Plant-galling insect interactions: a data set of host plants and their gall-inducing insects for the Cerrado

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Introduction

Galling insects are considered the most specialized guild of phytophagous insects. Their unique ability to modify plant tissues before their consumption is remarkable (Shorthouse et al. 2005). Such changes in plant tissues are attributed to abnormal growth and development of plant cells (hyperplasia and hypertrophy) induced by specific stimuli from an ovipositing female and/or her prole (Hartley 1998, Moura et al. 2008, Giron et al.

2016). This ability has evolved independently in many different taxa within six insect orders: Diptera, Hemiptera, Hymenoptera, Coleoptera, Thysanoptera and Lepidoptera (Shorthouse et al. 2005, Price 2005). There exists great diversity of galling insects in the Neotropics (Gagné 1994, Fernandes and Santos 2014), but mainly in the Cerrado (Brazilian Savannah) of central Brazil (Araújo et al. 2014), which includes campos rupestres (rupestrian fields; Lara and Fernandes 1996)

The Cerrado is the second largest phytogeographic biome in Brazil, occupying ca. 2 million km^2 or 23% of the national territory (Oliveira and Ratter 2002). As a continuous area, the Cerrado completely covers the states of Goiás and Tocantins and the Federal District, as well as portions of the states of Bahia, Ceará, Maranhão, Mato Grosso, Mato Grosso do Sul, Minas Gerais, Piauí, Rondônia and São Paulo. Disjointed areas also occur the north, in the states of Amapá, Amazonas, Pará and Roraima, and in the south, as small "islands" in the state of Paraná (Ribeiro and Walter 2008). The Cerrado is among the most botanically diverse biome in the world with over 12,000 species (Klink and Machado 2005, Mendonça et al. 2008), which represent potential host plants for galling insects (Fernandes and Gonçalves-Alvim 2006).

The Cerrado includes a wide variety of phytophysiognomies, such grassland, savanna and forest formations (Ribeiro and Walter 2008). Differences among habitat types can directly affect the distribution of galling species (Fernandes and Price 1992). There have been many inventories of insect gall diversity in mesic (non-sclerophyllous) and xeric (sclerophyllous) vegetation of the Cerrado (review in Araújo et al. 2019). Recent evidence indicates that interactions between galling insects and host plants can form complex ecological networks in the Cerrado (Araújo et al. 2019). Despite advances in knowledge of local interactions, there has been no synthesis to better understand patterns at regional and macroecological scales.

The present study compiled data from several inventories of galling insects in the Cerrado biome, community studies about species of Diptera with gall-inducing habit and host plants attacked by several galling insect species. The resulting data set contains 49 described species of Diptera (Cecidomyiidae and Tephritidae) and 505 species of host plants of 32 communities distributed throughout the Cerrado. All records of galling species were confirmed and the taxonomic nomenclature of host plants was updated to assure all

data are robust and reliable. The aim of compiling this dataset was to fill a knowledge gap about the geographical distribution of host plants and gall-inducing insects in an area considered a global biodiversity hotspot.

The data set can contribute to several areas of knowledge, including natural history, ecology, botany, zoology and evolution. Gall-inducing insects have proven to be good study models because they: (a) have high taxonomic and ecological diversity; (b) are sedentary during the larval phase, which facilitates sampling on host plants; (c) are abundant on host plants; (d) occur in all biogeographic regions of the world; (e) possess a high level of specificity for their host plants; (f) are easily identified through gall morphology since galls are considered an extended phenotype of gall inducers; (g) have an important functional role in ecosystems through herbivory; and (h) have predictable responses to environmental variation as a function of their close relationship with host plant species. For all these reasons, gall-inducing insects are good tool for basic, applied and experimental studies. They are also useful for understanding ecological, evolutionary and mechanistic aspects, such as: host-plant preferences and selection; the process of adaptive radiation; how patterns of geographic distribution and diversity of host plants affect galling insects; phytochemical patterns in host plants; plant defense against gall induction; theory of island biogeography applied to host plants; and several hypotheses about plant architecture, plant vigor and preference performance, among others (Price et al. 2004, Price 2005, Fernandes et al. 2011, Stone & Schönrogge 2003, Fernandes and Santos 2014, Tooker and Helms 2014, Carneiro et al. 2015, Grandez-Rios et al. 2015, Giron et al. 2016, Oates et al. 2016).

Metadata

Class I. Data set descriptors

A. Data set identity:

Title: Plant-galling insect interactions: a data set of host plants and their gall-inducing insects for the Cerrado.

B. Data set and metadata identification codes:

Suggested data set identity codes:

plant-galling_insect_diptera.csv
plant-galling_insect_host_plants_information.csv
plant-galling_insect_host_plant_references.csv

C. Data set description

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Abstract: Recent decades have seen increased research interest in the processes and mechanisms related to insect gall richness and host plants. The data set provided here includes 968 records of interactions between galling insects and host plants for the Cerrado biome. The data set comprises 505 species of 222 genera and 67 families of host plants.

The botanical families most represented in the data set are Asteraceae, Fabaceae, Myrtaceae, Malpighiaceae and Melastomataceae, which account for ca. 48.5% of all records and 52% of the total number of species. The gall-inducing insects listed in the data set include 48 species of Cecidomyiidae and one species of Tephritidae. This data set is the first to compile inventories of plant-galling insect communities and information about the diversity and distribution of insect galls and their host plants in the Cerrado. The data set reveals knowledge gaps and opportunities for future research on patterns of diversity and distribution, and provides a basis for generating and testing new ecological hypotheses. Please cite this data paper when using the current data in publications and let us know how the data are used in the publications. There are no copyright restrictions.

