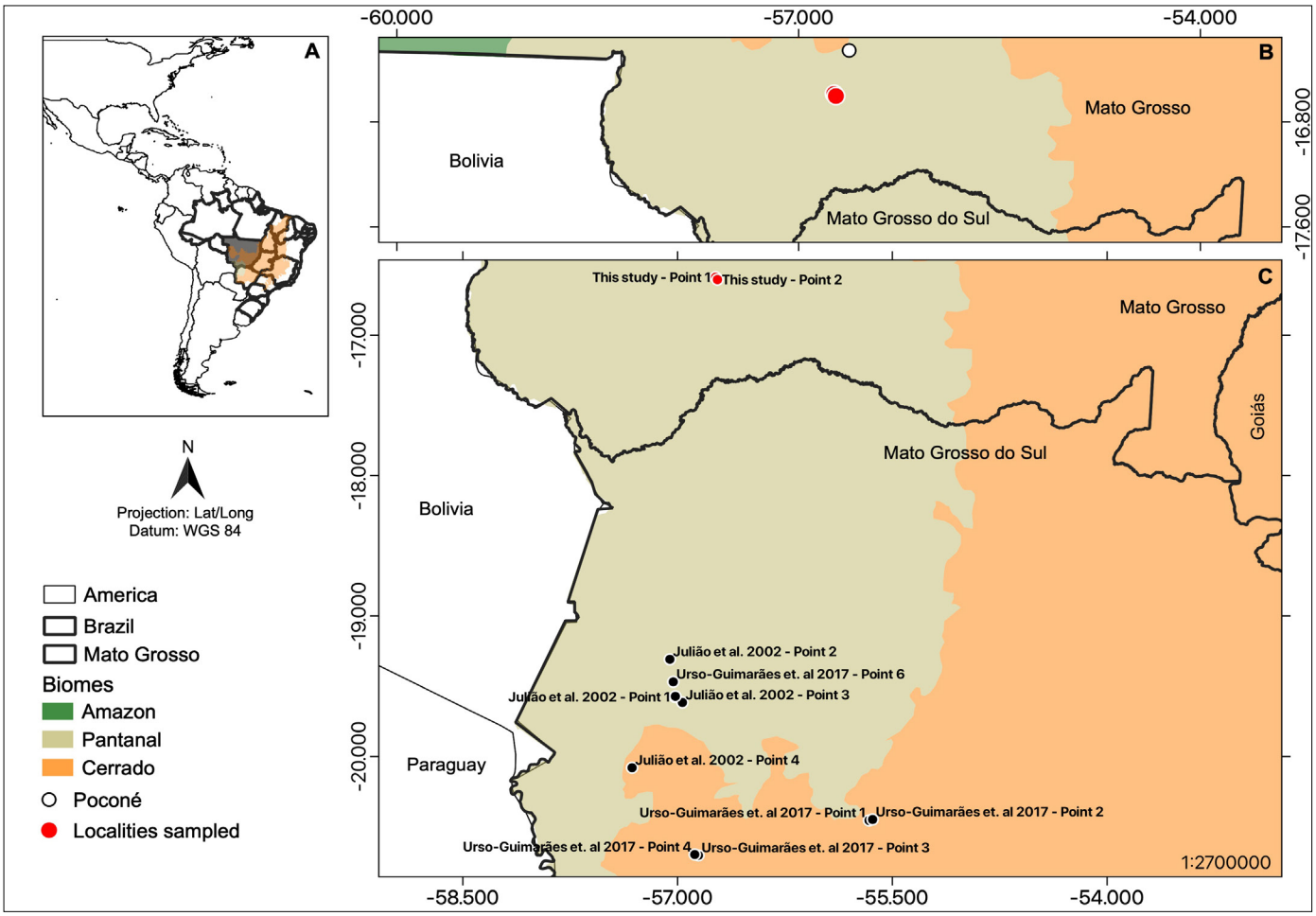

Figure 1. A. Map of South America indicating the Mato Grosso State and Cerrado and Pantanal Biomes extension in Brazil. B. Map of the of Cerrado and Pantanal areas with the sampling localities of North Pantanal in Poconé. C. Map of the sampling localities of Urso-Guimarães et al. (2017) (Point 1- Universidade Estadual do Mato Grosso do Sul (UEMS), Aquidauana; Point 2 – Distrito de Camisão, Aquidauana; Point 3 – Sede da Fazenda Califórnia, Bodoquena; Point 4 – Base de Estudos do Pantanal, Corumbá; Point 5- Fazenda São Bento, Corumbá; Point 6 – Trilha Fazenda Retiro Conceição, Porto Murtinho; Point 7 – Trilha da Fazenda Campo Florido, Porto Murtinho) and of Julião et al. (2002) (Point 1 – Rio Vermelho; Point 2 – Base de Estudos do Pantanal; Point 3 – MS-184 Highway; Point 4 – Fazenda São Bento) in Mato Grosso do Sul, Brazil.

