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Inventory

Insect galls of the Reserva Biológica União, Rio de Janeiro, Brazil

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Abstract: Several inventories of insect galls have been performed in the Atlantic Forest of Rio de Janeiro, mostly in restingas, whereas the other phytophysiognomies remain poorly sampled. The present study inventoried the insect galls of Reserva Biológica União (RJ), a protected area comprising mainly Ombrophilous Forest. Field work was performed every two months from January to October, 2013. Insect galls were collected, photographed, characterized and transported to the laboratory. Adults were obtained by rearing and immature stages by gall dissection. The insects were deposited in the Cecidomyiidae Collection of the Museu Nacional. A total of 153 gall morphotypes were found on plants representing 37 plant families, 69 genera, 55 species and 53 morphospecies. Among them, two plant genera and five species were reported for the first time as host plants in Ombrophilous Forest. REBIO União showed little similarlity of host plant species and insect gall morphotypes when compared with other investigated Ombrophilous Forest areas. The leaf was the most attacked plant organ as expected. Asteraceae, Bignoniaceae, Fabaceae and Myrtaceae, and *Mikania* (Asteraceae) and *Myrcia* (Myrtaceae) were the richest host families and genera, respectivey, in number of gall morphotypes, all previously indicated as superhosts by other Brazilian Ombrophilous Forest inventories, except Bignoniaceae. Their great species richness may be related to their great gall richness, adding evidence in support of the taxon size hypothesis. Fusiform and globose galls were the most frequent, green was the predominant color, and most morphotypes did not present an indumentum. The highest gall richness was recorded in June and August. The gallers were distributed among Diptera (Cecidomyiidae), Lepidoptera, Hymenoptera, Hemiptera and Thysanoptera, with the first being predominant, following a global pattern. Eight gall-inducing species are recorded for the first time in REBIO União and four in Ombrophilous Forest. About 25% of the gall morphotypes were occupied by dwellers other than those that created the gall. They comprised parasitoids (Hymenoptera), inquilines (Diptera: Sciaridae and Muscomorpha, Hemiptera, and Lepidoptera) and successors (Psocoptera, mites, and Hymenoptera: Formicidae). Although these taxa were previously reported by Brazilian inventories of insect galls, 12 new association with plants are recorded. The amount of new records reinforces the importance of inventories.

Keywords: *Ombrophilous Forest, Atlantic Forest, insect-plant interaction, associated fauna.*

Galhas de insetos da Reserva Biológica União, Rio de Janeiro, Brasil

Resumo: Vários inventários de galhas de insetos vem sendo desenvolvidos no estado do Rio de Janeiro, principalmente em restingas, enquanto as outras fitofisionomias permanecem pouco estudadas. O presente estudo inventariou as galhas de insetos da Reserva Biológica União (RJ), uma área protegida ocupada principalmente por Floresta Ombrófila. Trabalhos de campo foram realizados a cada dois meses de janeiro a outubro de 2013. Galhas de insetos foram coletadas, fotografadas, caracterizadas e transportadas para o laboratório. Adultos foram obtidos por criação e os imaturos pela dissecção das galhas. Os insetos foram depositados na Coleção de Cecidomyiidae do Museu Nacional (MMRJ). Um total de 153 morfotipos de galhas foram encontrados em plantas de 37 famílias, 69 gêneros, 55 espécies e 53 morfoespécies. Dentre estas, dois gêneros botânicos e cinco espécies foram registradas pela primeira vez como plantas hospedeiras em Floresta Ombrófila. A REBIO União mostrou uma pequena similaridade de plantas hospedeiras e morfotipos de galhas quando comparada com outras áreas de Floresta Ombrófila. As folhas foram o órgão vegetal mais atacado, como o esperado. Asteraceae, Bignoniaceae, Fabaceae e Myrtaceae, e *Mikania* (Asteraceae) e *Myrcia* (Myrtaceae) foram as famílias hospedeiras e gêneros botânicos mais ricos em número de morfotipos de galhas, todos previamente indicados como superhospedeiros em outros inventários na Floresta Ombrófila brasileira, exceto Bignoniaceae. A grande riqueza de espécies destes táxons pode estar relacionada a sua grande riqueza de galhas, adicionando evidências para a hipótese do tamanho do

táxon. Galhas fusiformes e globoides foram as mais frequentes, a cor verde predominou e a maioria dos morfotipos não apresentou indumento. A maior riqueza de galhas ocorreu em junho e agosto. Diptera (Cecidomyiidae), Lepidoptera, Hymenoptera, Hemiptera e Thysanoptera foram as ordens indutoras encontradas, com predomínio dos Cecidomyiidae, seguindo o padrão mundial. Oito espécies galhadoras são registradas pela primeira vez na REBIO União e quatro em Floresta Ombrófila. Cerca de 25% dos morfotipos de galhas foram ocupados por outros artrópodes, que atuaram como parasitoides (Hymenoptera), inquilinos (Diptera: Sciaridae and Muscomorpha, Hemiptera, and Lepidoptera) e successores (Psocoptera, ácaros e Hymenoptera: Formicidae). Embora estes táxons já tivessem sido reportados em inventários de galhas de insetos do Brasil, 12 novas associações com plantas são registradas. A quantidade de novos registros reforça a importância dos inventários.

Palavras-chave: *Floresta Ombrófila, Mata Atlântica, interação inseto-planta, fauna associada.*

Introduction

Although several gall inventories have been developed in the state of Rio de Janeiro (RJ), Brazil, they have focused mainly on restinga ecosystems. Other physiognomies of the Atlantic Forest have been little investigated, including Dense Ombrophilous Forest, the focus of the present sudy. Dense Ombrophilous Forest is characterized by abundant phanerophytes, woody lianas and epiphytes, high rainfall distributed throughout the year and warm temperatures (annual mean of 25ºC) (Veloso et al. 1991). Due to the scarcity of studies, the insect galls of this physiognomy are poorly known.

Only two gall inventories have been developed in protected areas of Dense Ombrophilous Forest in Brazil, one in Santa Teresa, state of Espírito Santo (Maia et al. 2014) and the other in the Parque Nacional do Itatiaia (PNI), Southeast Brazil (Maia & Mascarenhas 2017). Other data can be found in various publications (Tavares 1915, 1916, 1917a, 1917b, 1918, 1920a, 1920b, 1922, Kieffer 1913, Gagné 1998, 2001). The main goal of this study was to provide a list of host plants, gall morphotypes and gallers of the Reserva Biológica União.

Material and Methods

1. Study site

This research was carried out in Reserva Biológica União (REBIO União), which has an area of about 2,500 hectares that encompasses parts of three municipalities in northern Rio de Janeiro State: Casimiro de Abreu, Macaé and Rio das Ostras (Figure 1). With about 250 tree species of 45 plant families, REBIO União hosts primary elements of the Atlantic Forest flora and fauna (MMA/ICMBio 2008a). Among these, Myrtaceae, Lauraceae and Sapotaceae exhibit the greatest species richness (Rodrigues 2004).

There are four official trails within REBIO União - Buracão, Interpretativa, Lavapé and Três Pontes - all of which were investigated during the present study. About 50% of Três Pontes and Lavapé trails are occupied by preserved forest, while the other two trails are more impacted, with the presence of roads, antropic fields, recuperating areas and exotic vegetation (MMA/ICMBio 2008b, c).

