Biota Neotropica 18(4): e20180523, 2018
www.scielo.br/bn

biotaneotropica
ISSN 1676-0611 (online edition)

Article

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

Leticia Salvioni Ansaloni*[1], *Julia Rodrigues Salmazo*[1] & *Maria Virginia Urso Guimarães*[1]

[1]*Universidade Federal de São Carlos, Sorocaba, SP, Brasil*
**Corresponding author: Maria Virginia Urso Guimarães, e-mail: mvirginiaurso@gmail.com*

ANSALONI, L. S., SALMAZO, J. R., URSO-GUIMARÃES, M.V. **Entomogen galls in a Seasonal Semideciduous Forest area in Sorocaba, Southeast of São Paulo State, Brazil**. Biota Neotropica. 18(4): e20180523. http://dx.doi.org/10.1590/1676-0611-BN-2018-0523

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 successores. Duas espécies de Cecidomyiidae com hábito inquilino também foram obtidas, *Neolasioptera* sp. e *Trotteria* sp. Cinco espécies de plantas foram registradas 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. 2017), 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, totalizing 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 Isaías 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 trichomae, 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

 http://dx.doi.org/10.1590/1676-0611-BN-2018-0523

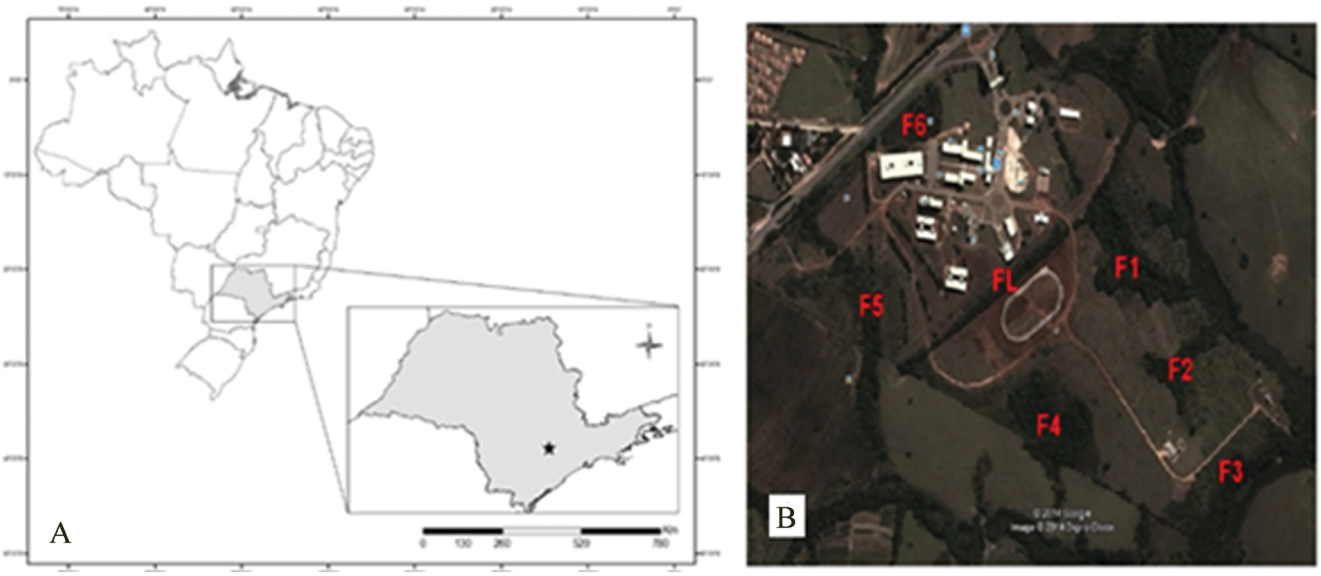

Figure 1. A. Localization of the Sorocaba Municipality in Southeast of São Paulo State; B. Aerial view of the Sorocaba campus of Universidade de São Carlos, Southeast of São Paulo State, Brazil, with reference of the fragments of the area sampled (FL, F1, F2, F3, F4, F5, F6). (Source: Google Earth, 2017).

Table 1. Richness of gall morphotypes in localities with Seasonal Semideciduous Forest phytophysiognomy.