Dolichandra quadrivalvis (Jacq.) L.G.Lohmann, *Galactia glaucescens* Kunth, *Leptobalanus gardneri* (Hook.f.) Sothers & Prance, *Myrcia neolucida* A.R.Lourenço & E.Lucas, *Polygonum acuminatum* Kunth, *Serjania caracasana* (Jacq.) Willd., *Symmeria paniculata* Benth., and *Triplaris gardneriana* Wedd (Flora do Brasil 2020).

From the insect galls, 28 (30.8%) of the gall inducers were obtained and identified in 24 host plant species. Among the insect inducers, 60.7% belong to Diptera (N=17) and 21.4% to Hymenoptera (N=7), 7.1% to Hemiptera, and Thysanoptera (N=2 each), and 3.6% to Coleoptera (N=1). Associated fauna and other details are in Table 3. The gall inducers of 63 morphotypes are undetermined because the galls were collected empty, the specimens obtained were damaged or the morphological information in the instars obtained was insufficient to the identification. As in all surveys, the species of Cecidomyiidae were the predominant gall inducer species (Table 3).

Discussion

The morphotype richness found in the gallery forests was significantly higher (N=83) when compared with the dry forest (N=8). The leaves are the organ most attacked by the gall makers in all environments (Araújo et al. 2019), except for few studies with stems as the most affected organ always associated with dry environments (Veldtman & McGeoch 2003, Fernandes et al. 2002, Carneiro et al. 2009, Coelho et al. 2013, Toma & Mendonça 2013, Kuzmanich et al. 2018). Thus, the host plant species' leaves loss during the dry season must have influenced the low number of galls found in the dry forest.

Fabaceae and Myrtaceae are two of the richest plant families in Pantanal (Pott et al. 2011). Pattern recovered in our study corroborating the hypothesis that families with the highest number of plant species also have the highest number of gall-forming species associated with them in all Brazilian biomes (Araújo et al. 2019, Santos-Silva & Araújo 2020). Sapindaceae appears as the third richest family, because of *Serjania* Mill. It is a super host genus, with eight gall morphotypes in only three species, the same situation found by Urso-Guimarães et al. (2017) in Corumbá. These results show the super host species' contribution to increasing the local richness of the insect-plant interactions, independently of plant species richness (Veldtman & McGeoch 2003).

Comparing with other studies in South Pantanal, our average (1.7) is similar to the other areas, Abobral region (1.7, Julião et al. 2002), and Corumbá/Porto Murtinho areas (1.4, Urso-Guimarães et al. 2017) (Fig.

Figure 2. Insect galls of North Pantanal in Poconé, Mato Grosso State, Brazil in host plants indicated. Anacardiaceae. A. *Astronium graveolens*, Annonaceae. B. *Annona cornifolia*, Bignoniaceae. C. *Dolichandra quadrivalvis*, D. Bignoniaceae sp.1, E. Bignoniaceae sp.3, Chrysobalanaceae. F–G. *Couepia* sp., H. *Leptobalanus gardneri*, I. *Leptobalanus humilis*, J. *Licania* sp., Combretaceae. K–P. *Combretum laxum*, Q. *Terminalia argentea*, Dilleniaceae. R. *Davilla elliptica*, Euphorbiaceae. S. *Maprounea guianensis*, Fabaceae. T. *Andira vermifuga*, U–Z. *Bauhinia* cf. *pulchella*.

