Entomogen galls in a Seasonal Semideciduous Forest area in Sorocaba, Southeast of São Paulo State, Brazil

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Abstract: In this paper we studied the occurrence of insect galls and gall makers in a Seasonal Semideciduous Forest area in Sorocaba Municipality, Southeast of São Paulo State, Brazil. One hundred and thirteen morphotypes of galls on 54 species of host plants of 24 different families were found. The families of host plants richer in gall morphotypes were Fabaceae (N = 26) and Malpighiaceae (N = 19); the super host plants species were Copaifera langsdorffii Desf. (Fabaceae) (N = 16), Stigmaphyllon lalandianum (Aubl.) Marchand (Malpighiaceae) (N = 11), Protium heptaphyllum A. Juss. (Burseraceae) (N = 10), Serjania lethalis A.St.-Hil. (Sapindaceae) (N = 5). Most of the galls were found empty, but insects of the family Cecidomyiidae (Diptera) were responsible for the induction of 92% (N = 11) of the galls and Hymenoptera (N = 1) for 8%. We registered insects of the order Hymenoptera (N = 11) as parasitoids and as successors Hemiptera (N = 8), Acari (N = 7), Psocoptera (N = 4), Hymenoptera (Formicidae, N = 2), Collembola and Thysanoptera (N = 1 each). Two species of Cecidomyiidae with inquiline habit were also obtained, Neolasioptera sp. and Trotteria sp. Five plant species were registered as hosts for cecidomyiids for the first time: Aloysia virgata (Ruiz & Pav.) Juss., Calliandra foliolosa Benth., Myrcia splendens (Sw.) DC., Serjania lethalis A.St.-Hil., and Tapirira guianiensis Aubl. This is the first study of gall characterization, gall makers and associated fauna of the Southeast of the State of São Paulo.

Keywords: Atlantic Forest Biome, biodiversity, gall makers, Neotropical region, plant-insect interaction.

Galhas entomógenas em uma área de Mata Estacional Semidecidual em Sorocaba, Sudeste do Estado de São Paulo, Brasil

Resumo: Neste trabalho, estudamos a ocorrência de galhas entomógenas e insetos galhadores em uma área de Mata Estacional Semidecidual em Sorocaba, Sudeste do Estado de São Paulo, Brasil. Cento e treze morfotipos de galhas em 54 espécies de plantas hospedeiras de 24 famílias distintas foram encontradas. As famílias de plantas hospedeiras mais ricas em morfotipos de galhas foram Fabaceae (N=26) e Malpighiaceae (N=19) e as espécies de plantas super hospedeiras foram Copaifera langsdorffii Desf. (Fabaceae) (N = 16), Stigmaphyllon lalandianum (Aubl.) Marchand (Malpighiaceae) (N = 11), Protium heptaphyllum A. Juss. (Burseraceae) (N = 10), Serjania lethalis A.St.-Hil. (Sapindaceae) (N = 5). A maioria das galhas foi encontrada vazia, mas insetos da família Cecidomyiidae (Diptera) foram responsáveis pela indução de 92% (N=11) das galhas e Hymenoptera (N = 1) por 8%. Nós registramos insetos da Ordem Hymenoptera (N = 11) como parasitoides e Hemiptera (N = 8), Acari (N = 7), Psocoptera (N = 4), Hymenoptera (Formicidae, N = 2), Collembola e Thysanoptera (N = 1 cada) como sucessores. Duas espécies de Cecidomyiidae com hábito inquilino também foram obtidas, Neolasioptera sp. e Trotteria sp. Cinco espécies de plantas foram registadas como hospedeiras para cecidomiídeos pela primeira vez: Aloysia virgata (Ruiz & Pav.) Juss., Calliandra foliolosa Benth., Myrcia splendens (Sw.) DC., Serjania lethalis A.St.-Hil. e Tapirira guianiensis Aubl. Este é o primeiro estudo de caracterização de galhas entomógenas, galhadores e fauna do Sudeste do Estado de São Paulo.