Locality	Richness of gall morphotypes	Richness of host plant species	Average number of gall/host plant species
Sorocaba/Southeast SP (this study)	113	54	2.1
Altinópolis, SP (Ribeiro et al. – submitted Papéis Avulsos de Zoologia)	41	21	1.95
Serra da Bodoquena, MS (Urso-Guimarães et al. 2017)	65	39	1.6
Maringá, PR (Carvalho et al. 2015)*	40	35	1.2
Goiânia, GO (Santos et al. 2010)	34	20	1.7

* In Carvalho et al. *(2015) the plant species were not identified and the morphotypes were not characterized, however we chose to include these data because it is one of the few works in the area of Seasonal Semideciduous Forest phytophysiognomy.

richer in 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 = 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 guianiensis*. 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
	Duguetia furfuracea (A.St.-Hil.) Saff.	Leaf	Globoid	Green	Yes	2G
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
	Moquiniastrum polymorphum	Stem	Fusiform	Green/Brown	No	2P
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

 http://dx.doi.org/10.1590/1676-0611-BN-2018-0523

Continued Table 1.

Host plant family	Host plant species	Organ	Shape	Color	Pube-scence	Figure
	Bauhinia longifolia	Stem	Fusiform	Brown	No	3R
	Calliandra foliolosa Benth.	Stem	Globoid	Brown	No	3S
	Calliandra foliolosa	Stem	Fusiform	Brown	No	3T
	Copaifera langsdorffii Desf.	Leaf	Lenticular	Green/Yellowish/Brown	No	4A
	Copaifera langsdorffii	Leaf	Cylindrical	Pink/Green/Brown	No	4B
	Copaifera langsdorffii	Leaf	Conical	Brown	No	-
	Copaifera langsdorffii	Leaf	Globoid	White/Pink	No	-
	Copaifera langsdorffii	Leaf	Globoid	Black	No	4C
	Copaifera langsdorffii	Leaf	Globoid	Green	No	-
	Copaifera langsdorffii	Leaf	Globoid	Green/Brown	No	-
	Copaifera langsdorffii	Leaf	Globoid	Cream	Yes	-
	Copaifera langsdorffii	Leaf	Globoid	Green	No	4D
	Copaifera langsdorffii	Leaf vein/ Stem	Globoid	Brown	No	-
	Copaifera langsdorffii	Stem	Fusiform	Cream	No	-
	Copaifera langsdorffii	Stem	Globoid	Green	No	-
	Copaifera langsdorffii	Stem	Globoid	Green	No	-
	Copaifera langsdorffii	Stem	Globoid	Brown	No	-
	Copaifera langsdorffii	Stem	Globoid	Cream	No	4E
	Copaifera langsdorffii	Stem	Globoid	Brown	No	4F
	Inga edulis Mart.	Flower	Amorphous	Green	No	4G
Lauraceae	*Nectandra grandiflora* Ness	Stem	Globoid	Cream	No	4H
	Persea sp.	Leaf	Globoid	Green	No	4I
	Persea willdenovii 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
	Miconia sp.	Leaf	Globoid	Green	No	5D
	Miconia sp.	Leaf	Lenticular	Cream	No	5E
	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 sp.2	Stem	Globoid	Brown	No	5H
	Campomanesia sp.	Leaf	Lenticular	Yellowish/Red/Brown	No	5I
	Eugenia bimarginata DC.	Leaf	Lenticular	Brown/Red	No	5J
	Eugenia bimarginata	Leaf	Globoid	Green	No	5K
	Eugenia pluriflora DC.	Flower/ Fruit	Amophous	Green	No	5L
	Eugenia pluriflora	Leaf	Cylindrical	Cream/Red/Brown	No	5M
	Myrcia sp.	Leaf	Globoid	Red	No	5N
	Myrcia sp.	Leaf	Marginal roll	Green	No	-
	Myrcia splendens (Sw.) DC.	Leaf vein	Globoid	Green	No	5O
	Myrcia splendens	Leaf	Conical	Green	No	5P
Passifloraceae	*Passiflora pohlii* Mast.	Leaf	Lenticular	Green	No	5Q
	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
	Myrsine umbellata	Leaf	Lenticular	Green	No	6A
	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
	Serjania lethalis	Leaf	Concave	Green	Yes	6E
	Serjania lethalis	Leaf	Linear	Green	No	6F
	Serjania lethalis	Leaf	Globoid	Green	No	6G
	Serjania lethalis	Leaf	Lenticular	Green/Brown/Black	No	6H
Smilacaceae	*Smilax quinquenervia* Vell.	Leaf	Globoid	Green	No	6I
	Smilax cf. *fluminensis* Steud.	Leaf	Lenticular	Green	No	6J
Verbenaceae	*Aloysia virgata* (Ruiz & Pav.) Juss.	Leaf	Globoid	Green	No	6K