D. Key words: Asteraceae, insect galls, Fabaceae, Neotropical savannah, host plant communities, Diptera, Cecidomyiidae, Tephritidae

E. Description: The data set developed here is restricted to the Cerrado biome and comprises data only from peer reviewed scientific publications. The Cerrado has been the most studied Brazilian biome with regard to galling insects (Araújo et al. 2019). The data set includes only the occurrence of insect-gall host plants and gall-inducing species of Diptera, and excludes all other galling insect taxa (e.g., Hemiptera, Hymenoptera and Lepidoptera). In addition, other gall-inducing interactions are not included, such as those involving mites, nematodes, fungi, bacteria and viruses. The data set of consists of 968 records of 505 species, 222 genera and 67 families of host plants. Nine of the species are considered either Vulnerable (VU) or Endangered (EN), according to the red list of flora in Brazil (MMA Ordinance # 443/2014; CNCFlora 2020). The three Vulnerable species are *Baccharis concinna* G.M.Barroso (Asteraceae), *Lychnophora ramosissima* Gardner (Asteraceae) and *Lychnophora tomentosa* (Mart. ex DC.) Sch.Bip. (Asteraceae). The six Endangered species are *Anemopaegma arvense* (Vell.) Stellfeld ex de Souza (Bignoniaceae), *Lychnophoriopsis candelabrum* (Sch.Bip.) H.Rob. (Asteraceae), *Baccharis elliptica* Gardner (Asteraceae), *Mikania glabra* D.J.N.Hind (Asteraceae), *Mikania glauca* Mart. ex Baker (Asteraceae) and *Peixotoa cipoana* C.E.Anderson (Malpighiaceae).

Most of the sampled communities are located in the states of Minas Gerais (n=13; 41%), Goiás (n=9; 28%) and Bahia (n=7; 22%), which accounted for ca. 91% of all the communities in the data set (Figure 1). The concentration of most of the sampling effort in these states is a consequence of logistics, with it being dominated by just a few research groups based in Minas Gerais, Goiás and Bahia.

More studies were conducted outside (n=18; 62%) than inside (n=11; 38%) protected areas; two studies (6%) did not state whether they occurred in a protected area or not, while only one study (6%) was conducted both inside and outside of a protected area (see Carneiro et al. 2009). Among the studies conducted in protected areas, 55% (N=6) occurred in state protected areas, 36% (N=4) in federal protected areas and one (9%) in a Private Natural Heritage Reserve and in state-level protected areas (see Carneiro et al. 2009). Multiple phytophysiognomies of the Cerrado were sampled, including: Cerrado-Caatinga transition, cerrado *sensu stricto*, campo rupestre (rupestrian fields), campo cerrado, campo sujo, cerradão, cerrado rochoso, campo limpo, seasonal forest, seasonal deciduous forest, seasonal semideciduous forest, riparian rainforest, gallery forest, ciliary forest, dry forest, and semideciduous forest. In addition, many studies did not report the phytophysiognomy in which they took place (see Oliveira-Filho and Ratter 2002 for the classification system of Cerrado phytophysiognomies).

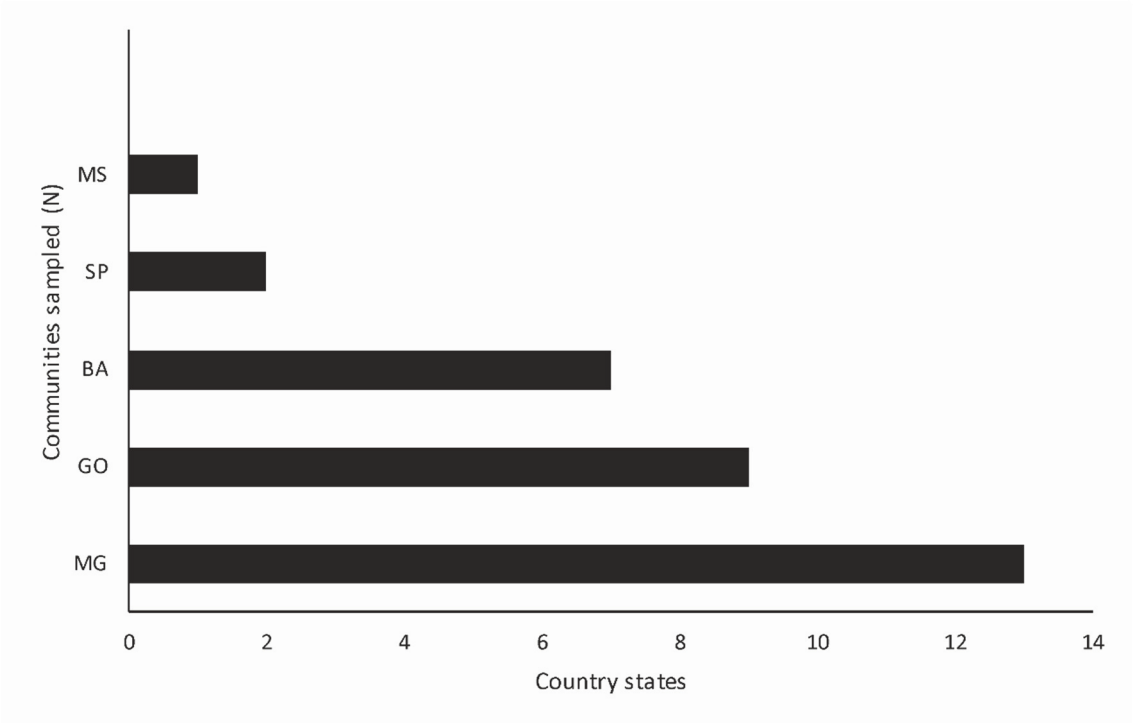

Figure 1. Number of communities sampled per Brazilian states in this study, from a total of 32 communities. The abbreviations of states are: BA = Bahia, GO = Goiás, MG = Minas Gerais, MS = Mato Grosso do Sul and SP = São Paulo.