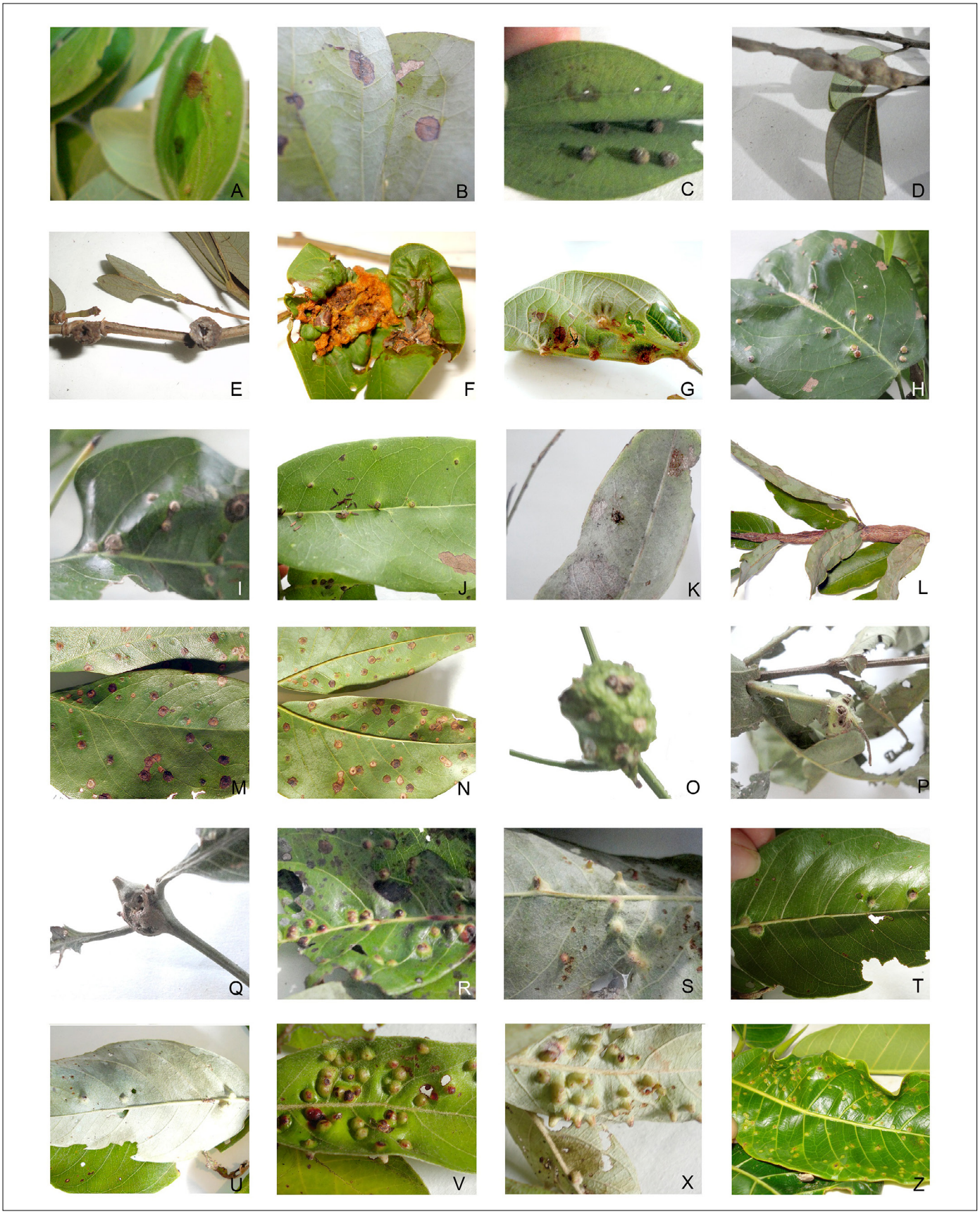

Figure 3. Insect galls of North Pantanal in Poconé, Mato Grosso State, Brazil in host plants indicated. Fabaceae. A–B. *Bauhinia mollis*, C–E. B. *pentandra*, F–G. *B. platypetala*, H–J. Fabaceae sp., K–L. *Galactia glaucescens*, M–N. *Hymenaea courbaril*, O. *Senegalia* sp., Lamiaceae. P. *Aegiphila* sp. 1, *Q. Aegiphila* sp., 2. Malpighiaceae. R–U. Byrsonima crassifolia, V–X. B. *cydoniifolia*, Moraceae. Z. *Ficus* sp.