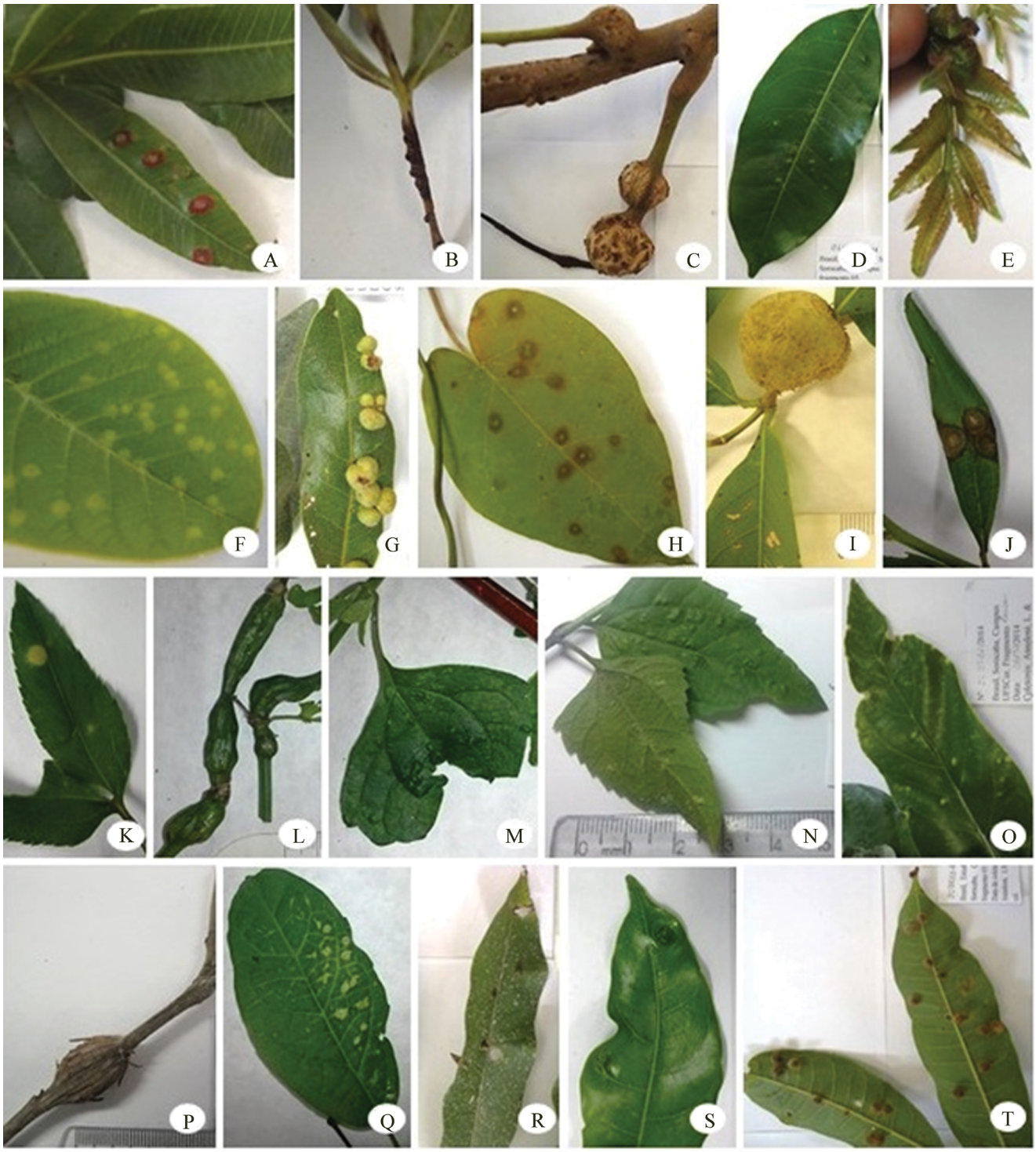

Figure 2. Gall morphotypes of Sorocaba, Southeast of São Paulo State, Brazil by host plant. Anacardiaceae: A-B. *Lithraea molleoides*, C-D. *Tapirira guianiensis*, E. *Schinus terebinthifolius*. Annonaceae: F. *Annona dioica*, G. *Duguetia furfuracea*. Apocynaceae: H. *Oxypetalum banksii*, I. *Condylocarpon* 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.).