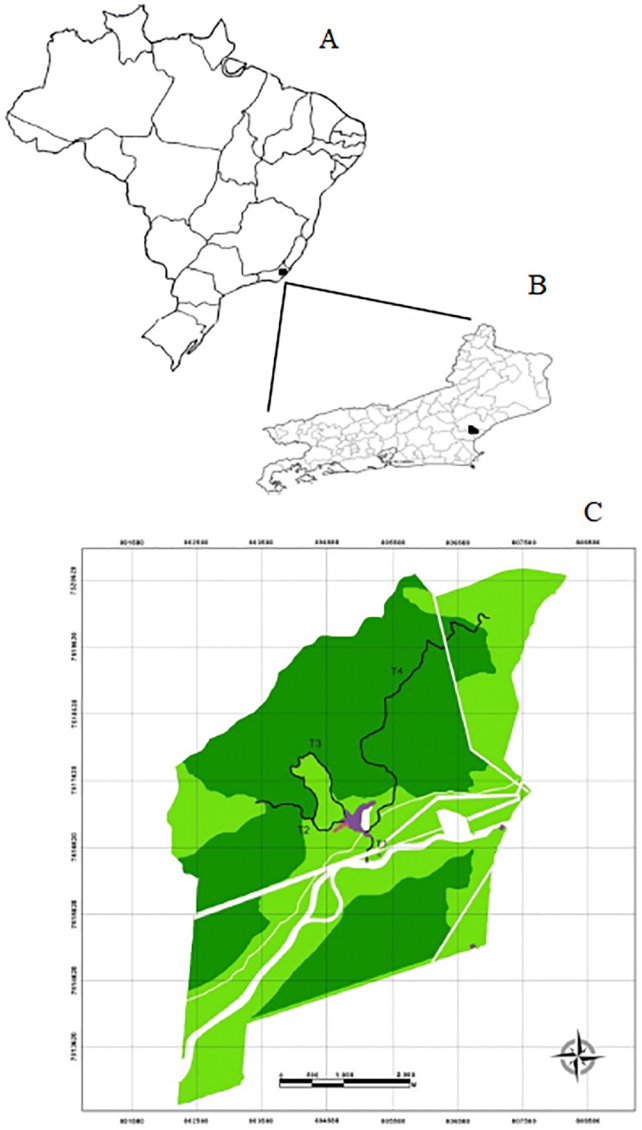

Figure 1. A) Map of Brazil, B) State of Rio de Janeiro and C) Reserva Biológica União. T1 – Buracão, T2 – Lavapé, T3 – Interpretativa, T4 – Três Pontes.

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2. *Field work*

Expeditions were undertaken every two months, from January to October, 2013, for a total of five. Each trail was investigated for insect galls for four hours by a single person per expedition, who obtained the geographic coordinates for each gall found using GPS.

Herbaceous, shrubby and arboreous plants were examined, the last up to 2 m high. Only aerial organs were investigated for galls. Branches (whenever possible with flowers and fruits) were removed from each host plant, labeled and pressed for preparation as exsiccates. The exsiccates were identified by Dr. Gracialda Costa Ferreira at Universidade Federal Rural da Amazonia, according to APGII, and deposited in the herbarium of the same institution. Galled branches were collected, packed and transported in labelled plastic bags. The galls were photographed and characterized according to their external morphology (shape, color, presence or absence of trichomes, and plant organ of occurrence).

3. *Laboratory work*

In the laboratory, samples of each gall morphotype were dissected to obtain the immature insects, observe the number of internal chambers and determine the food habit of the dwellers. They were classified into parasitoids (by observing parasitized galling larvae), inquilines (by observing different species cohabiting the same gall. In this case, early gall samples were examined to determine the galler) and successors (by observing dwellers in after dehiscent galls). To obtain adults, other samples were conditioned in labelled plastic pots lined with a layer of toilet paper. Each gall morphotype was kept in a separate pot to avoid mixing of the material. All pots were checked daily until newly emerged adults were encountered or the galls began to putrefy. When adults were found, the pots were placed in a refrigerator for some minutes to induced insect lethargy, at which time the adults were transferred to tubes with 70% ethanol. All insects were preserved in 70% ethanol and identified by the authors. Specimens of Cecidomyiidae were later mounted on microscope slides, following the methodology outlined in Gagné (1994), identified to genus, using the keys of Gagné (1994), and to species, based on gall morphology, host plant and original descriptions. Sciaridae (Diptera), Psocoptera and Hymenoptera were identified based on the keys of Steffan 1981, Aldrete and Mockford 2012 and Gibson et al. 1997, respectively. All insects were deposited in the Entomological Collection of Museu Nacional (MNRJ).

Botanical names and their respective authors, data on plant species distribution in Brazilian biomes, and origin (if exotic, native, or endemic) were obtained from Flora do Brasil 2018.

The geographic distribution of each gall morphotype in Brazil was updated based on the literature. New records of interactions between host plants and gallers were reported.

The similarity of gall composition among the investigated paths was measured using Sorensens´s index. We adopted this same index to evaluate the similarity among REBIO União and Santa Teresa and PNI, the two previous investigated areas of Dense Ombrophilous Forest in Brazil, using only the host plants which were identified to the species level.

Results

A total of 153 insect gall morphotypes (Figs. 2-6) were found in REBIO União on 108 plant species, 55 identified to the species level, 43 to genus and 10 to family, for an average of 1.42 gall morphotypes per plant species. The galled plants belonged to 37 families, of which Asteraceae, Bignoniaceae, Fabaceae, and Myrtaceae had the highest gall richness (the first three with 15 gall morphotypes each, followed by Myrtaceae with 13). *Mikania* Willd. (Asteraceae) and *Myrcia* DC. (Myrtaceae) were the genera with the greatest number of gall morphotypes (10 and 9, respectively) (Table 1).

Among the identified plant species, 51 were native — 16 of which were endemic — two naturalized, and one exotic; there were no data regarding origin for one of the identified species. The 153 gall morphospecies were distributed among 37 native genera and two endemic genera of plants. Native host plants (species and morphospecies) harbored 149 gall morphotypes, 27 of them on endemic plants, while exotic and naturalized species harbored one and three morphotypes, respectively. Twelve endemic species harbored a single gall morphotype, whereas *Mikania pilosa* Baker (Asteraceae), *Piper vicosanum* Yunck. (Piperaceae) and *Cupania racemosa* (Vell.) Radlk. (Sapindaceae) harbored two morphotypes, and *Myrcia splendens* (Sw.) DC. (Myrtaceae) three (Table 1).

Galls were found on both vegetative and reproductive plant organs (Table 2), and were most frequent on leaves (64.0%), followed by stems (30.7%), buds (9.1%), tendrils (1.3%), aerial roots (0.6%) and flower buds (0.6%). No galls were found on fruits. Nine gall morphotypes were observed on two or three plant organs simultaneously.