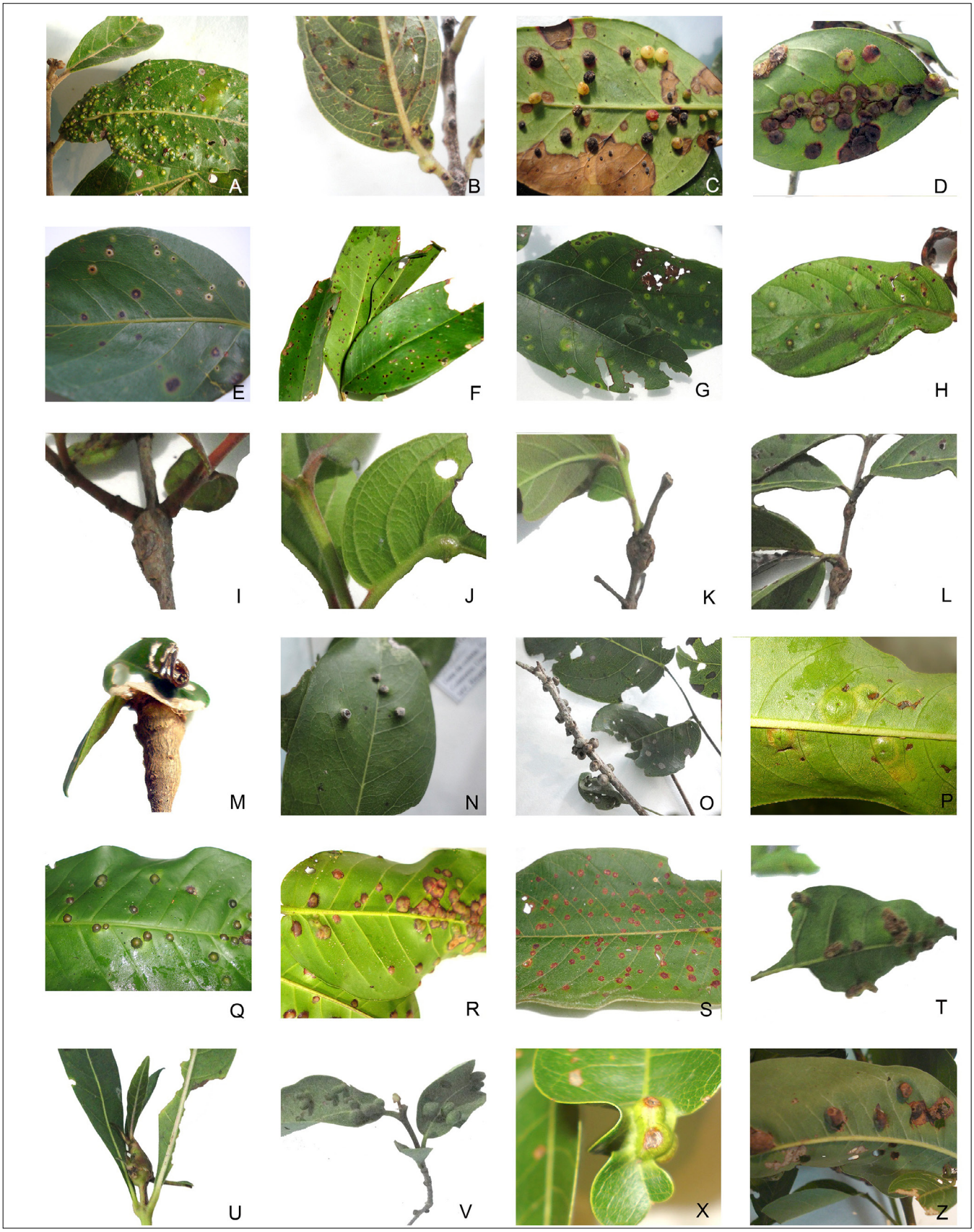

Figure 4. Insect galls of North Pantanal in Poconé, Mato Grosso State, Brazil in host plants indicated. Myrtaceae. A–B. *Campomanesia* sp. C–D. *Eugenia* cf. *florida*, E. *Eugenia* sp., F. *Myrcia neolucida*, G–L. *Psidium guineense*, M. Myrtaceae sp., Polygonaceae. N–O. *Symmeria paniculata*, P. *Polygonum acuminatum*, Q. *Triplaris gardneriana*, R–S. *Coccoloba cujabensis*, Rubiaceae. T. *Amaioua intermedia*, U. *Psychotria* sp., Salicaceae. V. *Casearia* sp., Sapindaceae. X. *Magonia pubescens*, Z. *Matayba* sp. 3.