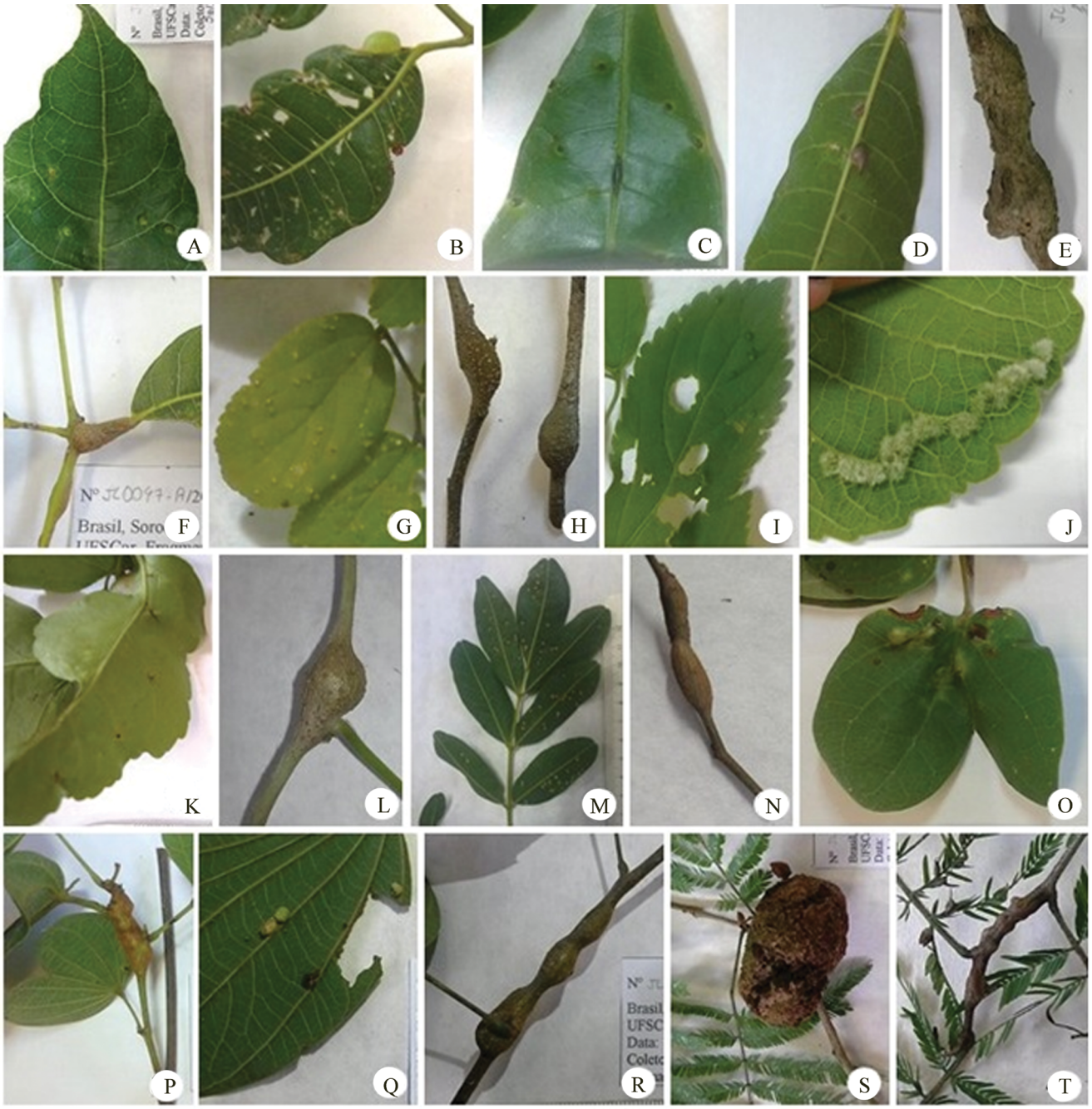

Figure 3. Gall morphotypes of Sorocaba, Southeast of São Paulo State, Brazil by host plant. Burseraceae: A-F. *Protium heptaphyllum*. Cannabaceae: G-I. *Celtis iguanaea*. Caryocaraceae: J. *Caryocar brasiliense*. Celastraceae: K. *Hippocratea volubilis*, L. *Ipomoea* sp. Fabaceae: M. *Andira humilis*, N. *Bauhinia forficata*, O-P. *Bauhinia holophylla*, Q-R. *Bauhinia longifolia*, S-T. *Calliandra foliosa*. (Pictures: Ansaloni, L. S. and Salmazo, J. R.).