With regard to gall morphology, there was a predominance of globoid-shaped galls (49.0%), followed by fusiform (35.9%), lenticular (8.5%), marginal roll (4.6%), conical (3.9%), cylindrical (2.0%), imbricate (1.3%), toroid (1.3%), and amorphous (0.6%). Three morphotypes exhibited variation in shape, occuring as both globoid and fusiform. Green was the most frequent color (62.1%), followed by brown (34.0%), yellow (3.9%), red (1.3%), and purple (1.3%); greenish-yellow was also found (three morphotypes). A single morphotype exhibited color variation during development, changing from green to yellow. Additionally, all galls became brown when dried. Most of the galls were glabrous (81.7%), while trichomes were observed in just a few morphotypes (15.7%) (Table 2).

Concerning the trails, Três Pontes and Buracão had higher gall richness (65 and 56 morphotypes, respectively), while Lavapé and Interpretativa had lower (29 and 25, respectively). Thirty-eight morphotypes were observed exclusively along Três Pontes and 35 along Buracão, while the richness of exclusive morphotypes for the other two trails was considerably lower with 19 along Interpretativa and 18 along Lavapé. Sorensen's index revealed little similarity among paths; Buracão and Três Pontes were the most similar (0.28), followed by Lavapé and Três Pontes (0.19), Buracão and Lavapé (0.12), and Interpretativa and Três Pontes (0.11), with Interpretativa and Lavapé, and Buracão and Interpretativa being the most different (0.03 and 0.02, respectively) (Table 2).

Most galls were recorded in June and August, while the other months (January, April and October), the gall richness was lower (Table 2).

Figure 2. Insect galls of the Reserva Biológica União: A) On Acanthaceae, *Dicliptera mucronifolia*, stem gall, B-D) On Annonaceae, B) *Xylopia sericea,* marginal roll, C-D) Annonaceae (not determined), C) Leaf vein gall, D) Leaf gall, E-G) On Apocynaceae, E) *Aspidosperma* sp., stem gall, F) *Mandevilla* sp., stem gall, G) Apocynaceae (not determined), leaf gall, H-O) On Asteraceae, H) *Mikania gleasonii*, leaf vein gall, I-J) *Mikania glomerata*, I) Leaf vein gall, J) Leaf gall, K) *Mikania pilosa*, stem gall, L) *Mikania* sp.1, stem gall, M) *Piptocarpha lundiana*, stem gall, N) *Vernonia* sp., bud gall, O) Asteraceae (not determined), leaf vein gall, P-Z) On Bignoniaceae, P) *Adenocalymma subsessilifolium*, leaf vein gall, Q) *Adenocalymma validum*, stem gall, R) *Amphilophium* sp., leaf petiole gall, S) *Anemopaegma chamberlaynii*, leaf vein gall, T-U) *Fridericia conjugata*, T) Leaf gall, U) Leaf vein gall, V) *Fridericia* sp., leaf vein gall, W) *Lundia* sp., leaf vein gall, X) *Mansoa angustidens*, leaf gall, Y-Z) *Mansoa* sp., Y) Stem gall, Z) Leaf gall.

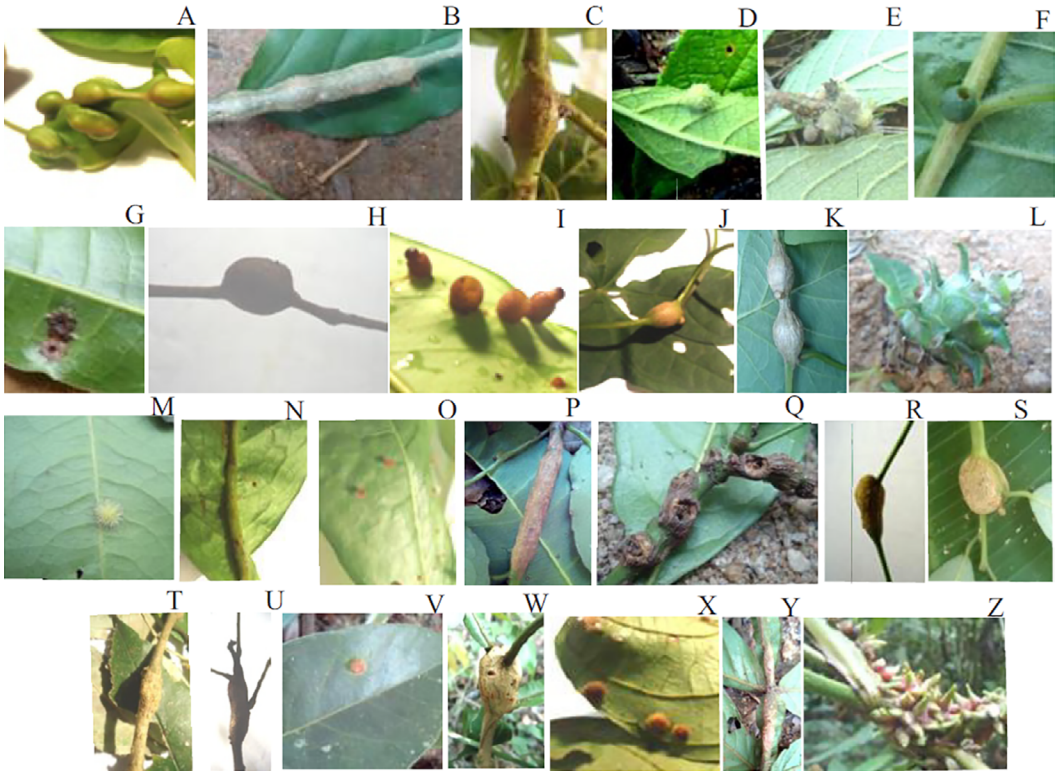

Figure 3. Insect galls of the Reserva Biológica União: A-B) On Bignoniaceae, *Pyrostegia* sp., A) Tendril gall, B) Stem gall, C-E) On Boraginaceae, C-D) *Varronia curassavica*, C) Leaf gall, D) Bud flower gall, E) Boraginaceae (not determined), bud gall, F) On Burseraceae, *Protium* sp., leaf gall, G) On Chrysobalanaceae, *Licania* sp., stem gall, H) On Combretaceae, *Combretum* sp., leaf gall, I-J) On Convolvulaceae, I) *Ipomoea hederifolia*, stem gall, J) *Ipomoea* sp., stem gall, K) On Dilleniaceae, *Davilla* sp., bud gall, L-N) On Erythroxylaceae, L-M) *Erythroxylum macrophyllum*, L) Leaf gall, M) Leaf vein gall, N) *Erythroxylum* sp., leaf gall, O-S) On Euphorbiaceae, O) *Dodecastigma* sp., leaf vein gall, P) *Mabea piriri*, stem gall, Q) *Mabea speciosa*, stem gall, R) *Mabea* sp., stem gall, S) Euphorbiaceae (not determined), stem gall, T-Z) On Fabaceae, T) *Bowdichia* sp., stem gall, U-V) *Inga alba,* U) Leaf gal, V) Stem gall, W-X) *Inga capitata*, W) Leaf gall, X) Stem gall, Y-Z) On Fabaceae, Y) *Machaerium* sp., leaf gall, Z) *Martiodendron* sp., stem gall.