Palavras-chave: Bioma Mata Atlântica, biodiversidade, galhador, região Neotropical, interação ineto-planta.
Introduction

Studies on the occurrence and characterization of galls in Brazil have increased significantly in the last 30 years, especially in Cerrado Biome (Fernandes et al. 1988, Fernandes et al. 1997, Urso-Guimarães et al. 2003, Maia & Fernandes 2004, Scareli-Santos et al. 2005, Urso-Guimarães & Scareli-Santos 2006, Maia et al. 2008, Saito & Urso-Guimarães 2012, Carneiro et al. 2009, Coelho et al. 2009, Malves & Frieiro-Costa 2012, Maia 2012, Araújo et al. 2013, Bergamini et al. 2017), Restinga and Ombrophilous Forest from Atlantic Forest Biome (Maia et al. 2008, Bregonci et al. 2010, Maia 2013a, Maia 2013b, Rodrigues et al. 2014, Maia et al. 2014, Maia & Carvalho-Fernandes 2016).

However, environments such as Pantanal (Julião et al. 2002, Urso-Guimarães et al. 2012), Caatinga (Carvalho-Fernandes et al. 2012, Santos et al. 2011), Amazonic Forest (Julião et al. 2015) and Seasonal Semideciduous Forest of Atlantic Forest Biome (Santos et al. 2010, Carvalho et al. 2015) are considered little sampled and their biodiversity is still poorly understood. Particularly, the Seasonal Semideciduous Forest is considered priority area for conservation in Atlantic Forest Biome due to two factors: the biological richness and the fast degradation in recent years to economic activities in the Southeast region of Brazil (Martins et al. 2003).

Considering that gall morphotypes are used as a surrogate for species of gall-inducing insects because of the host-specificity of insect and host plant species (Carneiro et al. 2009, Bergamini et al. 2017), we described in this study the gall morphotypes with the register of the association between gall maker and their host plant species in a Seasonal Semideciduous Forest area in Sorocaba Municipality, the first survey to the Southeast region of São Paulo State, Brazil.

Material and Methods

1. Study area

The Seasonal Semideciduous Forest fragment of the sampling area is located on the campus of the Universidade Federal de São Carlos (UFSCar), located in the municipality of Sorocaba (47º 31 ‘28 “W and 23º 34’ 53” S), Southeast region of São Paulo State, 580 m altitude and climate Cwa-Köppen classification. This area is located in the transition between the Planalto Atlântico and the São Paulo State Peripheral Depression. Among forest remnants, Cerrado elements are found in the flatter areas and Seasonal Semideciduous Forest in the areas closest to water bodies or slopes (Corrêa et al. 2014). The Sorocaba campus of UFSCar is 700,000 m² in size and has a vegetative mosaic composed by two typical phytophysiognomies of the region, the Seasonal Semideciduous Forest and the Cerrado, remaining of continuous forest before its exploration for economic activities (Fig. 1).

2. Sampling

The samplings of this study were carried out between the years 2014 to 2016, with seasonal frequency (trimonthly), in twelve samplings of four hour each, totaling 48 hours of sampling effort. Branches of the host plants with galls were collected, pictured and placed for rearing in labeled plastic pots to obtain the adults of the associated fauna. All individuals obtained were preserved in 80% alcohol.

3. Treatment of the samples

The gall midges were mounted later on microscope slides following Gagné (1994) methodology. The Cecidomyiids were identified using keys of Gagné (1994). Other arthropods and host plant species were sent to specialists for identification. The gall morphotypes were characterized according Isais et al. (2013). The specimens of the associated fauna are deposited in the Laboratório de Sistemática de Diptera/UFSCar and the exsiccates of host plants with reproductive material will be deposited in Herbário UFSCar Sorocaba (SORO).

Results and Discussion

A total of 113 gall morphotypes were found in 54 species of 24 host family families in the remnants of Seasonal Semideciduous Forest in the Southeast of São Paulo State. The average of gall morphotypes per plant species is 2.1, a high average when compared with other areas with the same phytophysiognomy (Table 1) and comparable to dry environments (see Urso-Guimarães et al. 2017 for detailed discussion). The morphotypes are characterized in Table 2 and are presented in Figures 2 to 6.

