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 inventoried 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 biodiversity 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.) B.Dietr., B. penniandra (Bong.) B.Dietr., B. platypetala Burch. ex Benth., Byrsonima cydoniifolia A.Juss., Cocoloba cuyabensis Wedd, Amaioua intermedia Mart. ex Schult. & Schult.f., Annona cornifolia A.St.-Hil., Bauhinia mollis (Bong.) B.Dietr., B. penniandra (Bong.) B.Dietr., B. platypetala Burch. ex Benth., Byrsonima cydoniifolia A.Juss., Cocoloba cuyabensis 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     | Bignoniae sp.1 | Stem | Globoid | Green | No | Gallery forest | 2D |
| Bignoniaceae     | Bignoniae sp.2 | Stem | Globoid | Brown | No | Gallery forest | 2E |
| Bignoniaceae     | Bignoniae sp.2 | Tendril | Fusiform | Brown | No | Gallery forest | 2E |
| Chrysobalanaceae | Couepia sp. | Leaf | Lenticular | Green/brown | No | Gallery forest | 2F, 2G |
| Chrysobalanaceae | Leptobalamus gardneri (Hook.f.) Sothers & Prance * | Leaf | Lenticular | Brown | No | Gallery forest | 2H |
| 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 vernifuga (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         | Hymenea 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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| Family              | Species                          | Part     | Shape       | Color       | Gallery | Forest Type   |
|---------------------|----------------------------------|----------|-------------|-------------|---------|---------------|
| Malpighiaceae       | Byrsonima cydoniifolia A.Juss.*  | Leaf     | Conical     | Green       | No      | Gallery forest |
| Moraceae            | Ficus sp.                        | Leaf     | Lenticular  | Purple      | No      | Gallery forest |
| Myrtaceae           | Campomanesia sp.                 | Leaf     | Globoïd     | Green       | No      | Gallery forest |
| Myrtaceae           | Campomanesia sp.                 | Leaf, stem| Globoïd     | Green       | No      | Gallery forest |
| Myrtaceae           | Eugenia cf. florida DC.          | Leaf     | Globoïd     | Green/red   | No      | Gallery forest |
| Myrtaceae           | Eugenia cf. florida              | Leaf     | Lenticular  | Green       | Yes     | Gallery forest |
| Myrtaceae           | Eugenia sp.                      | Leaf     | Lenticular  | Black       | No      | Gallery forest |
| Myrtaceae           | Myrcia neolucida A.R.Lourenço & E.Lucas* | Leaf, stem | Lenticular  | Black       | No      | Gallery forest |
| Moraceae            | Psidium guineense Sw.            | Leaf     | Lenticular  | Brown       | No      | Gallery forest |
| Myrtaceae           | Psidium guineense                | Leaf     | Globoïd     | Green       | Yes     | Gallery forest |
| Myrtaceae           | Psidium guineense                | Stem     | Fusiform    | Brown       | No      | Gallery forest |
| Myrtaceae           | Psidium guineense                | Leaf     | Globoïd     | Green       | No      | Gallery forest |
| Myrtaceae           | Psidium guineense                | Stem     | Globoïd     | Brown       | No      | Gallery forest |
| Myrtaceae           | Psidium guineense                | Leaf     | Lenticular  | Brown       | No      | Gallery forest |
| Myrtaceae           | Psidium guineense                | Stem     | Fusiform    | Brown       | No      | Gallery forest |
| Myrtaceae           | Myrica sp.                       | Leaf     | Lenticular  | Brown       | No      | Gallery forest |
| Moraceae            | Coccoloba cuyabensis Wedd.*      | Leaf     | Lenticular  | Brown       | No      | Gallery forest |
| Polygonaceae        | Coccoloba cuyabensis*            | Leaf     | Lenticular  | Brown       | No      | Gallery forest |
| Polygonaceae        | Coccoloba cuyabensis*            | Stem     | Globoïd     | Brown       | No      | Gallery forest |
| Polygonaceae        | Polygonum acuminatum Kunth*      | Leaf     | Lenticular  | Green/grey  | No      | Gallery forest |
| Polygonaceae        | Symmeria paniculata Benth.*      | Leaf     | Lenticular  | Brown       | No      | Gallery forest |
| Polygonaceae        | Triplaris gardneriana Wedd.*     | Leaf     | Globoïd     | Green       | No      | Gallery forest |
| Rubiaceae           | Amaioua intermedia Mart. ex Schult. & Schult.f.* | Leaf, stem | Cylindrical | Green/brown | Yes | Gallery forest |
| Rubiaceae           | Psychotria sp.                   | Leaf bud | Fusiform    | Brown       | No      | Gallery forest |
| Salicaceae          | Casearia sp.                     | Leaf     | Globoïd     | Green       | Yes     | Gallery forest |
| Sapindaceae         | Magonia pubescens A. St.-Hil.    | Leaf vein| Globoïd     | Green       | No      | Dry forest    |
| Sapindaceae         | Matayba sp.                      | Leaf     | Globoïd     | Brown       | Yes     | Dry forest    |
| Sapindaceae         | Paullinia sp.                    | Leaf     | Lenticular  | Green       | No      | Gallery forest |