The fourteen most frequently recorded plant species represent about 14.7% of all the records: *Copaifera langsdorffii* Desf. (Fabaceae), *Duguetia furfuracea* (A.St.-Hil.) Saff. (Annonaceae), *Erythroxylum suberosum* A.St.-Hil. (Erythroxylaceae), *Qualea parviflora* Mart. (Vochysiaceae), *Roupala montana* Aubl. (Proteaceae), *Caryocar brasiliense* Cambess. (Caryocaraceae), *Qualea grandiflora* Mart. (Vochysiaceae), *Eugenia punicifolia* (Kunth) DC. (Myrtaceae), *Protium heptaphyllum* (Aubl.) Marchand (Burseraceae), *Bauhinia brevipes* Vogel (Fabaceae), *Eremanthus erythropappus* (DC.) MacLeish (Asteraceae), *Handroanthus ochraceus* (Cham.) Mattos (Bignoniaceae), *Palicourea rigida* Kunth (Rubiaceae) and *Terminalia argentea* Mart. (Combretaceae). Many of these species are typical of the Cerrado and are widely distributed throughout the biome. Of the 505 species recorded, 328 (ca. 65%) are registered only once, which represents about 34% of all the records.

Eight plant genera stand out for having large numbers of records: *Baccharis* N=62, 6.4%), *Byrsonima* (N=36, 3.7%), *Erythroxylum* (N=30, 3.1%), *Qualea* (N=30, 3.1%),

Bauhinia (N=29, 3.0%), *Eugenia* (N=29, 3.0%), *Myrcia* (N=25, 2.6%) and *Copaifera* (N=21, 2.2%; Table 1). These eight genera account for ca. 27% of the recorded plant species. The genera with the most recorded species are: *Baccharis* (N=44 spp., 8.7%), *Byrsonima* (N=14 spp., 2.8%), *Myrcia* (N=12 spp., 2.4%), *Eugenia* (N=11 spp., 2.2%), *Bauhinia* (N=10 spp., 2%), *Erythroxylum* (N=10 spp., 2%), *Chamaecrista* (N=9 spp., 1.8%) and *Croton* (N=9 spp., 1.8). These results show the importance of the diversity of *Baccharis* as a super host genus of insect galls.

Table 1. Genera of host plants of galling insects from the Cerrado. Also includes the number of records and the number of species for each genus.

Host genera	Species records (N)	Species records (%)	Host plant richness (N)	Host plant richness (%)
Achyrocline	2	0.2	2	0.4
Acritopappus	1	0.1	1	0.2
Aegiphila	1	0.1	1	0.2
Ageratum	1	0.1	1	0.2
Agrianthus	1	0.1	1	0.2
Alibertia	1	0.1	1	0.2
Amorimia	1	0.1	1	0.2
Amphilophium	1	0.1	1	0.2
Anacardium	6	0.6	2	0.4
Anadenanthera	8	0.8	2	0.4
Andira	8	0.8	4	0.8
Anemopaegma	1	0.1	1	0.2
Annona	11	1.1	6	1.2
Aspidosperma	12	1.2	6	1.2
Aspilia	4	0.4	4	0.8
Astronium	2	0.2	2	0.4
Baccharis	62	6.4	44	8.7
Banisteriopsis	6	0.6	6	1.2
Bauhinia	29	3.0	10	2.0
Blepharocalyx	1	0.1	1	0.2
Bocageopsis	1	0.1	1	0.2
Bowdichia	3	0.3	1	0.2
Bredemeyera	1	0.1	1	0.2
Brosimum	3	0.3	1	0.2
Buchenavia	1	0.1	1	0.2
Buchnera	1	0.1	1	0.2

Bunchosia	1	0.1	1	0.2
Byrsonima	36	3.7	14	2.8
Calliandra	6	0.6	4	0.8
Callisthene	2	0.2	2	0.4
Calolisianthus	1	0.1	1	0.2
Calophyllum	3	0.3	1	0.2
Campomanesia	4	0.4	3	0.6
Cantinoa	2	0.2	2	0.4
Capsicum	1	0.1	1	0.2
Caryocar	10	1.0	1	0.2
Casearia	5	0.5	2	0.4
Cassia	1	0.1	1	0.2
Celtis	8	0.8	2	0.4
Chamaecrista	9	0.9	9	1.8
Cheiloclinium	1	0.1	1	0.2
Chomelia	1	0.1	1	0.2
Chromolaena	3	0.3	3	0.6
Chrysophyllum	2	0.2	1	0.2
Chusquea	1	0.1	1	0.2
Cissampelos	1	0.1	1	0.2
Cissus	1	0.1	1	0.2
Coccoloba	1	0.1	1	0.2
Cochlospermum	1	0.1	1	0.2
Combretum	4	0.4	1	0.2
Connarus	7	0.7	1	0.2
Copaifera	21	2.2	4	0.8
Cordia	4	0.4	2	0.4
Cordiera	2	0.2	2	0.4
Couepia	3	0.3	1	0.2
Croton	14	1.4	9	1.8
Cupania	1	0.1	1	0.2
Cuphea	1	0.1	1	0.2
Cyanocephalus	1	0.1	1	0.2
Cyrtocymura	1	0.1	1	0.2
Dalbergia	5	0.5	1	0.2
Dasyphyllum	1	0.1	1	0.2
Davilla	9	0.9	3	0.6
Deguelia	1	0.1	1	0.2
Dimorphandra	2	0.2	1	0.2
Diospyros	4	0.4	1	0.2
Diplopterys	5	0.5	1	0.2