Figure 5. Insect galls of North Pantanal in Poconé, Mato Grosso State, Brazil in host plants indicated. Sapindaceae. A. *Paullinia* sp., B–D. *Serjania caracasana,* E–H. *Serjania erecta*, I. *Serjania sp.,* Smilacaceae. J–K. *Smilax sp.,* Solanaceae. L. *Cestrum* sp., Symplocaceae. M. *Symplocos* sp., Unidentified. N. Unidentified sp. 1, O. Unidentified sp. 2, P–R. Unidentified sp. 3, S. Unidentified sp. 4, T. Unidentified sp. 5.

Table 2. Richness of gall morphotypes and plant super-hosts families and species from localities in Brazilian Pantanal areas.

Inventories	Locality/ Brazilian States	Biome	Richness				Super-host	
			Gall morphotypes	Plant species	Plant family	Average morphotype/ plant species	Families	Species
Urso-Guimarães, Koch & Castelo (this study)	**Poconé/MT**	**Pantanal (Gallery Forest, Chaco)**	**91**	**54**	**19**	**1.7**	**Fabaceae (19), Myrtaceae (14), Sapindaceae (11)**	*Psidium guineense* **(N=7),** *Combretum laxum* **(N=5),** Unidentified sp. 3 **(N=5)**
Julião et al. (2002)	**Abobral region/MS**	**Pantanal**	**133**	**75**	**37**	**1.8**	**Bignoniaceae (18), Fabaceae (13), Sapindaceae (11), Hippocrateaceae (7)**	*Hippocratea volubilis* **(6),** *Inga vera* **(5)**
Urso-Guimarães et al. (2017)	**Corumbá, Porto Murtinho/ MS**	**Pantanal (Gallery Forest, Chaco)**	**52**	**38**	**16**	**1.4**	**Fabaceae (12), Sapindaceae (11), Apocynaceae (5)**	*Serjania* sp. 2 **(4)**

Table 3. Gall makers and associated fauna in galls of North Pantanal in Poconé, Mato Grosso State, Brazil.

Host plat family	Host plant species	Gall inducer	Associated fauna
Anacardiaceae	*Astronium graveolens*	Diptera, Cecidomyiidae	not observed
Chrysobalanaceae	*Couepia* sp.	Hymenoptera	not observed
Chrysobalanaceae	*Licania* sp.	Hemiptera, Cicadidae	not observed
Combretaceae	*Combretum laxum*	Diptera, Cecidomyiidae	not observed
Combretaceae	*Combretum laxum*	Hymenoptera, Perilampidae	not observed
Combretaceae	*Combretum laxum*	Diptera, Cecidomyiidae	not observed
Combretaceae	*Terminalia argentea*	Hymenoptera	not observed
Fabaceae	*Bauhinia pentandra*	Hymenoptera, Chalcidoidea	not observed
Fabaceae	*Bauhinia pentandra*	Hymenoptera, Chalcidoidea	not observed
Fabaceae	*Bauhinia platypetala*	Diptera, Cecidomyiidae, *Schizomyia* sp.	not observed
Fabaceae	*Senegalia* sp.	Coleoptera, Curculionidae, Scolytinae	not observed
Lamiaceae	*Aegiphila* sp. 1	Diptera, Cecidomyiidae	Hymenoptera, Chalcidoidea; Hemiptera
Lamiaceae	*Aegiphila* sp. 2	Diptera, Cecidomyiidae	not observed
Malpighiaceae	*Byrsonima crassifolia*	Thysanoptera, Phlaeothripidae	not observed
Malpighiaceae	*Byrsonima cydoniifolia*	Diptera, Cecidomyiidae	not observed
Moraceae	*Ficus* sp.	Diptera, Cecidomyiidae	not observed
Myrtaceae	*Eugenia* cf. *florida*	Diptera, Cecidomyiidae, *Bruggmanniella* sp.	Coleoptera, Curculionidae; Hymenoptera, Ichneumonidae; Hemiptera, Cicadellidae
Myrtaceae	*Eugenia* cf. *florida*	Diptera, Cecidomyiidae, Oligotrophini	Psocoptera
Polygonaceae	*Symmeria paniculata*	Diptera, Cecidomyiidae	Hemiptera, Cicadelidae
Rubiaceae	*Amaioua intermedia*	Diptera, Cecidomyiidae	not observed
Rubiaceae	*Psychotria* sp.	Diptera, Cecidomyiidae	not observed
Salicaceae	Casearia sp.	Hemiptera	not observed
Sapindaceae	*Serjania caracasana*	Thysanoptera, Phlaeothripidae	not observed
Sapindaceae	*Serjania caracasana*	Diptera, Cecidomyiidae, *Youngomyia* sp.	Psocoptera
Solanaceae	*Cestrum* sp.	Diptera, Cecidomyiidae	not observed
Unidentified	Unidentified sp. 1	not observed	Psocoptera
Unidentified	Unidentified sp. 3	Hymenoptera, Torymidae	not observed
Unidentified	Unidentified sp. 4	Diptera, Cecidomyiidae	Hymenoptera
Unidentified	Unidentified sp. 5	Diptera	empty gall