http://dx.doi.org/10.1590/1676-0611-BN-2018-0523

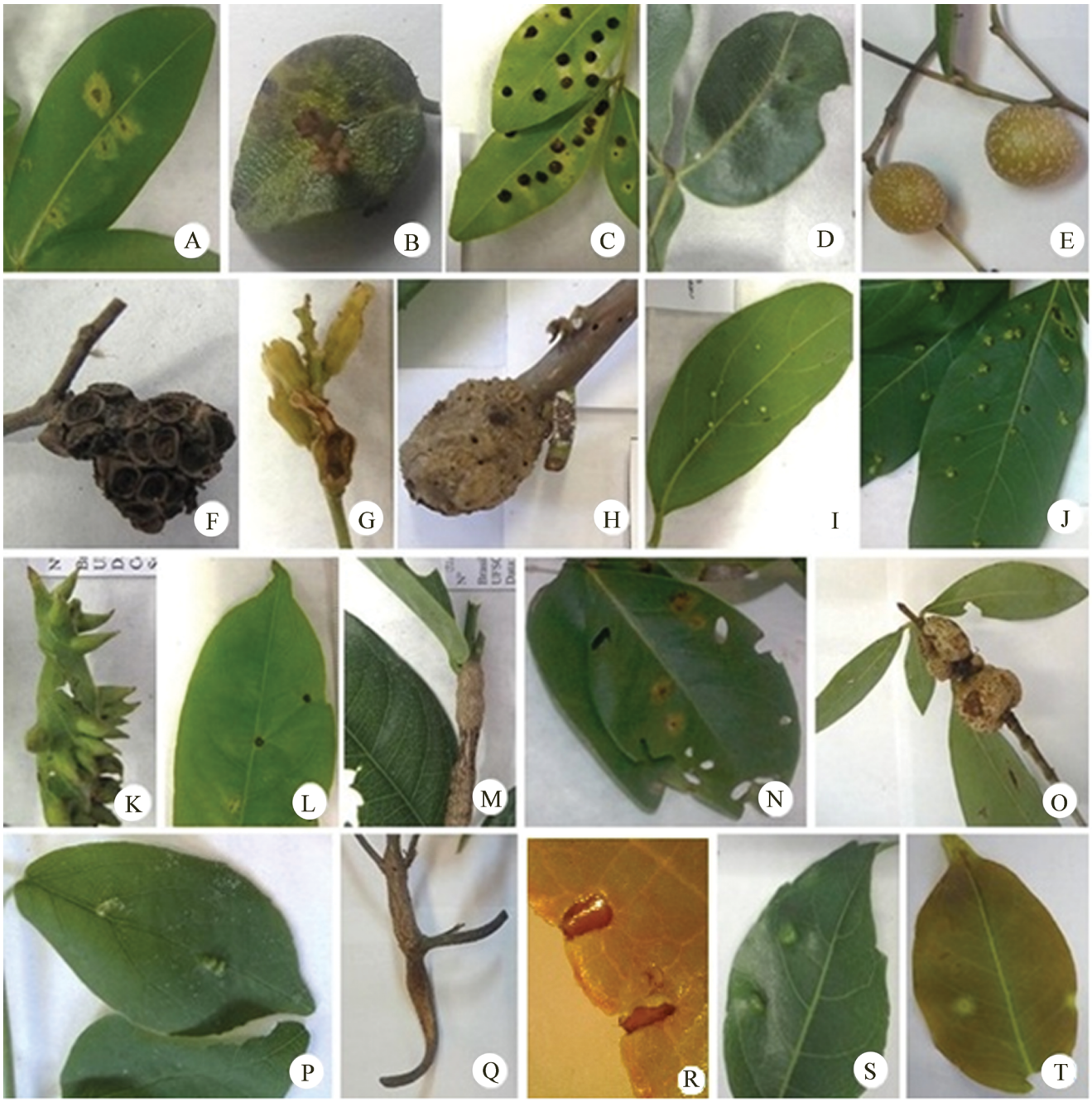

Figure 4. Gall morphotypes of Sorocaba, Southeast of São Paulo State, Brazil by host plant. Fabaceae: A-F. *Copaifera langsdorffii*. G. *Inga edulis*. Lauraceae: H. *Nectandra grandiflora*, I. *Persea* sp., J. *Persea willdenovii*. Malpighiaceae: K-M. *Diplopterys pubipetala*, N-O. *Byrsonima intermedia*, P-Q. *Janusia guaranitica*, R-T. *Stigmaphyllon lalandianum*. (Pictures: Ansaloni, L. S. and Salmazo, J. R.).