The morphotypes were obtained most frequently in leaves (70%) followed by stems (30%), flower bud (2%), tendril and fruit (1%). Three morphotypes occurred in more than one vegetal organ; the fusiform morphotypes on leaf and stem of Protium heptaphyllum, the globoid morphotype on leaf vein and stem of Copaifera langsdorffii, and the amorphous morphotype on flower and fruit of Eugenia pluriflora. Our results are slightly lower than other surveys conducted in different environments (Maia, 2001, Urso-Guimarães et al. 2003, Fernandes & Negreiros, 2006 Maia et al. 2008, Saito & Urso-Guimarães 2012, Maia & Carvalho-Fernandes 2016, Bergamini et al. 2017, Urso-Guimarães et al. 2017) where the percentage of leaf galls ranges from 75 to 90%. The shape of galls more frequent was globoid (42%) followed by lenticular (26%), fusiform (18%), conical (7%), cylindrical (3%), amorphous, concave and marginal roll (2% each), and linear (1%). The color more frequently sampled in galls were green (42%) and brown (27%), followed by cream (10%), red and yellow (3% each) with other colors appearing in less than 1%. Frequently there are changes of color along the development of gall and as observed in the most galls, it passes from green to brown. In Campomanesia sp., Eugenia pluriflora, Copaifera langsdorffii, Moquiniastrum polymorphum, and Serjania lethalis it was observed changing in three different colors during maturation process. Lithraea molleoides presented the largest color variation found on galls in this study: four different colors – pink, red, green, and brown. In relation to the pubescence and internal chambers, most galls were glabrous (94%) and unilocular (100%) (for detailed discussion about presence/absence of trichomes, see Saito & Urso-Guimarães, 2012). In the Table 2 are presented a detailed morphological description of the collected galls.

In a decreasing order of occurrence of galls morphotypes appear the Fabaceae (N = 26), followed by Malpighiaceae (N = 19), Myrtaceae (N = 11), Burseraceae (N = 10), Asteraceae (N = 7), Anacardiaceae and Sapindaceae (N = 5 each).

Information about richness of morphotypes of other families and species is given in Table 3. This study corroborates others in the Neotropical region that indicates the richest families as the...
richer in the number of gall morphotypes (Gagné 1994, Araújo 2011, Santana & Isaias 2014). It’s important to highlight the high number of morphotypes found in the same plant species (the super host plants sensu Veldtman & McGeoch 2003). The presence of super hosts increase the counting of morphotypes per family in the studied area, as related by Araújo (2011) to Goiânia (GO, Brazil) and Ribeiro et al. (submitted Papéis Avulsos de Zoologia) to Altinópolis (SP, Brazil). The presence of Copaifera langsdorffii with 16 morphotypes, Stigmaphyllon lalandianum with 11, Protium heptaphyllum with 10, and Serjania lethalis with five morphotypes in this study are examples of it. Protium heptaphyllum was referred before as super host in Maia & Fernandes (2004) and Copaifera langsdorffii in Oliveira et al. (2008), Fernandes et al. (1988) and Drummond et al. (2008), both from cerrado areas in Minas Gerais State.

Most of the galls were found empty. Although only 12% of gall makers were obtained (Table 4), insects of the family Cecidomyiidae (Diptera) were responsible for the induction of 92% of galls (N = 11) and the order Hymenoptera (N = 4), Psocoptera (N = 1) for 8%. The other insects associated with galls (30%, N = 34) were considered parasitoids, successors or inquilines. As parasitoids were registered insects of the order Hymenoptera (N = 11) and as successors, the orders Hemiptera (N = 8), Acari (N = 7, Iphiseiodes zuluagai Denmark & Muma, Iphiseiodes saopaulus Denmark & Muma), Psocoptera (N = 4), Hymenoptera (Formicidae, N = 2), Collembola and Thysanoptera (N = 1 each). Two species of Cecidomyiidae with inquiline habit were also obtained, Neolasioptera sp. and Trotteria sp.

This is the first survey of the association of gall, gall makers, host plants and associated fauna in Seasonal Semidecidual Forest to the Southeast of the State of São Paulo. In addition to the associations, five plant species were registered as hosts for cecidomyiids for the first time: Aloysia virgata, Calliandra foliolosa, Myrcia splendens, Serjania lethalis and Tapirira guianensis. In the Southeast of the State of São Paulo there are several areas preserved in Conservation Units (UC), but the majority is dedicated to the protection of Dense Ombrophylous Forest vegetation. Few fragments of Seasonal Semideciduous Forest are included in that Conservation Units. Studies like this are still essential for the registration of host plants that may be at risk of extinction as well as the entire trophic network dependent on them in Seasonal Semideciduous Forest environments, a priority area for conservation in Atlantic Forest Biome, due to the biological richness and the fast degradation in recent years to economic activities in the Southeast region of Brazil, as stated to Martins et al. (2003).
Table 2. Characterization of insect galls recorded in Sorocaba, Southeast of São Paulo State, Brazil by host plant. “Figure” refers to gall morphotype’s picture, and “-” refers to no pictured morphotypes.