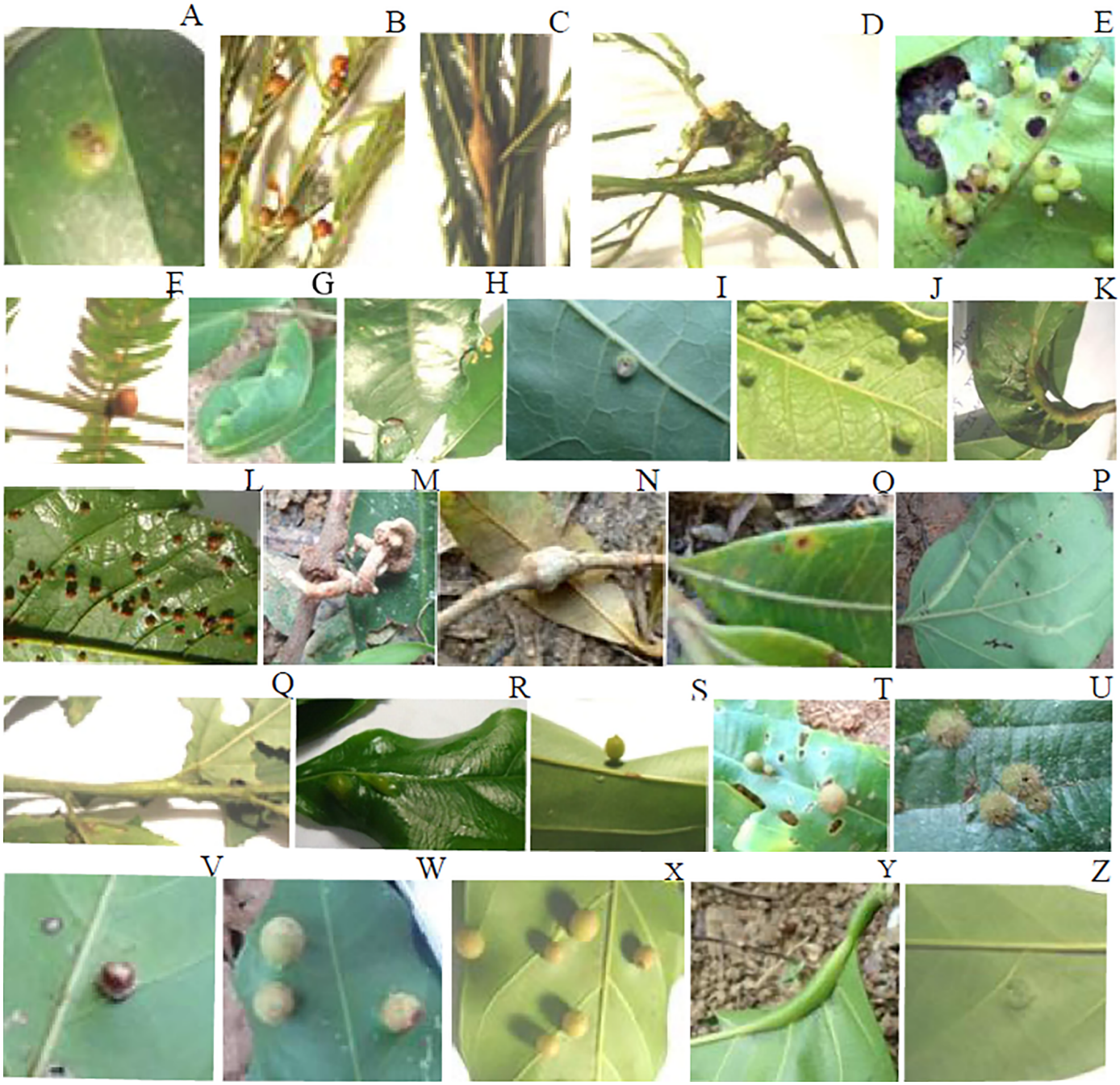

Figure 4. Insect galls of the Reserva Biológica União: A-I) On Fabaceae, A) *Myroxylon peruiferum*, leaf gall, B-D) *Parapiptadenia* sp., B) Leaf gall, C) Bud gall, D) Stem gall, E) *Pterocarpus* sp., leaf gall, F) *Senegalia serra*, leaf petiole gall, G) *Senna obtusifolia*, leaf gall, H) On Lacistemataceae, *Lacistema serrulatum*, leaf gall, I-J) On Lamiaceae, *Aegiphila integrifolia,* I) Leaf gall, J) Leaf gall, K) On Lauraceae, *Ocotea* sp., leaf vein gall, L) On Lecythidaceae, *Lecythis pisonis*, leaf gall, M) On Loranthaceae (not determined), aerial root gall, N-P) On Malpighiaceae, N-O) *Byrsonima sericea***,** N) Stem gall, O) Leaf gall, P) *Stigmaphyllon* sp., leaf vein gall, Q) On Malvaceae, *Sida acuta*, stem gall, R-U) On Melastomataceae, R) *Miconia prasina*, leaf gall, S-T) *Miconia pusilliflora*, S) Leaf gall, T) Leaf vein gall, U) *Tibouchina estrellensis*, leaf gall, V-Z) On Meliaceae, V-W) *Guarea guidonia*, V) Leaf gall, W) Leaf gall, X-Z) *Guarea kunthiana*, X) Leaf gall, Y) Leaf vein gall, Z) Leaf gall.

Galls were induced by Diptera (Cecidomyiidae), Lepidoptera, Hymenoptera, Hemiptera and Thysanoptera, the first being the most frequent gallers (49.0%). The other taxa were responsible for a single gall morphotype each. As several galls were found empty, parasitized or occupied by more than one insect taxon, we could not determined the gallers responsible for 48.4% of the morphotypes (Table 2).

Seven species of Cecidomyiidae were identified among the gallers: *Alycaulus globulus* Gagné, 2001, *Arrabiadaeamyia serrata* Maia, 2001, *Asphondylia cfr. cordiae* Möhn, 1959, *Brugmannia robusta* Maia and Couri, 1993, *Cordiamyia globosa* Maia, 1996, *Dasineura byrsonimae* Maia, 2010, *Liodiplosis conica* Gagné, 2001, and *Schismatodiplosis lantanae* Rübsaamen, 1908.