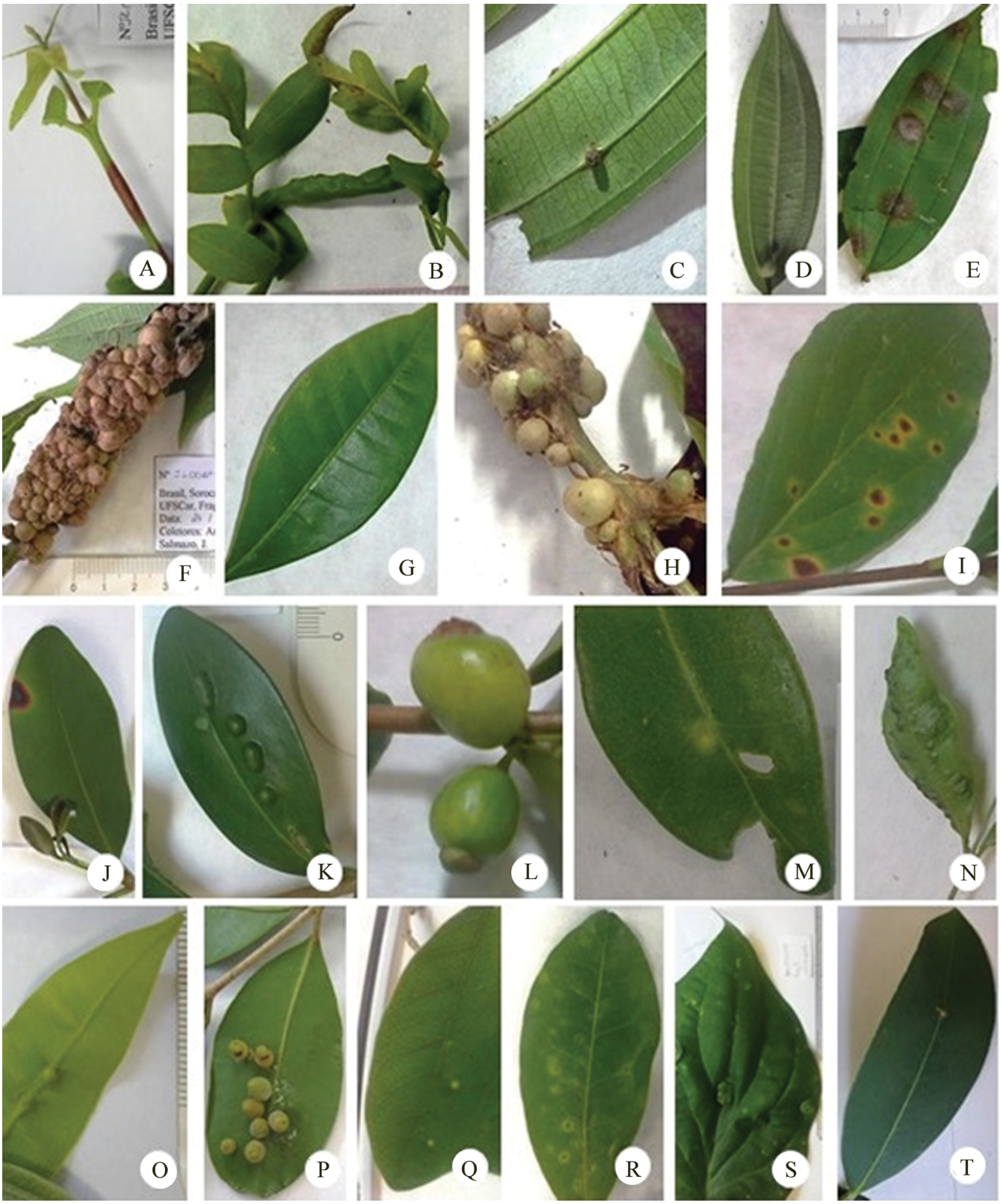

Figure 5. Gall morphotypes of Sorocaba, Southeast of São Paulo State, Brazil by host plant. Malpighiaceae: A-B. *Stigmaphyllon lalandianum*. Melastomataceae: C-F. *Miconia* sp. Meliaceae: G. *Trichilia* sp. Myrtaceae: H. Myrtaceae sp. 2, I. *Campomanesia* sp., J-K. *Eugenia bimaginata*, L-M. *Eugenia 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.).