Diplusodon	5	0.5	4	0.8
Dipteryx	1	0.1	1	0.2
Drimys	2	0.2	1	0.2
Duguetia	12	1.2	1	0.2
Epidendrum	1	0.1	1	0.2
Eremanthus	10	1.0	3	0.6
Eriope	1	0.1	1	0.2
Eriotheca	8	0.8	3	0.6
Erythroxylum	30	3.1	10	2.0
Eugenia	29	3.0	11	2.2
Eumachia	1	0.1	1	0.2
Fridericia	2	0.2	2	0.4
Galipea	1	0.1	1	0.2
Gaylussacia	2	0.2	2	0.4
Gochnatia	4	0.4	2	0.4
Grazielia	1	0.1	1	0.2
Guapira	6	0.6	3	0.6
Guarea	1	0.1	1	0.2
Guatteria	1	0.1	1	0.2
Guazuma	1	0.1	1	0.2
Guettarda	1	0.1	1	0.2
Handroanthus	11	1.1	4	0.8
Heterocondylus	2	0.2	1	0.2
Heteropterys	6	0.6	2	0.4
Himatanthus	1	0.1	1	0.2
Hirtella	4	0.4	3	0.6
Hololepis	2	0.2	1	0.2
Hymenaea	10	1.0	3	0.6
Hyptidendron	1	0.1	1	0.2
Hyptis	1	0.1	1	0.2
Ilex	3	0.3	2	0.4
Inga	6	0.6	5	1.0
Ipomoea	1	0.1	1	0.2
Jacaranda	2	0.2	1	0.2
Kielmeyera	8	0.8	4	0.8
Lantana	4	0.4	1	0.2
Lavoisiera	1	0.1	1	0.2
Leandra	4	0.4	1	0.2
Leonotis	1	0.1	1	0.2
Lepidaploa	1	0.1	1	0.2
Leptolobium	6	0.6	1	0.2

Lessingianthus	9	0.9	7	1.4
Licania	5	0.5	3	0.6
Lippia	6	0.6	5	1.0
Lithraea	2	0.2	1	0.2
Lonchocarpus	2	0.2	1	0.2
Lourteigia	1	0.1	1	0.2
Luehea	4	0.4	1	0.2
Lychnophora	5	0.5	5	1.0
Lychnophoriopsis	1	0.1	1	0.2
Mabea	1	0.1	1	0.2
Macairea	4	0.4	1	0.2
Machaerium	7	0.7	4	0.8
Magonia	2	0.2	1	0.2
Manihot	3	0.3	2	0.4
Maprounea	5	0.5	1	0.2
Marcetia	3	0.3	1	0.2
Mascagnia	1	0.1	1	0.2
Matayba	3	0.3	2	0.4
Medusantha	1	0.1	1	0.2
Merremia	2	0.2	1	0.2
Mesosphaerum	1	0.1	1	0.2
Metrodorea	1	0.1	1	0.2
Miconia	11	1.1	5	1.0
Microlicia	8	0.8	7	1.4
Microstachys	1	0.1	1	0.2
Mikania	9	0.9	8	1.6
Mimosa	6	0.6	2	0.4
Minaria	1	0.1	1	0.2
Moquiniastrum	2	0.2	2	0.4
Myracrodruon	1	0.1	1	0.2
Myrcia	25	2.6	12	2.4
Myrciaria	2	0.2	2	0.4
Myrsine	4	0.4	3	0.6
Nectandra	3	0.3	1	0.2
Neea	2	0.2	1	0.2
Ocotea	6	0.6	5	1.0
Oocephalus	1	0.1	1	0.2
Ouratea	16	1.7	7	1.4
Oxalis	1	0.1	1	0.2
Palicourea	8	0.8	1	0.2
Peixotoa	2	0.2	2	0.4

Peltogyne	1	0.1	1	0.2
Periandra	1	0.1	1	0.2
Phoradendron	1	0.1	1	0.2
Piper	5	0.5	1	0.2
Piptadenia	3	0.3	1	0.2
Piptocarpha	4	0.4	1	0.2
Piptolepis	1	0.1	1	0.2
Piriqueta	1	0.1	1	0.2
Platymiscium	1	0.1	1	0.2
Plenckia	2	0.2	1	0.2
Pleroma	5	0.5	4	0.8
Plinia	1	0.1	1	0.2
Porophyllum	1	0.1	1	0.2
Pouteria	10	1.0	2	0.4
Prestonia	1	0.1	1	0.2
Prockia	1	0.1	1	0.2
Protium	9	0.9	1	0.2
Pseudobombax	2	0.2	1	0.2
Pseudobrickellia	3	0.3	2	0.4
Pseudopiptadenia	2	0.2	1	0.2
Psidium	5	0.5	5	1.0
Psychotria	4	0.4	4	0.8
Pterandra	1	0.1	1	0.2
Pyrostegia	1	0.1	1	0.2
Qualea	30	3.1	5	1.0
Randia	1	0.1	1	0.2
Remijia	1	0.1	1	0.2
Rhamnidium	1	0.1	1	0.2
Rollinia	1	0.1	1	0.2
Roupala	11	1.1	1	0.2
Rourea	2	0.2	1	0.2
Ruellia	1	0.1	1	0.2
Sabicea	1	0.1	1	0.2
Salacia	1	0.1	1	0.2
Sapium	1	0.1	1	0.2
Schefflera	6	0.6	3	0.6
Schinus	2	0.2	1	0.2
Senegalia	4	0.4	2	0.4
Senna	1	0.1	1	0.2
Serjania	7	0.7	5	1.0
Sida	3	0.3	3	0.6

Sidastrum	1	0.1	1	0.2
Siparuna	5	0.5	1	0.2
Smilax	6	0.6	5	1.0
Solanum	2	0.2	1	0.2
Stachytarpheta	3	0.3	3	0.6
Stigmaphyllon	1	0.1	1	0.2
Strychnos	5	0.5	3	0.6
Stryphnodendron	4	0.4	3	0.6
Styrax	9	0.9	3	0.6
Symphyopappus	4	0.4	3	0.6
Tabebuia	2	0.2	1	0.2
Tachigali	5	0.5	2	0.4
Talisia	1	0.1	1	0.2
Tanaecium	1	0.1	1	0.2
Tapirira	3	0.3	1	0.2
Terminalia	10	1.0	2	0.4
Ternstroemia	1	0.1	1	0.2
Tibouchina	4	0.4	3	0.6
Toulicia	1	0.1	1	0.2
Trema	1	0.1	1	0.2
Trembleya	2	0.2	2	0.4
Trichilia	1	0.1	1	0.2
Trichogonia	2	0.2	2	0.4
Trigonia	3	0.3	1	0.2
Vachellia	1	0.1	1	0.2
Varronia	3	0.3	1	0.2
Verbesina	1	0.1	1	0.2
Vernomia	1	0.1	1	0.2
Vernonanthura	5	0.5	1	0.2
Virola	2	0.2	1	0.2
Vochysia	3	0.3	2	0.4
Xylopia	6	0.6	2	0.4
All genera	**968 records**	**100**	**505 species**	**100**