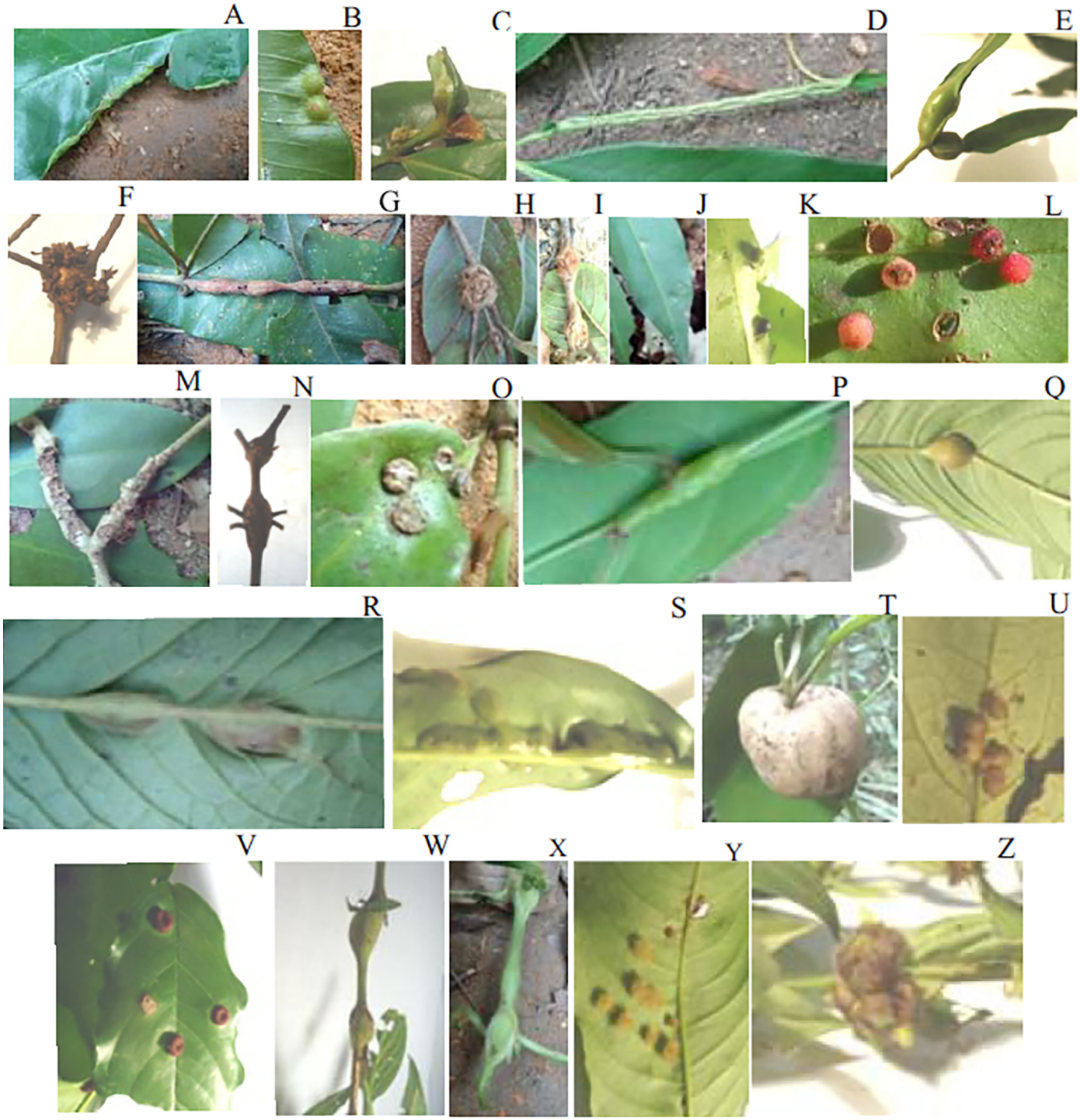

Figure 5. Insect galls of the Reserva Biológica União: A-J) On Myrtaceae, A) *Eugenia florida*, leaf gall, B-D) *Myrcia splendens*, B) Leaf vein gall, C) Bud gall, D) Leaf gall, E-G) *Myrcia* sp., E) Bud gall, F) Bud gall, G) Stem gall, H) *Psidium guineense*, stem gall, I) *Psidium laruotteanum*, stem gall, J) Myrtaceae (not determined), leaf gall, K-O) On Nyctaginaceae, K-L) *Guapira opposita*, K) Leaf gall, L) Leaf gall, M) *Neea acuminata*, stem gall, N-O) *Neea* sp., N) Stem gall, O) Leaf gall, P) On Olacaceae, *Chaunochiton* sp., stem gall, Q) On Onagraceae, *Ludwigia* sp., leaf vein gall, R-V) On Piperaceae, R) *Piper aduncum*, leaf vein gall, S) *Piper tuberculatum*, leaf gall, T-U) *Piper vicosanum*, T) Bud gall, U) Leaf gall, V) *Piper* sp., leaf gall, W-Z) On Rubiaceae, W) *Borreria verticillata*, stem gall, X) *Diodia* sp., stem gall, Y) *Psychotria nuda*, leaf gall, Z) Rubiaceae (not determined), flower bud gall.

Additionally, 11 cecidomyiid morphospecies were recorded distributed among seven genera: *Asphondylia* Loew, 1850, *Bruggmannia* Tavares, 1906, *Bruggmanniella* Tavares, 1909, *Clinodiplosis* Kieffer, 1894, *Lopesia* Rübsaamen, 1908, *Neolasioptera* Felt, 1908, and *Zalepidota* Rübsaamen, 1908. Among these genera, *Asphondylia* and *Clinodiplosis* were the most diversified, with nine and the five morphospecies, respectively, while the others were represented by a single morphospecies each.

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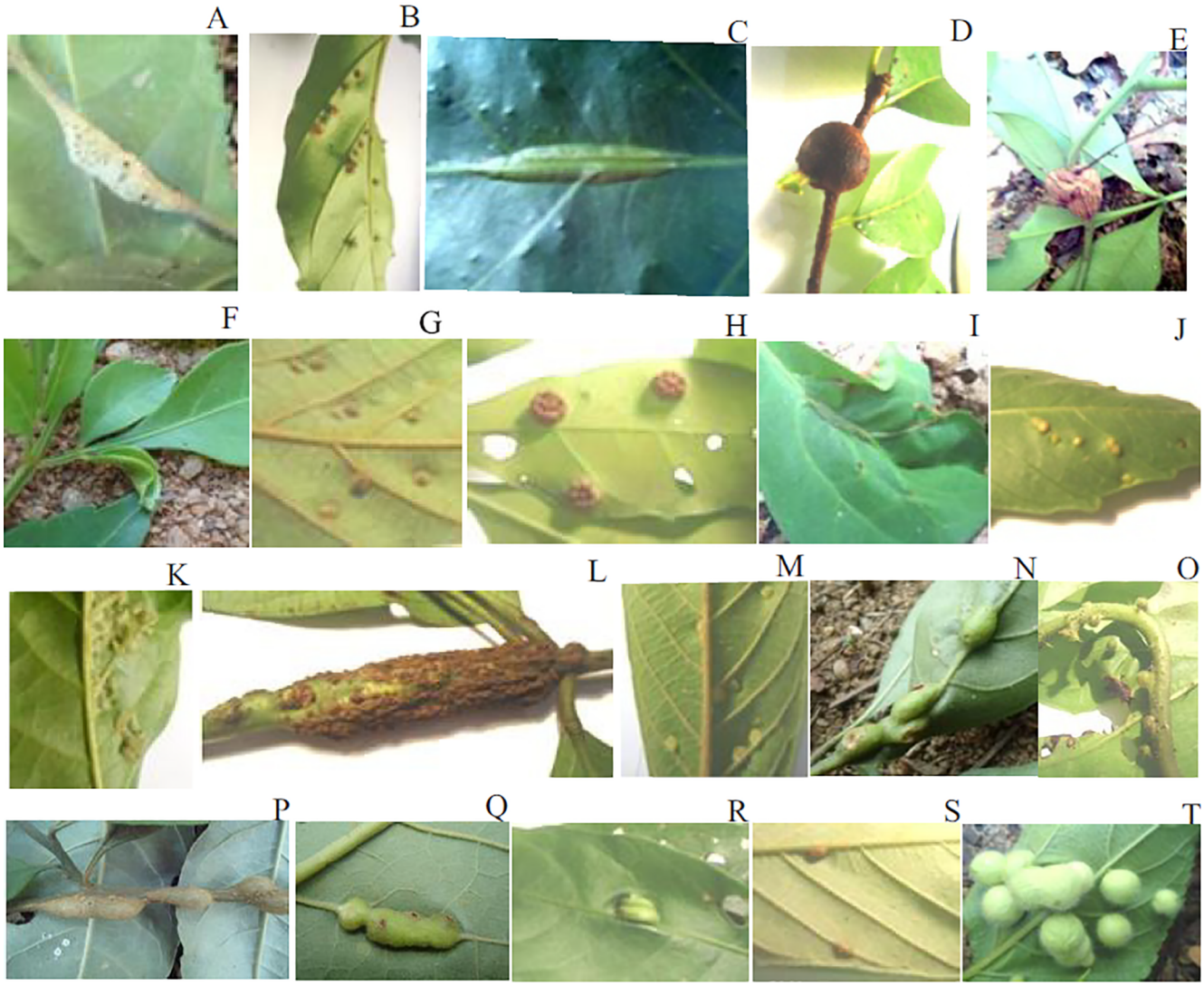