| Host plant family | Host plant species                  | Organ     | Shape    | Color            | Pube-scence | Figure |
|-------------------|-------------------------------------|-----------|----------|------------------|-------------|--------|
| Anacardiaceae     | Lithraea molleoides (Vell.) Engl.   | Leaf      | Globoid  | Pink/Red/Green/Brown | No          | 2A     |
|                   | Lithraea molleoides                 | Stem      | Globoid  | Brown            | No          | 2B     |
|                   | Tapirira guianensis Aubl.          | Stem      | Globoid  | Cream            | No          | 2C     |
|                   | Tapirira guianensis                | Leaf      | Lenticular | Green   | No          | 2D     |
|                   | Schinus terebinthifolia Raddi      | Leaf      | Marginal roll | Red      | No          | 2E     |
| Annonaceae        | Annona dioica A.St.-Hil.           | Leaf      | Globoid  | Cream            | No          | 2F     |
| Apocynaceae       | Oxypetalum banksii R.Br. ex Schult.| Leaf      | Lenticular | Green/Brown | No | 2H     |
|                   | Condylocarpon sp.                  | Stem      | Globoid  | Cream            | No          | 2I     |
| Asteraceae        | Chromolaena laevigata (Lam.) R.M.King & H.Rob.| Leaf | Lenticular | Brown | No | 2J     |
|                   | Bidens segetum Mart. ex Colla      | Leaf      | Lenticular | Yellowish | No | 2K     |
|                   | Calea pinnatifida (R.Br.) Less.    | Stem      | Fusiform | Green            | No          | 2L     |
|                   | Mikania sp.                        | Leaf      | Globoid  | Green            | No          | 2M     |
|                   | Mikania sp.                        | Leaf      | Lenticular | Green   | No          | 2N     |
|                   | Moquiniastrum polymorphum (Less.) G. Sancho | Leaf | Lenticular | Green/Yellowish/Brown | No | 2O     |
| Bignoniaceae      | Bignoniaceae sp.                   | Leaf      | Lenticular | White   | No          | 2Q     |
| Burseraceae       | Protium heptaphyllum (Aubl.) Marchand | Leaf | Conical | Brown | Yes | 2R     |
|                   | Protium heptaphyllum               | Leaf      | Lenticular | Brown   | No          | 2S     |
|                   | Protium heptaphyllum               | Leaf      | Globoid  | Brown            | Yes         | 2T     |
|                   | Protium heptaphyllum               | Leaf      | Globoid  | Green/Brown      | No          | 3A     |
|                   | Protium heptaphyllum               | Leaf      | Globoid  | Green            | No          | 3B     |
|                   | Protium heptaphyllum               | Leaf vein | Fusiform | Brown            | No          | 3C     |
|                   | Protium heptaphyllum               | Leaf vein | Cylindrical with apical projection | Brown | No | 3D     |
|                   | Protium heptaphyllum               | Stem      | Globoid  | Brown            | No          | -      |
|                   | Protium heptaphyllum               | Stem      | Fusiform | Brown            | No          | 3E     |
|                   | Protium heptaphyllum               | Leaf/Stem | Fusiform | Green/Brown      | No          | 3F     |
| Cannabaceae       | Celtis iguanaea (Jacq.) Sarg.      | Leaf      | Conical | Green            | No          | 3G     |
|                   | Celtis iguanaea                    | Stem      | Fusiform | Brown            | No          | 3H     |
|                   | Celtis iguanaea                    | Leaf      | Globoid  | Green            | No          | 3I     |
| Caryocaraceae     | Caryocar brasiliense Cambess.      | Leaf      | Globoid  | Green            | No          | 3J     |
| Celastraceae      | Hippocratea volubilis L.           | Leaf      | Lenticular | Brown   | Yes         | 3K     |
| Convolvulaceae    | Ipomoea sp.                       | Stem      | Globoid  | Cream            | No          | 3L     |
| Fabaceae          | Andira humilis Mart. ex Benth.     | Leaf      | Globoid  | Green            | No          | 3M     |
|                   | Bauhinia sp.                      | Leaf      | Fusiform | Green            | No          | -      |
|                   | Bauhinia forficata Link            | Stem      | Fusiform | Brown            | No          | 3N     |
|                   | Bauhinia holophylla (Bong.) Steud. | Leaf      | Globoid  | Green            | No          | 3O     |
|                   | Bauhinia holophylla               | Stem      | Fusiform | Green            | No          | 3P     |
|                   | Bauhinia longifolia (Bong.) Steud. | Leaf      | Globoid  | Green            | No          | 3Q     |
### Continued Table 1.