The plant families with the most records are: Fabaceae (N=154, 15.9%), Asteraceae (N=145, 15.0%), Myrtaceae (N=67, 6.9%), Malpighiaceae (N=60, 6.2%) and Melastomataceae (N=42, 4.3%) (Figure 2A). These five families account for ca. 48.3% of the recorded plant species. The plant families with the most recorded species are: Asteraceae (N=104 spp., 21%), Fabaceae (N=69 spp., 13.7%), Myrtaceae (N=35 spp., 6.9%), Malpighiaceae (N=30 spp., 5.9%) and Melastomataceae (N=25 spp., 5.0%) (Figure

2B), which together account for ca. 52% of the species found. These results indicate that, as host plant families, Fabaceae is well represented and that Asteraceae is well diversified.

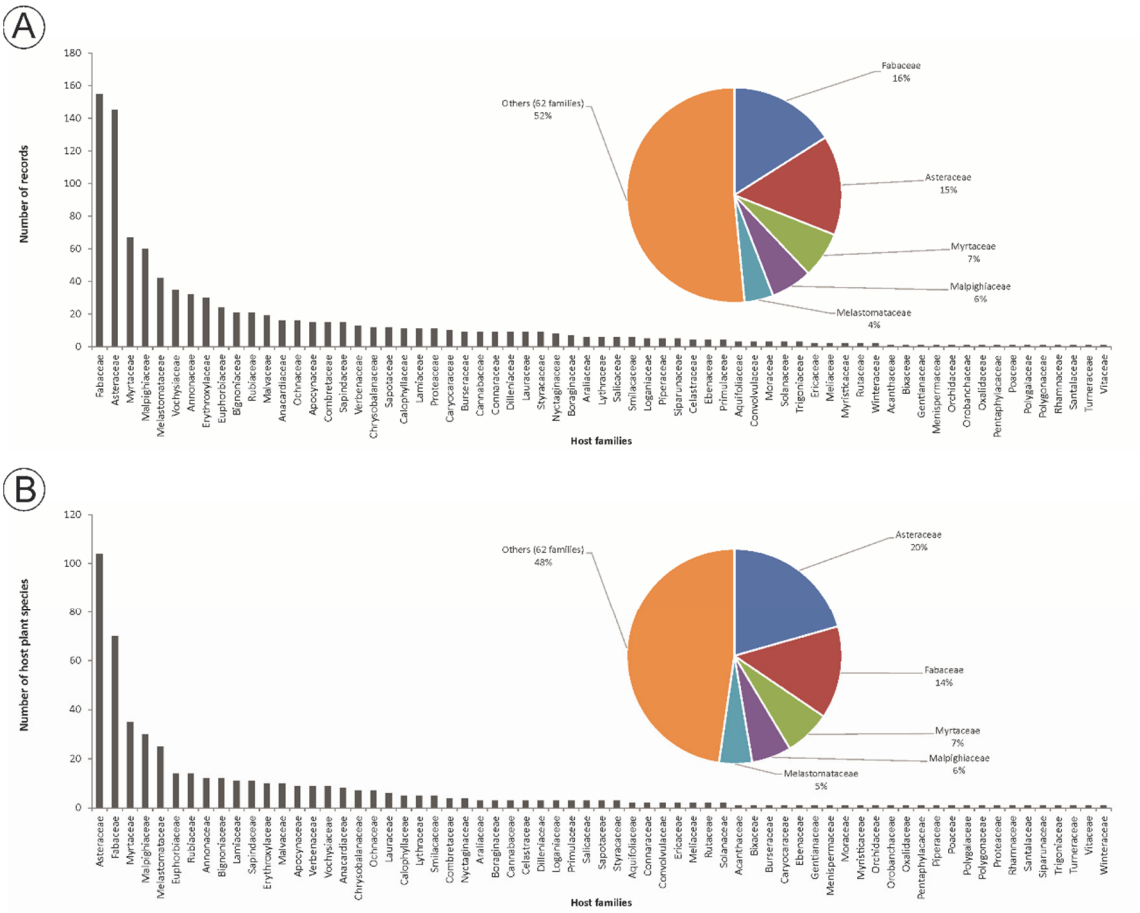

Figure 2. Rank plots of the number of records (A) and number of host plant species (B). In the right corner, we show the five families with the highest number of records (%), highest number of host plant species (%) and the greatest proportion of 62 other families.

Only gall-inducing insect species of the families Cecidomyiidae and Tephritidae were recorded (Table 2). Cecidomyiidae is the most predominant family with 48 species of 26 genera, while Tephritidae is represented by a single species: *Tomoplagia rudolphi* (Lutz and Lima 1918). The most speciose cecidomyiid genera are *Lopesia* (N=11 spp., 22.9%), *Asphondylia* (N=6 spp., 12.5%) and *Bruggmanniella* (N=3 spp., 6.3%), which together account for ca. 41% of species recorded. The genera *Clinodiplosis*, *Myrciariamyia*, *Schizomyia* and *Youngomyia* are represented by two species each while the remaining 19 cecidomyiid genera are represented by a single species.