Figure 6. Insect galls of the Reserva Biológica União, A) On Salicaceae, *Casearia arborea*, stem gall, B-J) On Sapindaceae, *Cupania racemosa*, B) Leaf gall, C) Leaf vein gall, D) *Matayba* sp., stem gall, E-F) *Paullinia glomerulosa*, E) Stem gall, F) Leaf vein gall, G) *Paullinia* sp., leaf gall, H) *Serjania lethalis*, leaf gall, I-J) *Serjania* sp., I) Leaf vein gall, J) Leaf gall, K-M) On Siparunaceae, K-L) *Siparuna guianensis*, K) Leaf gall, L) Stem gall, M) *Siparuna* sp., leaf gall, N-R) On Solanaceae, N) *Solanum campaniforme*, leaf vein and petiole gall, O-Q) *Solanum* sp., O) Leaf and stem gall, P) Stem gall, Q) Leaf vein gall, R) Solanaceae (not determined), leaf vein gall, S) On Urticaceae, *Pourouma* sp., leaf vein gall, T) On Verbenaceae, *Lantana camara*, leaf gall.

Table 1. List of galled plants in the Reserva Biológica União (Rio de Janeiro, Brazil), their origin and number of gall morphotypes.

Host Plant		Origin	Number of gall morphotypes
Family	**Species**		
Acanthaceae	*Dicliptera mucronifolia* Nees	Endemic	1
	Thunbergia alata Bojer ex Sims	naturalized spe-cies	1
Total			2
Annonaceae	*Xylopia sericea* A.St.-Hil	endemic species	1
	Not determined	-	2
Total			3
Apocynaceae	*Aspidosperma* sp.	native genus	1
	Mandevilla sp.	endemic genus	1
	Not determined	-	1
Total			3

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Asteraceae	*Barrosoa organensis* (Gardner) R.M.King and H.Rob.	endemic species	1
	Mikania gleasonii B.L.Rob.	native species	1
	Mikania glomerata Spreng.	native species	2
	Mikania pilosa (Baker)	endemic species	2
	Mikania sp.1	native genus	1
	Mikania sp.2	native genus	1
	Mikania sp.3	native genus	1
	Mikania sp.4	native genus	1
	Mikania sp.5	native genus	1
	Piptocarpha lundiana (Less.) Baker	endemic species	1
	Vernonia sp.	native genus	1
	Not determined	-	2
Total			15
Bignoniaceae	*Adenocalymma subsessili-folium* DC.	endemic species	1
	Adenocalymma validum L.G.Lohmann	native species	1
	Amphilophium sp.	native genus	1
	Anemopaegma chamber-laynii (Sims) Bureau and K.Schum.	native species	1
	Cuspidaria sp.	native genus	1
	Fridericia conjugata (Vell.) L.G.Lohmann	native species	2
	Fridericia sp.	native genus	1
	Lundia sp.	native genus	1
	Mansoa angustidens (DC.) Bureau and K.Schum.	endemic species	1
	Mansoa sp.	native genus	2
	Pyrostegia sp.	native genus	2
	Tabebuia sp.	native genus	1
Total			15
Boraginaceae	*Tournefortia candidula* (Miers) Johnst.	native species	1
	Varronia curassavica Jacq.	native species	3
	Not determined	-	2
Total			6
Burseraceae	*Protium* sp.	native genus	1
Total			1
Calophyllaceae	*Calophyllum* sp.	native genus	1
Total			1
Chrysobalanaceae	*Licania* sp.	native genus	1
Total			1
Combretaceae	*Combretum* sp.	native genus	1
Total			1
Convolvulaceae	*Ipomoea hederifolia* L.	native species	1
	Ipomoea sp.	native genus	1
Total			2
Dilleniaceae	*Davilla rugosa* Poir.	native species	2
	Davilla sp.	native genus	1
Total			3

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Erythroxylaceae	*Erythroxylum macrophyl-lum* Cav.	native species	2
	Erythroxylum sp.	native genus	1
Total			3
Euphorbiaceae	*Dodecastigma* sp.	native genus	1
	Mabea piriri Aubl.	native species	1
	Mabea speciosa Müll. Arg.	native species	1
	Mabea sp.	native genus	1
	Not determined	-	1
Total			5
Fabaceae	*Bowdichia* sp.	native genus	1
	Inga alba (Sw.) Willd.	native species	2
	Inga capitata Desv.	native species	2
	Inga edulis Mart.	native species	1
	Machaerium sp.	native genus	1
	Martiodendron sp.	native genus	1
	Myroxylon peruiferum L.f.	native species	1
	Parapiptadenia sp.	native genus	3
	Pterocarpus sp.	native genus	1
	Senegalia serra (Benth.) Seigler and Ebinger	endemic species	1
	Senna obtusifolia (L.) H.S.Irwin and Barneby	native species	1
Total			15
Lacistemataceae	*Lacistema serrulatum* Mart.	endemic species	1
Total			1
Lamiaceae	*Aegiphila integrifolia* (Jacq.) Moldenke	native species	2
Total			2
Lauraceae	*Ocotea* sp.	native genus	2
Total			2
Lecythidaceae	*Lecythis pisonis* Cambess.	endemic species	1
Total			1
Loranthaceae	not determined	-	1
Total			1
Malpighiaceae	*Byrsonima sericea* DC.	native species	2
	Stigmaphyllon sp.	native genus	1
Total			3
Malvaceae	*Sida acuta* Burm.f.	native species	1
Total			1
Melastomataceae	*Miconia prasina* (Sw.) DC.	native species	1
	Miconia pusilliflora (DC.) Naudin	native species	2
	Tibouchina estrellensis (Raddi) Cogn.	endemic species	1
Total			4
Meliaceae (N= 5)	*Guarea guidonia* (L.) Sleumer	native species	2
	Guarea kunthiana A. Juss..	native species	3
Total			5

continuation...