http://dx.doi.org/10.1590/1676-0611-BN-2018-0523

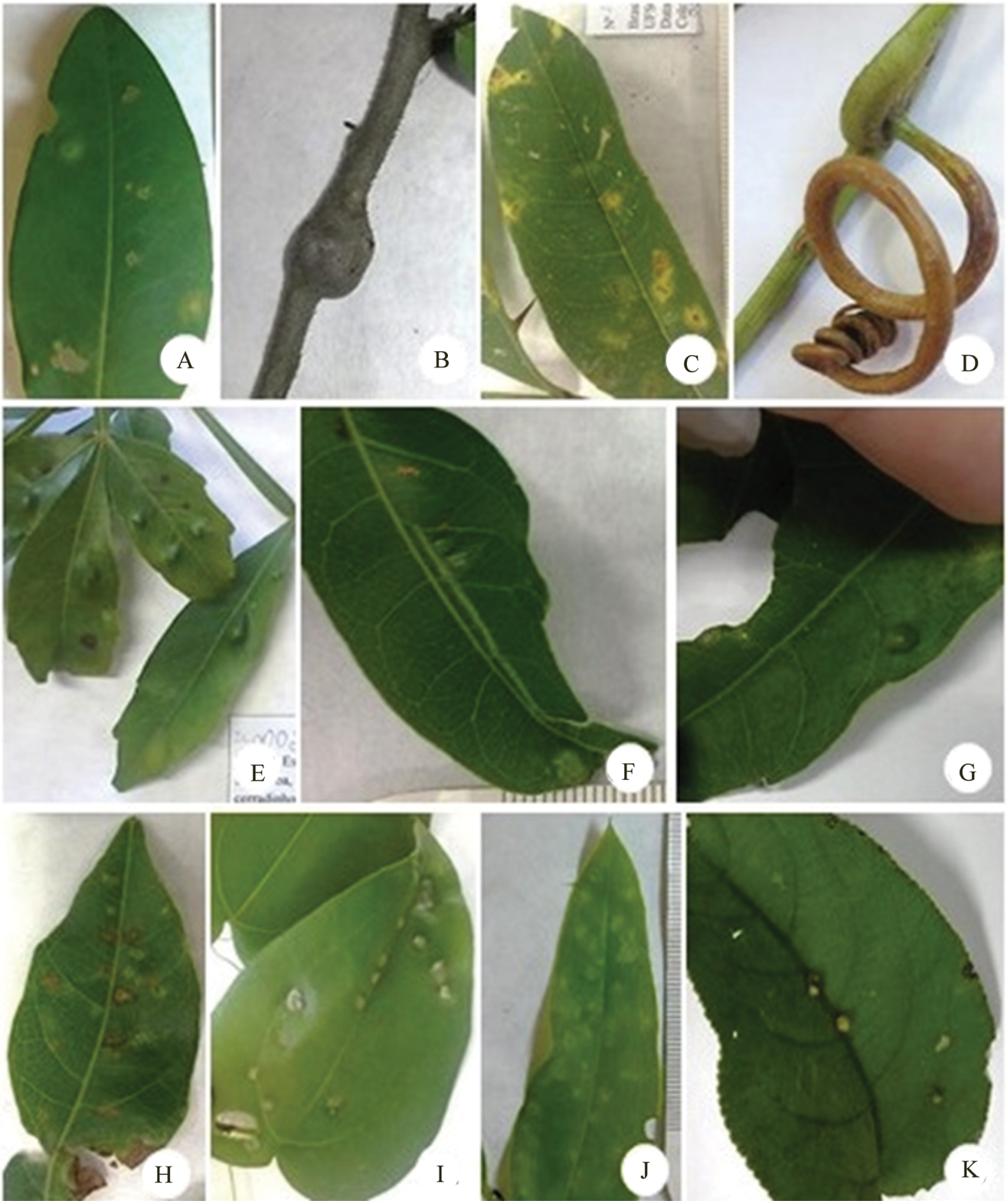

Figure 6. Gall morphotypes of Sorocaba, Southeast of São Paulo State, Brazil by host plant. Primulaceae: A. *Myrsine umbellata*, B. *Myrsine coriacea*, Rutaceae: C. *Zanthxylum riedelianum*, Sapindaceae: D-H. *Serjania lethalis*. Smilacaceae: I. *Smilax quinquenervia*, J. *Smilax* cf. *fluminensis*. 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 guianiensis*	Cecidomyiidae	-	2D
Annonaceae	*Annona dioica*	*Contarinia* sp. or *Prodiplosis* sp. (Cecidomyiidae)	Hemiptera	2F
Annonaceae	*Duguetia furfuracea*	Hymenoptera	-	2G
Asteraceae	*Calea pinnatifida*	-	Hymenoptera	2L
Asteraceae	*Mikania* sp.	-	Hemiptera	2M
Asteraceae	*Moquiniastrum polymorphum*	-	Hymenoptera/Acari	2O
Bignoniaceae	*Bignoniaceae* sp.	Cecidomyiinae (larva)	Acari	2Q
Burseraceae	*Protium heptaphyllum*	-	Psocoptera	2R
Burseraceae	*Protium heptaphyllum*	-	Hemiptera	2T
Fabaceae	*Bauhinia longifolia*	Cecidomyiidae (larva)	Psocoptera	3R
Fabaceae	*Callindra foliolosa*	*Contarinia* sp. (Cecidomyiidae)	Hymenoptera	3T
Fabaceae	*Copaifera langsdorffii*	-	Psocoptera/Hemiptera/Hymenoptera (Formicidae)/Acari	4D
Lauraceae	*Persea willdenovii*	-	Hemiptera	4J