| Host plant family | Host plant species | Organ | Shape | Color | Pube-science | Figure |
|-------------------|--------------------|-------|-------|-------|-------------|--------|
| Bauhinia longifolia | Stem | Fusiform | Brown | No | 3R |
| Calliandra foliolosa Benth. | Stem | Globoid | Brown | No | 3S |
| Calliandra foliolosa | Stem | Fusiform | Brown | No | 3T |
| Copaifera langsdorfii Desf. | Leaf | Lenticular | Green/Yellowish/Brown | No | 4A |
| Copaifera langsdorfii | Leaf | Cylindrical | Pink/Green/Brown | No | 4B |
| Copaifera langsdorfii | Leaf | Conical | Brown | No | - |
| Copaifera langsdorfii | Leaf | Globoid | White/Pink | No | - |
| Copaifera langsdorfii | Leaf | Globoid | Black | No | 4C |
| Copaifera langsdorfii | Leaf | Globoid | Green | No | - |
| Copaifera langsdorfii | Leaf | Globoid | Green/Brown | No | - |
| Copaifera langsdorfii | Leaf | Globoid | Cream | Yes | - |
| Copaifera langsdorfii | Leaf | Globoid | Green | No | 4D |
| Copaifera langsdorfii | Leaf vein/Stem | Globoid | Brown | No | - |
| Copaifera langsdorfii | Stem | Fusiform | Cream | No | - |
| Copaifera langsdorfii | Stem | Globoid | Green | No | - |
| Copaifera langsdorfii | Stem | Globoid | Green | No | - |
| Copaifera langsdorfii | Stem | Globoid | Brown | No | - |
| Copaifera langsdorfii | Stem | Globoid | Cream | No | 4E |
| Copaifera langsdorfii | Stem | Globoid | Brown | No | 4F |
| Copaifera langsdorfii | Leaf | Globoid | Green | Yes | 4G |
| Inga edulis Mart. | Flower | Amorphous | Green | No | 4H |
| Lauraceae | Nectandra grandiflora Ness | Stem | Globoid | Cream | No | 4I |
| | Persea sp. | Leaf | Globoid | Green | No | 4J |
| | Persea wilddenovii Kosterm. | Leaf | Globoid | Green | No | 4J |
| Malpighiaceae | Diplopterys pubipetala (A.Juss.) W.R.Anderson & C.C.Davis | Leaf | Conical | Green | No | 4K |
| | Diplopterys pubipetala | Leaf | Lenticular | Brown | No | 4L |
| | Diplopterys pubipetala | Stem | Fusiform | Brown | No | 4M |
| | Byrsonima intermedia A.Juss. | Leaf | Lenticular | Brown | No | 4N |
| | Byrsonima intermedia | Stem | Globoid | Cream | No | 4O |
| | Janusia guaranitica (A.St.-Hil.) A.Juss. | Leaf | Globoid | Green | Yes | 4P |
| | Janusia guaranitica | Stem | Fusiform | Brown | No | 4Q |
| | Niedenzuella multiglandulosa (A.Juss.) W.R.Anderson | Leaf | Lenticular | Green | No | - |
| | Stigmaphyllon lalandianum A.Juss. | Leaf | Fusiform | Brown | No | 4R |
| | Stigmaphyllon lalandianum | Leaf | Conical | Green | No | - |
| | Stigmaphyllon lalandianum | Leaf | Conical | Green | No | - |
| | Stigmaphyllon lalandianum | Leaf | Concave | Green | No | 4S |
| | Stigmaphyllon lalandianum | Leaf | Lenticular | Green | No | 4T |
| | Stigmaphyllon lalandianum | Leaf | Lenticular | Green | No | - |
| | Stigmaphyllon lalandianum | Leaf | Lenticular | Yellowish | No | - |
| | Stigmaphyllon lalandianum | Stem | Fusiform | Cream | No | - |
| | Stigmaphyllon lalandianum | Stem | Fusiform | Red | No | - |
Continued Table 1.