This study is unprecedented since it provides the first data set of host plants and their gall-inducing insects for the Cerrado, a global biodiversity hotspot. Highlights of the data set include: (a) there are at least 505 species of host plants in the Cerrado, and given the enormous diversity of plants in the Cerrado (about 12,400 spp.) the number of host plants must be much greater; (b) the number of gall-inducing insect species (Diptera) is relatively low (49 spp.) compared to the number of host plants recorded in this study – if there are, on average, two species of galling insects per host plant species, then, just for the 505 species of host plants in the present data-set, there would be at least 1,010 spp. of gall-inducing insect species in the Cerrado, 95% of which are unknown; (c) more inventories of galling insects and their host plants are needed in the Cerrado; (d) galling insects represent a hidden diversity and should be further investigated; and (e) threatened plants can host several specialized species of galling insects, which raises concerns about the impact of modern extinctions on co-dependents of host plants. We hope that the compiled data set of host plants and gall-inducing insects encourages researchers to explore new ecological processes and patterns involving plant-insect interactions.

Class II. Research origin descriptors

A. Overall project description

1. Identity: A compilation of host plants for communities of gall-inducing insects and species of Cecidomyiidae of the Cerrado biome.

2. Originators: The project *Plant-galling insect interactions for the Cerrado* is part of the doctoral thesis of Fernanda Cintra at USP. Host plant inventories were coordinated by Dr. Jean Carlos Santos and Dr. Wanessa Rejane de Almeida from Universidade Federal de Sergipe (UFS). Taxonomic revision of cecidomyiids was coordinated by Dr. Valeria Cid Maia (Museu Nacional) and Dr. Maria V. Urso-Guimarães (UFSCar). All databases were assembled with help from all the other authors. This is part of the *Insect Galls-Host Plants in Biomes Series*, led by Dr. Jean Carlos Santos (UFS).

3. Period of Study: Data sampling occurred from 1949 to 2019.

4. Objectives: The aims of this data paper were to: (i) compile information available in the literature (Portuguese and English) about sites sampled for insect galls and their host plant communities in the Cerrado, focusing on cecidomyiid and tephritid taxa and taxonomic

revision of host plants; (ii) communicate the current state of knowledge of plant-galling insect communities of the Cerrado biome; (iii) provide data for future sampling efforts of insect galls and their host plants; and (iv) promote future testing of hypotheses at a variety of local, regional, and landscape ecological scales.

5. Abstract: Same as above.

6. Sources of funding: The compilation of this data set was supported by Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) and Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) [CNPq grants 312752/2018-0 (JC Santos) and fellowships 140128/2019-0 (FCF Cintra) and 140158/2018-9 (H Venâncio)].

B. Specific subproject description

1. Site description: We adopted a broad delimitation of the Cerrado biome because it is an important biodiversity hotspot (Myers et al. 2000). The Cerrado is in an area highly anthropized by deforestation and land-use change and more than 50% of its area has been transformed to pasture (cattle ranching), monoculture crops, hydroelectric reservoirs and urban areas (Ratter et al. 1997, Cavalcanti and Joly 2002). In addition, ~20 million people live in the Cerrado. This anthropic pressure has contributed to the drastic deterioration of this ecosystem (Klink and Machado 2005). Conservation of the Cerrado is critical now, with protected areas accounting for only 8.3% of the original biome, and only 6.5% if only native vegetation is considered (Françoso et al. 2015). As a consequence, 645 plant species of the Cerrado (~30% of all endangered plants in Brazil) now figure in the Brazilian list of threatened species (Martinelli and Moraes 2013).

The Cerrado is considered to have the greatest floral richness among the world's savannas (Klink and Machado 2005). It supports at least 12,420 species, 1,662 genera and 187 families of angiosperms (FLORA 2020). The Cerrado has one of the highest rates of endemism (~44% in vascular plants) in the world (Silva and Bates 2002, Mendonça et al. 2008). The biome possesses remarkable physiognomic variation comprising a mosaic of savannas, grasslands and forests with highly heterogeneous environmental conditions (Oliveira-Filho and Ratter 2002).

2. Data set source: Data for host plants were obtained only from published literature (32 papers). We searched for potential studies using online academic databases: ISI Web of Knowledge, Google Scholar, Scielo, Scopus and JStor. The search terms used were: “insect gall”, “inventories”, “richness”, “Brazilian Savanah” and “Cerrado”, which were combined in different ways. Searches were conducted in English and Portuguese since, to our knowledge, no relevant article has been published in any other language (e.g., Spanish).

There are two families of Diptera for which galls have been registered: Cecidomyiidae and Tephritidae. The data for cecidomyiids described until 2016 was extracted from the fourth edition of A Catalogue of the Cecidomyiidae of the World (Gagné and Jaschhof 2017). Species described from 2017 to 2019 were checked in MNRJ (Museu Nacional of Universidade Federal do Rio de Janeiro) and MZUSP (Museu de Zoologia of Universidade de São Paulo).

3. Compilation methods: The data set is the result of compiling records of galling insects and their host plant communities in different localities in the Cerrado. For host plants we only recorded their identity. Morphotypes of insect galls were not included in the compilations since galls are used as a phenotypic trait representing insect species, which are already represented in Table 2. We selected all available publications about inventories and/or communities of galling insects and their host plants. We discarded articles that contained only case studies (e.g., studies involving ecology, zoology and botany). We also recorded basic information for each study (author, title, year, journal, volume, publisher and the link or DOI to the document), the geographical location when provided (latitude, longitude, locality, municipality and state), conservation status of each area based on Brazilian conservation units, and type of phytophysiognomy. The FLORA 2020 data set also provided us with the following information for each plant: national threat status, life form, vegetation type, occurrence, establishment and domain. Missing information was indicated as “NA”.

Data for Diptera were extracted from Gagné and Jaschhof (2017), original papers (Table 2) and museum specimens. We recorded basic information for each species: family and species of host plants; family and species of gall-inducing insects; author of host plant and gall-inducing insect species; state, municipality, and specific sites of sampling;

vegetation and phytophysiognomy types; and year of publication of the gall-inducing insect species description or mention of the species.