Myrtaceae	*Eugenia florida* DC.	endemic species	1
	Myrcia splendens (Sw.) DC.	endemic species	3
	Myrcia sp.	native genus	6
	Psidium guineense Sw.	native species	1
	Psidium laruotteanum Cambess.	native species	1
	Not determined	-	1
Total			13
Nyctaginaceae	*Guapira opposita* (Vell.) Reitz	native species	2
	Neea acuminata Benth	no data	1
	Neea sp.	native genus	2
Total			5
Olacaceae	*Chaunochiton* sp.	native genus	1
Total			1
Onagraceae	*Ludwigia* sp.	native genus	1
Total			1
Piperaceae	*Piper aduncum* L.	native species	1
	Piper tuberculatum Jacq.	native species	1
	Piper vicosanum Yunck.	endemic species	2
	Piper sp.	native genus	1
	Not determined	-	2
Total			7
Rubiaceae	*Borreria verticillata* (L.) G.Mey.	native species	1
	Diodia sp.	native genus	1
	Psychotria nuda (Cham. and Schltdl.) Wawra	endemic species	1
	Not determined	-	1
Total			4
Salicaceae	*Casearia arborea* (Rich.) Urb.	native species	1
Sapindaceae	*Cupania racemosa* (Vell.) Radlk	endemic species	2
	Matayba sp.	native genus	1
	Paullinia glomerulosa Radlk	exotic species	2
	Paullinia sp.	native genus	1
	Serjania lethalis A. St.-Hil.	native species	1
	Serjania sp.	native genus	2
Total			9
Simaroubaceae	*Simarouba amara* Aubl.	native species	1
Total			1
Siparunaceae	*Siparuna guianensis* Aubl.	native species	2
	Siparuna sp.	native genus	1
Total			3
Solanaceae	*Solanum campaniforme* Roem. and Schult.	native species	1
	Solanum sp.	native genus	3
	not determined		1
Total			5
Urticaceae	*Pourouma* sp.	native genus	2
Total			2
Verbenaceae	*Lantana camara* L.	naturalized speci-es	2
Total			2

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Table 2. Host plant species, gall-inducing insects, gall characterization, sampled localities and dates of collecting in Reserva Biológica União (state of Rio de Janeiro, Brazil). BU - Buracão, IN - Interpretativa, LV - Lavapé, TP - Três Pontes. New records in Brazil are indicated by numbers: 1. new record of host plant genus, 2. new record of host plant species, 3. new record of gall morphotype.

Host plant spe-cies	Gall-inducing insect	Gall characterization				Locality/ Date of collect-ing	Fig.
		Plant organ	Shape	Color	Trichomes		
Dicliptera mu-cronifolia[1]	not det.	stem	fusiform	purple	absent	-/ VI.2013	2A
Thunbergia ala-ta[1]	not det.	stem	fusiform	-	absent	LV VIII.2013	-
Xylopia sericea[2]	not det.	leaf	marginal roll	green	absent	BU VIII/IX.2013	2B
Annonaceae (not det.)	not det.	leaf vein	fusiform	green	absent	TP, IN VI.2013	2C
Annonaceae (not det.)	not det.	leaf	conical	green	absent	IN VI.2013	2D
Aspidosperma sp.	Cecidomyiidae	stem[3]	fusiform	brown	absent	BU I.2013	2E
Mandevilla sp.	not det.	stem[3]	fusiform	green	absent	TP VIII.2013	2F
Apocynaceae (not det.)	not det.	leaf	globoid	greenish-yellow	absent	BU I.2013	2G
Barrosoa orga-nensis	Asphondylini (Cecidomyiidae)	leaf vein	globoid	-	present	BU I/VIII.2013	-
Mikania gleasonii	*Asphondylia* sp. (Cecidomyiidae)	leaf vein[3]	globoid	green	absent	TP I/VI.2013	2H
Mikania glomerata	*Alycaulus globulus* Gagné, 2001	leaf vein	fusiform	green	absent	LV IV.2013	2I
Mikania glomerata	*Liodiplosis conica* Gagné, 2001 (Cecidomyiidae)	leaf	conical	green	absent	LV IV.2013	2J
Mikania pilosa[2]	Cecidomyiidae	stem	globoid	green	absent	TP, BU VI.2013	2K
Mikania pilosa	Cecidomyiidae	leaf vein	fusiform	green	absent	LV VIII.2013	-
Mikania sp.1	*Asphondylia* sp. (Cecidomyiidae)	stem, leaf vein, petiole	globoid or fusiform	yellow, green or brown	present	BU VIII/X.2013	2L
Mikania sp.2	Cecidomyiidae	stem,	fusiform	green	present	BU/ IV/V/VIII. 2013	-
Mikania sp.3	*Asphondylia* sp. (Cecidomyiidae)	leaf vein	globoid	green	absent	BU, LV VI/X.2013	-
Mikania sp.4	Lasiopteridi (Ce-cidomyiidae)	stem	fusiform	brown	absent	TP VIII.2013	-
Mikania sp.5	*Asphondylia* sp. (Cecidomyiidae)	leaf vein petiole,	fusiform	green	absent	LV VIII.2013	-
Piptocarpha lundiana[2]	not det.	stem	fusiform	green	present	BU VI/VIII.2013	2M
Vernonia sp.	*Asphondylia* sp. (Cecidomyiidae)	bud	globoid	green	absent	BU, TP I/ VI.2013	2N
Asteraceae (not det.)	Lasiopteridi (Ce-cidomyiidae)	leaf vein	fusiform	green	absent	BU I.2013	2O
Asteraceae (not det.)	*Clinodiplosis* sp. (Cecidomyiidae)	leaf vein	globoid	green	absent	BU I.2013	-
Adenocalymma subsessilifolium[2]	not det.	leaf vein	fusiform	brown	absent	TP IV.2013	2P
Adenocalymma validum[2]	not det.	stem	globoid	green	absent	BU VIII.2013	2Q
Amphilophium sp.	Cecidomyiidae	leaf petiole[3]	fusiform	green	absent	BU IV/VI.2013	2R
Anemopaegma chamberlaynii	*Neolasioptera* sp. (Cecidomyiidae).	leaf vein	fusiform	brown	absent	BU, TP VI/ VIII.2013	2S
Cuspidaria sp.	not det.	leaf[3]	marginal roll	green	absent	BU VI.2013	-
Fridericia conjugata	*Arrabiadaeamyia* serrata, Maia 2001 (Ceci-domyiidae)	leaf	conical	green	absent	BU IV/VIII. 2013	2T

continuation...