| Host plant family | Host plant species | Organ | Shape     | Color         | Pube-scence | Figure |
|-------------------|--------------------|-------|-----------|---------------|-------------|--------|
| **Stigmaphyllon lalandianum** | Stem | Fusiform | Brown        | No                        | 5A                        |
| **Stigmaphyllon lalandianum** | Stem | Fusiform | Green        | No                        | 5B                        |
| **Melastomataceae** | **Miconia sp.** | Leaf vein | Conical | Brown         | No            | 5C        |
| **Melastomataceae** | **Miconia sp.** | Leaf | Globoid | Green         | No            | 5D        |
| **Melastomataceae** | **Miconia sp.** | Leaf | Lenticular | Cream        | No            | 5E        |
| **Melastomataceae** | **Miconia sp.** | Stem | Globoid | Brown         | No            | 5F        |
| **Meliaceae** | **Trichilia sp.** | Leaf | Lenticular | Green/Brown  | No            | 5G        |
| **Myrtaceae** | **Myrtaceae sp.1** | Leaf | Lenticular | Brown         | No            | -        |
| **Myrtaceae** | **Myrtaceae sp.2** | Stem | Globoid | Brown         | No            | 5H        |
| **Myrtaceae** | **Campomanesia sp.** | Leaf | Lenticular | Yellowish/Red/Brown  | No            | 5I        |
| **Myrtaceae** | **Eugenia bimarginata DC.** | Leaf | Lenticular | Brown/Red      | No            | 5J        |
| **Myrtaceae** | **Eugenia bimarginata** | Leaf | Globoid | Green         | No            | 5K        |
| **Myrtaceae** | **Eugenia pluriflora DC.** | Flower/Fruit | Amorphous | Green         | No            | 5L        |
| **Myrtaceae** | **Eugenia pluriflora** | Leaf | Cylindrical | Cream/Red/Brown  | No            | 5M        |
| **Myrtaceae** | **Myrcia sp.** | Leaf | Globoid | Red           | No            | 5N        |
| **Myrtaceae** | **Myrcia sp.** | Leaf | Marginal | Green         | No            | -        |
| **Myrtaceae** | **Myrcia splendens (Sw.) DC.** | Leaf vein | Globoid | Green         | No            | 5O        |
| **Myrtaceae** | **Myrcia splendens** | Leaf | Conical | Green         | No            | 5P        |
| **Passifloraceae** | **Passiflora pohlii Mast.** | Leaf | Lenticular | Green         | No            | 5Q        |
| **Passifloraceae** | **Passiflora crassifolia Killip** | Leaf | Lenticular | Green         | No            | -        |
| **Peraceae** | **Pera glabrata (Schott) Poepp. ex Baill.** | Leaf | Lenticular | Green         | No            | 5R        |
| **Piperaceae** | **Piper sp.** | Leaf | Lenticular | Green         | No            | 5S        |
| **Primulaceae** | **Myrsine umbellata Mart.** | Leaf | Globoid | Brown         | No            | 5T        |
| **Primulaceae** | **Myrsine umbellata** | Leaf | Lenticular | Green         | No            | 6A        |
| **Primulaceae** | **Myrsine coriacea (Sw.) R.Br. ex Roem. & Schult.** | Stem | Globoid | Brown         | No            | 6B        |
| **Rutaceae** | **Zanthoxylum riedelianum Engl.** | Leaf | Lenticular | Yellowish   | No            | 6C        |
| **Sapindaceae** | **Serjania lethalis A.St.-Hil.** | Tendril | Fusiform | Green/Brown | No            | 6D        |
| **Sapindaceae** | **Serjania lethalis** | Leaf | Concave | Green         | Yes           | 6E        |
| **Sapindaceae** | **Serjania lethalis** | Leaf | Linear | Green         | No            | 6F        |
| **Sapindaceae** | **Serjania lethalis** | Leaf | Globoid | Green         | No            | 6G        |
| **Sapindaceae** | **Serjania lethalis** | Leaf | Lenticular | Green/Brown/Black | No            | 6H        |
| **Smilacaceae** | **Smilax quinquenervia Vell.** | Leaf | Globoid | Green         | No            | 6I        |
| **Smilacaceae** | **Smilax cf. fluminensis Steud.** | Leaf | Lenticular | Green         | No            | 6J        |
| **Verbenaceae** | **Aloysia virgata (Ruiz & Pav.) Juss.** | Leaf | Globoid | Green         | No            | 6K        |
Figure 2. Gall morphotypes of Sorocaba, Southeast of São Paulo State, Brazil by host plant. Anacardiaceae: A-B. Lithraea molleoides, C-D. Tapirira guianensis, E. Schinus terebinthifolius. Annonaceae: F. Annona dioica, G. Duguetia furfuracea. Apocynaceae: H. Oxypetalum banksii, I. Condlyocarp sp. Asteraceae: J. Chromolaena laevigata, K. Bidens segetum, L. Calea pinnatifida, M-N. Mikania sp., O-P. Moquiniastrum polymorphum. Bignoniaceae: Q. Bignoniaceae sp. Burseraceae: R-T. Protium heptaphyllum. (Pictures: Ansaloni, L. S. and Salmazo, J. R.).
Figure 3. Gall morphotypes of Sorocaba, Southeast of São Paulo State, Brazil by host plant. Burseraceae: A-F. *Protium heptaphyllum*. Cannabaceae: G-I. *Celtis iguanaeana*. Caryocaraceae: J. *Caryocar brasiliense*. Celastraceae: K. *Hippocratea volubilis*, L. *Ipomoea* sp. Fabaceae: M. *Andira humilis*, N. *Bauhinia forficata*, O-P. *Bauhinia holophylla*, Q-R. *Bauhinia longifolia*, S-T. *Calliandra foliosa*. (Pictures: Ansaloni, L. S. and Salmazo, J. R.).
Figure 4. Gall morphotypes of Sorocaba, Southeast of São Paulo State, Brazil by host plant. Fabaceae: A-F. Copaifera langsdorffii. G. Inga edulis. Lauraceae: H. Nectandra grandiflora, I. Persea sp., J. Persea willdenovii. Malpighiaceae: K-M. Diplopterys pubipetala, N-O. Byrsonima intermedia, P-Q. Janusia guaranitica, R-T. Stigmaphyllon lalandianum. (Pictures: Ansaloni, L. S. and Salmazo, J. R.).
Figure 5. Gall morphotypes of Sorocaba, Southeast of São Paulo State, Brazil by host plant. Malpighiaceae: A-B. Stigmaphyllon lalandianum. Melastomataceae: C-F. Miconia sp. Meliaceae: G. Trichilia sp. Myrtaceae: H. Myrtaceae sp. 2, I. Campomanesia sp., J-K. Eugenia bimarginata, L-M. Eugenia pluriflora, N. Myrcia sp., O-P. Myrcia splendens. Passifloraceae: Q. Passiflora pohlii. Peraceae: R. Pera glabrata. Piperaceae; S. Piper sp. Primulaceae: T. Myrsine umbellata (Pictures: Ansaloni, L. S. and Salmazo, J. R.).
Figure 6. Gall morphotypes of Sorocaba, Southeast of São Paulo State, Brazil by host plant. Primulaceae: A. Myrsine umbellata, B. Myrsine coriacea, Rutaceae: C. Zanthxylum riedelianum, Sapindaceae: D-H. Serjania lethalis. Smilacaceae: I. Smilax quinquenervia, J. Smilax cf. fluminensis. Verbenaceae: K. Aloysia virgata. (Pictures: Ansaloni, L. S. and Salmazo, J. R.).
Table 3. Richness of gall morphotypes in plant host family and species in Sorocaba, Southeast of São Paulo State, Brazil.