Malpighiaceae	*Byrsonima intermedia*	*Asphondylia* sp. (Cecidomyiidae)	Hemiptera/Hymenoptera	4N
Malpighiaceae	*Stigmaphyllon lalandianum*	*Contarinia* (Cecidomyiidae)	Hymenoptera/Collembola/ *Neolasioptera* (Cecidomyiidae)	4S
Melastomataceae	*Miconia* sp.	*Bruggmanniella* sp. (Cecidomyiidae)	Thysanoptera/Hemiptera/Hymenoptera	5C
Myrtaceae	Myrtaceae sp.1	-	Psocoptera	-
Myrtaceae	*Eugenia pluriflora*	Cecidomyiinae	Hymenoptera/Acari	5L
Myrtaceae	*Myrcia 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

 http://dx.doi.org/10.1590/1676-0611-BN-2018-0523

Acknowledgments

The authors acknowledge Dr. Ingrid Koch (Unicamp), MSc. Ana Carolina Devides Castello (Unesp/Botucatu) and MSc. Ana Laura Scudeler (Unesp/Botucatu) for the identification of botanical species, Dr. Gilberto José de Moraes (Esalq/USP) for the identification of Acari species, and CNPq by scientific initiation grant of Leticia Salvioni Ansaloni (PIBIC/CNPq Proc. #102480/2015-0) and Julia Rodrigues Salmazo (PIBIC/CNPq Proc. #101881/2015-0).

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 intellectual content.

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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Received: 04/02/2018
Revised: 05/04/2018
Accepted: 21/06/2018
Published online: 16/07/2018