| Sapindaceae         | Serjania caracasana (Jacq.) Wild.*| Leaf     | Lenticular  | Brown       | No      | Gallery forest |
| Sapindaceae         | Serjania caracasana*             | Leaf     | Lenticular  | Green       | Yes     | Gallery forest |
| Sapindaceae         | Serjania caracasana*             | Leaf     | Cylindrical | Light green| Yes     | Gallery forest |
| Sapindaceae         | Serjania erecta Radlk.           | Leaf     | Lenticular  | Green       | No      | Gallery forest |
| Sapindaceae         | Serjania erecta                  | Leaf     | Conical     | Green       | Yes     | Gallery forest |
| Sapindaceae         | Serjania erecta                  | Stem     | Globoïd     | Brown       | No      | Gallery forest |
| Sapindaceae         | Serjania erecta                  | Leaf     | Conical     | Green/pink  | Yes     | Dry forest    |
| Sapindaceae         | Serjania sp.                     | Leaf     | Lenticular  | Brown       | No      | Gallery forest |
| Smilacaceae         | Smilax sp.                       | Leaf     | Amorphous   | Green       | No      | Gallery forest |
| Solanaceae          | Cestrum sp.                      | Leaf     | Conical     | Green       | Yes     | Gallery forest |
| Symplocaceae        | Symplocos sp.                    | Stem     | Conical     | Green       | No      | Gallery forest |
| Unidentified        | Unidentified sp. 1               | Leaf     | Rosette     | Brown       | No      | Gallery forest |
| Unidentified        | Unidentified sp. 2               | Leaf     | Lenticular  | Brown       | No      | Gallery forest |
| Unidentified        | Unidentified sp. 3               | Leaf     | Lenticular  | Green       | No      | Gallery forest |
| Unidentified        | Unidentified sp. 3               | Leaf     | Globoïd     | Green       | No      | Gallery forest |
| Unidentified        | Unidentified sp. 3               | Leaf     | Pineapple   | Green       | No      | Gallery forest |
| Unidentified        | Unidentified sp. 3               | Leaf     | Cylindrical | Green/brown| No      | Gallery forest |
| Unidentified        | Unidentified sp. 3               | Leaf     | Globoïd     | Green       | No      | Gallery forest |
| Unidentified        | Unidentified sp. 4               | Leaf     | Cylindrical | Green/brown| No      | Gallery forest |
| Unidentified        | Unidentified sp. 5               | Leaf     | Lenticular  | Green       | No      | Gallery forest |
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 leaves are the organ most attacked by the gall makers in all environments (Ararío et al. 2019), except for few studies with stems as the most affected organ always associated with dry environments (Veldman & 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 (Ararío et al. 2019, Santos-Silva & Ararío 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 (Veldman & 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. *Licantia* 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., Lamiaeae. P. Aegiphila sp. 1, Q. Aegiphila sp., 2. Malpighiaceae. R–U. Byrsonima crassifolia, V–X. B. cydoniifoila, 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 | 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) |
| Julião et al. (2002) | Abobral region/MS | Pantanal | 133 | 75 | 37 | 1.8 | Bignoniaceae (18), Fabaceae (13), Sapindaceae (11), Hippocrateaceae (7) |
| Urso-Guimarães et al. (2017) | Corumbá, Porto Murtinho/MS | Pantanal (Gallery Forest, Chaco) | 52 | 38 | 16 | 1.4 | Fabaceae (12), Sapindaceae (11), Apocynaceae (5) |

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

| Host plant 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 platypetalae* | 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     | *Byronima crassifolia* | Thysanoptera, Phlaeothripidae | not observed |
| Malpighiaceae     | *Byronima cydoniifolia* | Diptera, Cecidomyiidae | not observed |
| Moraceae          | *Ficus* sp. | Diptera, Cecidomyiidae | not observed |
| Myrtaceae         | *Eugenia cf. florida* | Diptera, Cecidomyiidae, *Bruggmanniella* sp. | Coleoptera, Curculionidae; Hymenoptera, Ichnemoniidae; Hemiptera, Cicadellidae |
| Myrtaceae         | *Eugenia cf. florida* | Diptera, Cecidomyiidae, Oligotrophini | Psocoptera |
| Polygonaceae      | *Symmeria paniculata* | Diptera, Cecidomyiidae | Hemiptera, Cicadellidae |
| Rubiaceae         | *Amaoua 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 |
Insect galls from Mato Grosso: Pantanal

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 globose 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 floridana 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 study (Table 2).

We also found that only three plant species, Coccoloba cuyabensis, Symmeria paniculata, and Tripilis 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 related to the publication of this manuscript.

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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