| Host Plant Families (N = 24) | Morphotypes (N = 113) | Number of species (N = 54) |
|-----------------------------|-----------------------|---------------------------|
| Fabaceae                    | 26                    | 8                         |
| Malpighiaceae               | 19                    | 6                         |
| Myrtaceae                   | 11                    | 7                         |
| Burseraceae                 | 10                    | 1                         |
| Asteraceae                  | 7                     | 5                         |
| Anacardiaceae               | 5                     | 3                         |
| Sapindaceae                 | 5                     | 1                         |
| Melastomataceae             | 4                     | 1                         |
| Cannabaceae                 | 3                     | 1                         |
| Lauraceae                   | 3                     | 3                         |
| Primulaceae                 | 3                     | 1                         |
| Annonaceae                  | 2                     | 2                         |
| Apocynaceae                 | 2                     | 2                         |
| Passifloraceae              | 2                     | 2                         |
| Smilacaceae                 | 2                     | 2                         |
| Bignoniaceae                | 1                     | 1                         |
| Caryocaraceae               | 1                     | 1                         |
| Celastraceae                | 1                     | 1                         |
| Convolvulaceae              | 1                     | 1                         |
| Meliaceae                   | 1                     | 1                         |
| Peraceae                    | 1                     | 1                         |
| Piperaceae                  | 1                     | 1                         |
| Rutaceae                    | 1                     | 1                         |
| Verbenaceae                 | 1                     | 1                         |