Host plants communities were compiled from the following literature: Fernandes et al. (1988), Fernandes et al. (1996), Fernandes et al. (1997), Gonçalves-Alvim and Fernandes (2001), Urso-Guimarães (2003), Maia and Fernandes (2004), Urso-Guimarães and Scareli-Santos (2006), Araújo et al. (2007a), Araújo et al. (2007b), Coelho et al. (2009), Carneiro et al. (2009), Araújo et al. (2011), Saito and Urso-Guimarães (2012), Santos et al. (2012), Luz et al. (2012), Malves and Frieiro-Costa (2012), Coelho et al. (2013a), Coelho et al. (2013b), Costa et al. (2014a), Costa et al. (2014b), Araújo et al. (2014), Maia et al. (2014), Araújo et al. (2015), Silva et al. (2015), Nogueira et al. (2016), Urso-Guimarães et al. (2017), Bergamini et al. (2017), Silva et al. (2018a), Silva et al. (2018b), Vieira et al. (2018), Santos et al. (2018), and Lima and Calado (2018).

Diptera species were compiled from the following literature: Felt (1907), Tavares (1917), Lutz and Lima (1918), Tavares (1918), Tavares (1920), Gagné (1984), Maia (2001), Madeira et al. (2002), Urso-Guimarães and Amorim (2002), Urso-Guimarães et al. (2003), Maia (2004), Maia and Fernandes (2005), Urso-Guimarães and Amorim (2005), Scarelli-Santos and Urso-Guimarães (2006), Maia and Fernandes (2007), Maia and Santos (2007), Maia et al. (2008), Maia et al. (2009), Maia and Carneiro (2012), Saito and Urso-Guimarães (2012), Pereira-Colavite and Urso-Guimarães (2013), Urso-Guimarães et al. (2014), Urso-Guimarães and Carmo-Neto (2015), Maia and Araújo (2016), Garcia et al. (2017), Urso-Guimarães et al. (2017), Garcia and Urso-Guimarães (2018), Maia and Flor (2018), Maia and Oliveira (2018), Proença and Maia (2018), Urso-Guimarães (2018a,b,c), Proença and Maia (2019), Ribeiro et al. (2019), Savaris et al. (2019), and Urso-Guimarães (2019a,b).

4. Taxonomic data: All species records (host plants and cecidomyiids) had their taxonomic classification revised and updated. For taxonomic information on host plant species we used FLORA 2020, and for dipteran species we used Gagné and Jaschhof (2017). We discarded taxonomically-uncertain records in species lists for the following situations: (a) cases where plants had a record of galling insects, but were not identified to species and family levels; (b) cases of host plant species where the family was identified,

but the species was not (contained only sp.); (c) cases where host plant genus was identified followed by "sp." or "cf." species; (d) a single case where the plant genus *Landia* was distributed in *Krameria*, *Mussaenda* and *Bremeria*; (e) a single case where the host plant was attacked by nematode galls [*Miconia albicans* (Sw.) Triana and *Miconia corallina* Spring] and was included as a host for galling insects; (f) a single case where host plant species names (*Koanophyllon hebecladum* and *Sapium lenheirensis*) were not found in any database; and (g) a single case where a host plant species, *Miconia theizans* (Bonpl.) Cogn., had the name misspelled and undefined status.

We discarded taxonomically uncertain records of dipterans in species lists when the gall-inducing insects were not identified to species. We also provide host plant species information for each cecidomyiid species. In these cases, we kept unidentified plant species (e.g., genus followed by "sp.") because galler identity was more important in this circumstance. We also checked plant taxonomy according to the FLORA 2020.

5. Statistical analysis: We provide some preliminary, descriptive statistical analyses for an overview of the data.

C. Data limitations and potential enhancements:

We recognize that documenting all host plants and galling insect interactions in a megadiverse ecosystem such as the Cerrado is a challenging task. The present data set is, therefore, only a subset of possible interactions. Therefore, caution is needed when drawing conclusions from this data set. The first limitation of our data is its representativeness. Our data set is arguably biased toward community studies only; we excluded case studies. Galling insects have been reported on numerous plant species, and there are several case studies in which these interactions are described. Another limitation is that some interactions are missing due to the lack of taxonomic identification of host plants. For example, many studies failed to identify the host plant to the species level. For this reason, many families and genera were not represented, which significantly reduced the representativeness of these host plant families and genera and thus limiting the data potentiality.

We designed the data set to (i) encourage new galling insect-host plant inventories in different locations; (ii) provide original information on the species richness of host plants of galling insects and on cecidomyiid species; and (iii) encourage the investigation of ecological and biogeographical patterns.

Class III. Data set status and accessibility

A. Status

Latest update: September 2019

Latest archive date: September 2019

Metadata status: Last update September 2019, version submitted

Data verification: We checked all the information such as species records and localization. Taxonomic information was homogenized. Any transcription errors were corrected.

B. Accessibility

Contact person: Jean Carlos Santos. Departamento de Ecologia. Universidade Federal de Sergipe. Campus São Cristóvão. Cidade Universitária Prof. José Aloísio de Campos. Av. Marechal Rondon, s/n, Bairro Jardim Rosa Elze. São Cristóvão. Sergipe. CEP: 49100-000, Brazil. E-mail: jcsantosbio@gmail.com.

Storage location and supporting information: The original PLANT-GALLING INSECT INTERACTIONS data set can be accessed as Supporting Information to this Data Paper release in Ecology. Updated versions of this data set can be accessed at: http://doi.org/10.5281/zenodo.3904383.

Copyright restrictions: None.

Proprietary restrictions: Please cite this data paper when using the current data in publications and let us know how the data are used in the publications.

Costs: None.

Class IV. Data structural descriptors

We divided the data set into three complementary files which can be found within DataS1.zip. The first file (plant-galling_insect_diptera.csv) contains the description of the fields related with the Diptera species (Table 2). The second file (plant-

galling_insect_host_plants_information.csv) contains data on the study area and host plant species information for each plant reported (states, municipality, study location, coordinates, conservation unit, phytophysiognomy type, plant species names, taxonomic information, threat status, life form, vegetation type, plant distribution and biogeographical domain) (Table 3). The third file (plant-galling_insect_host_plants_references.csv) describes the reference information for host plants (Table 4).