1, Table 3). From the richest plant genera in gall morphotypes, *Bauhinia* L. (Fabaceae) and *Serjania* (Sapindaceae) are species-rich genera. The plant species considered super host were *Psidium guineense* (N=7, 7.7%), *Combretum laxum*, and the Unidentified sp. 3 (N=5, 5.5% each) (Table 2). For the first time, *P. guineense* and *C. laxum* are reported as super hosts of gall morphotypes in the world.

The predominance of galls in leaves and stems with the globoid and lenticular shapes, the green and brown colors and glabrous is a pattern also found in Pantanal Sul-matogrossense (Julião et al. 2002, Urso-Guimarães et al. 2017) and in other biomes (Araújo et al. 2019).

We found 91 morphotypes of galls in 54 host plants, of which 87 are new registers. Only four morphotypes are common to the studies of Julião et al. (2002) and Urso-Guimarães et al. (2017): the lenticular, brown, and glabrous on leaves of *Bauhinia mollis*, the fusiform in stems of *Psidium guineense*, the globoid, green, and glabrous on leaves of *Magonia pubescens* A.St.-Hil., and the globoid, green, and glabrous on leaves of *Serjania caracasana*. Thus, Brazilian Pantanal has 269 morphotypes of galls in 157 plant species, of which only two species are common of the three studies, *Eugenia florida* DC. and *S. caracasana*.The fifteen new records of host plants found in this inventory represent 30% of the total host plant species sampled in the Poconé survey (Table 2).

We also found that only three plant species, *Coccoloba cujabensis*, *Symmeria paniculata*, and *Triplaris gardneriana*, occur in Pantanal and Cerrado areas. These species occur exclusively in Mato Grosso and Mato Grosso do Sul States, which means the insect's interactions and these species are endemic. The low endemicity was expected because the plant species distributed in North Pantanal undergoes other biomes' influence in its composition (Pott et al. 2011).

The interactions among plants and associated entomofauna are still unknown and threatened with extinction due to deforestation. Mato Grosso State is currently one of the agricultural frontiers in Brazil. The maintenance and encouragement of taxonomic studies, such as the SISBIOTA – Diptera Brazil Program (2010-2015), are necessary to understand gall inducers' richness. Before studies funded by the SISBIOTA, only of gall inducers (*Termitomastus leptoproctus* Silvestri, 1901 and *Schizomyia tuiuiu* Urso-Guimarães & Amorim, 2002 – Diptera, Cecidomyiidae) were registered in Mato Grosso State. Three new species of cecidomyiids found in this survey are under the process of description, one species of each of the genera *Bruggmanniella* Tavares, *Schizomyia Kieffer*, and *Youngomyia* Felt.

This inventory became a unique testimony of insect-plant interactions in Pantanal Biome in Brazil that may have been completely devastated by fire in the dry season of 2020. We hope that with its enormous resilience, the Pantanal biome will recover the unique biodiversity lost by fire. We also expected that international organizations help Brazilian institutions to pressure the Federal Government to adopt measures for the conservation of Pantanal, a biome from South America, but is essential for humanity.

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Author Contributions

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.

Ingrid Koch: Substantial contribution in the data analysis and interpretation, manuscript preparation, critical revision, adding intellectual content.

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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