Table 4. Gall makers and associated fauna found in gall morphotypes in host plants from Sorocaba, Southeast of São Paulo State, Brazil.

| Host plant family | Host plant species | Gall maker | Associated fauna | Figure |
|-------------------|--------------------|------------|------------------|--------|
| Anacardiaceae     | Tapirira guianensis | Cecidomyiidae | -                | 2D     |
| Annonaceae        | Annona dioica      | Contarinia or Prodiplosis (Cecidomyiidae) | Hemiptera | 2F     |
| Annonaceae        | Duguetia furcaracea | Hymenoptera | -                | 2G     |
| Asteraceae        | Calea pinnatifida  | -          | Hymenoptera     | 2L     |
| Asteraceae        | Mikania sp.        | -          | Hymenoptera     | 2M     |
| Asteraceae        | Moquiniastrum polymorphum | - | Hymenoptera/Acari | 2O    |
| Bignoniaceae      | Bignoniaceae sp.   | Cecidomyiinae (larva) | Acari | 2Q     |
| Burseraceae       | Protium heptaphyllum | -         | Pscooptera      | 2R     |
| Burseraceae       | Protium heptaphyllum | -         | Hemiptera       | 2T     |
| Fabaceae          | Bauhinia longifolia | Cecidomyiidae (larva) | Pscoptera | 3R     |
| Fabaceae          | Callindra foliolosa | Contarinia (Cecidomyiidae) | Hymenoptera | 3T     |
| Fabaceae          | Copaifera langsdorffii | -         | Pscoptera/Hemiptera/Hymenoptera | 4D     |
| Lauraceae         | Persea willdenovii | -          | Hemiptera       | 4J     |
| Malpighiaceae     | Byrsonima intermedia | Asphondylia (Cecidomyiidae) | Hemiptera/Hymenoptera | 4N     |
| Malpighiaceae     | Stigmaphyllon lalandianum | Contarinia (Cecidomyiidae) | Hymenoptera/Collombola/Neolasioptera (Cecidomyiidae) | 4S     |
| Melastomataceae   | Miconia sp.        | Bruggmanniella (Cecidomyiidae) | Thyasnoptera/Hemiptera/Hymenoptera | 5C     |
| Myrtaceae         | Myrtaceae sp.1     | -          | Pscoptera       | -      |
| Myrtaceae         | Eugenia pluriflora | Cecidomyiinae | Hymenoptera/Acari | 5L     |
| Myrtaceae         | Myrsia splendens   | Dasineura sp. (Cecidomyiidae) | Hymenoptera | 5O     |
| Primulaceae       | Myrsine coriacea   | -          | Acari           | 6B     |
| Sapindaceae       | Serjania lethalis  | -          | Trotteria (Cecidomyiidae) | Hymenoptera/Acari | 6D     |
| Smilacaceae       | Smilax quinquenervia | -         | Hymenoptera/Acari | 6I     |
| Verbenaceae       | Aloysia virgata    | Cecidomyiidae | Hemiptera       | 6K     |
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Author Contributions

Leticia Salvioni Ansaloni - Contribution in the: concept of the study; data collection; data analysis and interpretation; manuscript preparation, contribution to critical revision, adding design of the study; data collection; data analysis and interpretation; contribution to critical revision.

Julia Rodrigues Salmazo - Contribution in the: data collection; data analysis and interpretation; contribution to critical revision.

Maria Virginia Urso Guimarães - Contribution in the: concept and design of the study; data collection; data analysis and interpretation; manuscript preparation, contribution to 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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