A. Data set file

Identity: plant-galling_insect_diptera.csv
Size: 13 columns and 49 records, including header row, 90 KB.
Format and storage mode: comma-separated values (.csv)
Header information: See column descriptions in section B.
Alphanumeric attributes: Mixed.
Data anomalies: Missing information was classified as "NA" in each cell.

Identity: plant-galling_insect_host_plants_information.csv
Size: 17 columns and 969 records, including header row, 117 KB.
Format and storage mode: comma-separated values (.csv)
Header information: See column descriptions in section B.
Alphanumeric attributes: Mixed.
Data anomalies: Missing information was classified as "NA" in each cell.

Identity: plant-galling_insect_host_plants_references.csv
Size: 04 columns and 33 records, including header row, 76 KB.
Format and storage mode: comma-separated values (.csv)
Header information: See column descriptions in section B.
Alphanumeric attributes: Mixed.
Data anomalies: Missing information was classified as "NA" in each cell.

B. Variable information

Table 2. Reference information in the plant-galling insect data set. Description of the fields related to the Diptera information found in the file plant-galling_insect_diptera.csv.

Type of information	Field	Description	Levels	Examples
Diptera information	Diptera_family	Family taxonomic classification for Diptera	2	Cecidomyiidae
	Diptera_species	Current and specific taxonomic classification	Several	*Asteromyia modesta* (Felt, 1907)
	Species_authors_ Diptera	Species authors	Several	Maia, 2012
	Species_authors_ galls	Studies related to galls	Several	Maia and Carneiro, 2012
	Sampling_year	Specimen collection year	1917-2019	2012
Host plants information	Genus/Species_ host_plant_adjusted	Current and specific taxonomic classification	Several	*Eremanthus erythropappus* (DC.) MacLeish
	Genus/Species_ host_plant_original_paper	taxonomic classification reported originally by the authors	Several	*Vanilosmopsis erythropappa* DC.
	Host_plant_ family	Family taxonomic classification for host plants	Several	Asteraceae
Site information	Site_states	Brazilian states in which the insects were found	Several	Minas Gerais
	Site_municipality	Brazilian municipalities in which the insects were found	Several	Luz
	Study_location	Name of each study site	Several	Serra de São José
	Vegetation_type	Cerrado phytophysiognomy type reported by the authors	Several	Transição caatinga-cerrado
Reference information	Complete_ references	Complete references of the authors who described the Diptera species	Several	Gagné, R.J. 1984. Five new species of Neotropical Cecidomyiidae

		(author names, title, year, journal, DOI)		(Diptera) associated with cacao flowers, killing the buds of Clusiaceae, or preying on mites. Brenesia 22: 123-138.

Table 3. Reference information in the plant-galling insect data set. Description of the fields related to the host plant species information found in the file plant-galling_insect_host_plants_information.csv.

Type of information	Field	Description	Levels	Examples
Reference information	Ref_number	Number for each reference	Ref_01 - Ref_32	Ref_01
Site information	States	Brazilian states in which the plants were found	5	MS
	Municipality	Brazilian municipalities in which the plants were found	Several	Aquidauana
	Study_location	Name of each study site	Several	Ecological Station of Jataí
	Coordinates	Coordinates of study site	Several	15°48'S, 48°52'W
	Conservation_unit	Whether the authors reported whether the study was carried out inside or outside a conservation unit	Yes, No and 'NA'	Yes
	Status_ conservation_unit	Type of protected area reported in the study	Federal, State, RPPN and 'NA'	Federal
	Phytophysiognomy _type	Cerrado phytophysiognomy type reported by the authors	Several	Cerradão, cerrado
Host plant information	Plant_species_ original	taxonomic classification	Several	*Arrabidaea brachypoda*

		reported originally by the authors		
	Plant_species_ adjusted	Current and specific taxonomic classification	Several	*Fridericia platyphylla* (Cham.) L.G. Lohmann
	Plant_family	Family taxonomic classification	Several	Bignoniaceae
	Plant_genus	Genus taxonomic classification	Several	*Fridericia*
	Threat_status	IUCN classification for threatened plants according to the red list of flora in Brazil	EN: Endangered VU: Vulnerable LC: Least concern DD: Data deficient NE: Not evaluated	VU
	Life_form	Type of life form *sensu* FLORA 2020	Several	
	Vegetation_type	Type of vegetation *sensu* FLORA 2020	Several	
	Plant_distribution	Brazilian states in which the plants have been reported in the FLORA 2020	Several	GO|MG|MS|MT|SP
	Biogeographical _domain	Type of biogeographical regions *sensu* FLORA 2020	Several	Cerrado|Mata Atlântica

Table 4. Reference information in the plant-galling insect data set. Description of the fields related to the reference information found in the file plant-galling_insect_host_plant_references.csv.

Type of information	**Field**	**Description**	**Levels**	**Examples**
Reference information	Ref_number	Number for each reference	Ref_01 - Ref_32	Ref_01
	Publication_years	Year of publication of the article	1988 - 2018	1988

	Authors	Name of the authors	22	Fernandes et al.
	References	Complete references (author names, title, year, journal, DOI)	32	Araújo, Walter Santos de, Santos, Benedito Baptista dos, & Gomes-Klein, Vera Lúcia. (2011). Insect galls from Serra dos Pireneus, GO, Brazil. Biota Neotropica, 11(2), 357-365. https://dx.doi.org/10.1590/S1676-06032011000200034

CLASS V. SUPPLEMENTAL DESCRIPTORS

A. Data acquisition

1. Data request history: None

2. Data set updates history: None

3. Data entry/verification procedures: The authors reviewed the data jointly, twice.

G. History of data set usage: None.

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