Fridericia conjugata	*Neolasioptera* sp. (Cecidomyiidae)	leaf vein stem	fusiform	green	absent	BU VIII.2013	2U
Fridericia sp.	Cecidomyiidae	leaf vein	globoid	green	absent	TP VI.2013	2V
Lundia sp.	*Neolasioptera* sp. (Cecidomyiidae).	stem, tendril, leaf vein petiole[3]	globoid	green	absent	TP IV.2013	2W
Mansoa angustidens	not det.	leaf vein[3]	globoid	green	absent	LV/ IV.2013	2X
Mansoa sp.	*Neolasioptera* sp. (Cecidomyiidae)	stem leaf vein	fusiform	green or brown	absent	BU, TP IV/ VIII.2013	2Y
Mansoa sp.	not det.	leaf[3]	lenticular	green	absent	BU VIII.2013	2Z
Pyrostegia sp.	not det.	tendril	fusiform	brown	absent	BU I.2013	3A
Pyrostegia sp.	*Asphondylia* sp. (Cecidomyiidae)	stem	fusiform	brown	absent	LVIV.2013	3B
Tabebuia sp.	Cecidomyiidae	leaf vein	lenticular	green or yellow	absent	- VI.2013	-
Tournefortia candidula	not det.	stem[3]	fusiform globoid	green	absent	BU I.2013	-
Varronia curassavica	*Cordiamyia glo-bosa* Maia, 1996 (Cecidomyiidae)	leaf	globoid	green	present	TP IV/VI/X. 2013	3C
Varronia curassavica	*Asphondylia. cfr. cordiae* Möhn, 1959 (Cecidomyi-idae).	bud flower	globoid	green	present	TP VI.2013	3D
Varronia curassavica	Lepidoptera	leaf vein	fusiform	green	present	TP X.2013	-
Boraginaceae (not det.)	Cecidomyiidae	bud	globoid	green or brown	absent	BU, TP/ I/VI/ VIII. 2013	3E
Boraginaceae (not det.)	Cecidomyiidae	bud	globoid	green	present	LV IV.2013	-
Protium sp.	Hemiptera	leaf	lenticular	brown (dried)	absent	TP VIII.2013	3F
Calophyllum sp.	not det.	leaf	marginal roll	green	absent	IN IV.2013	-
Licania sp.	Cecidomyiidae	stem	globoid	brown	absent	BU I.2013	3G
Combretum sp	not det.	leaf[3]	globoid	brown	absent	BU I.2013	3H
Ipomoea hederifolia	Cecidomyiidae	stem	globoid	green or brown	absent	IN VIII.2013	3I
Ipomoea sp.	Cecidomyiidae	stem[3]	fusiform	green or brown	absent	LV/ IV.2013	3J
Davilla rugosa	Cecidomyiidae	leaf	lenticular	green	absent	TP VIII.2013	-
Davilla rugosa	*Clinodiplosis* sp. (Cecidomyiidae)	bud	imbricated	green	absent	TP X.2013	-
Davilla sp.	not det.	bud	imbricated	green	absent	TP VI.2013	3K
Erythroxylum macrophyllum	Cecidomyiidae	leaf[3]	globoid	yellow	present	BU, TP I/IV/VI/ VIII/X. 2013	3L
Erythroxylum macrophyllum	not det.	leaf vein[3]	fusiform	green	absent	BU VIII.2013	3M
Erythroxylum sp.	not det.	leaf[3]	cylindrical	reddish	present	LV I.2013	3N
Dodecastigma sp.	not det.	stem[3] petiole leaf vein	globoid	brown	absent	BU, TP I/VI/ VIII. 2013	3O
Mabea piriri	not det.	stem[3]	globoid	brown	absent	IN I.2013	3P
Mabea speciosa	not det.	stem[3]	fusiform	brown	absent	TP IV.2013	3Q
Mabea sp.	not det.	stem[3]	globoid	brown	absent	IN VIII.2013	3R
Euphorbiaceae (not det.)	not det.	stem	fusiform	brown	absent	IN VI.2013	3S
Bowdichia sp.	not det.	stem[3]	fusiform	brown	absent	BU I.2013	3T
Inga alba	Cecidomyiidae	leaf[3]	globoid	green	present	TP IV.2013	3U
Inga alba	not det.	stem	globoid	brown	absent	-/VI.2013	3V

continuation...

Inga capitata	Cecidomyiidae	leaf[3]	globoid	green or brown	present	LV, TP I.2013	3W
Inga capitata	Cecidomyiidae	stem	fusiform	brown	absent	- IV/VI.2013	3X
Inga edulis	Cecidomyiidae	leaf vein	fusiform	green	absent	IN VI.2013	-
Machaerium sp.	Cecidomyiidae	leaf	globoid	green	absent	BU I.2013	3Y
Martiodendron sp.	Schizomyiina (Cecidomyiidae)	stem[3]	conical	reddish or green	present	IN I/VI/VIII. 2013	3Z
Myroxylon peruiferum	not det.	leaf[3]	lenticular	greenish or yellow	absent	BU VIII.2013	4A
Parapiptadenia sp.	not det.	leaf[3]	globoid	green or brown	absent	IN VIII.2013	4B
Parapiptadenia sp.	not det.	stem[3]	fusiform	brown	absent	LV VI.2013	4C
Parapiptadenia sp.	not det.	bud[3]	globoid	green	absent	LV VI.2013	4D
Pterocarpus sp.	Cecidomyiidae	leaf[3]	globoid	green	absent	TP VI.2013	4E
Senegalia serra	not det.	petiole[3]	globoid	brown	absent	LV VIII/X.2013	4F
Senna obtusifolia	not det.	leaf	lenticular	green	absent	TP VI.2013	4G
Lacistema serrulatum	not det.	leaf[3]	marginal roll	green	absent	TP VIII.2013	4H
Aegiphila integrifolia	not det.	leaf[3]	globoid	green	absent	- VI.2013	4I
Aegiphila integrifolia	not det.	leaf[3]	globoid	green	present	BU VI.2013	4J
Ocotea sp.	not det.	leaf vein[3]	fusiform	green	absent	TP VIII/X.2013	4K
Ocotea sp.	not det.	leaf	globoid	brown	absent	TP VIII.2013	-
Lecythis pisonis	Lasiopteridi (Cecidomyiidae)	leaf[3]	globoid	brown	absent	BU I/VI/VIII. 2013	4L
Loranthaceae (not det.)	Cecidomyiidae	aerial root	fusiform	brown	absent	- VI.2013	4M
Byrsonima sericea	not det.	stem	globoid	brown	absent	TP IV/X.2013	4N
Byrsonima sericea	*Dasineura byrsonimae* Maia, 2010 (Cecidomyiidae)	leaf	lenticular	yellow or brown	absent	BU, TP VIII.2013	4O
Stigmaphyllon sp.	not det.	leaf vein[3]	fusiform	green	absent	- VI.2013	4P
Sida acuta	not det.	stem[3]	fusiform	green	present	IN VIII.2013	4Q
Miconia prasina	Cecidomyiidae	leaf vein	fusiform or globoid	greenish-yellow	absent	BU I/VI/VIII. 2013	4R
Miconia pusilliflora	Cecidomyiidae	stem, bud, leaf[3]	globoid	green	absent	BU, LV I/IV/ VIII. 2013	4S
Miconia pusilliflora	not det.	leaf vein[3]	globoid	green or brown	absent	TP VI.2013	4T
Tibouchina estrellensis	Cecidomyiidae	leaf[3]	globoid	green	present	BU, TP IV/ VI.2013	4U
Guarea guidonia	Cecidomyiidae	leaf	globoid	reddish	absent	BU VIII.2013	4V
Guarea guidonia	Cecidomyiidae	leaf	globoid	yellow	absent	BU VIII/2013	4W
Guarea kunthiana	Cecidomyiidae	leaf	globoid	green or brown	absent	BU, LV, I/VI/ VIII/X. 2013	4X
Guarea kunthiana	Cecidomyiidae	leaf vein	fusiform	green	absent	BU VI/VIII.2013	4Y
Guarea kunthiana	Cecidomyiidae	leaf[3]	lenticular	green	absent	BU VIII.2013	4Z
Eugenia florida	not det.	leaf[3]	marginal roll	green	absent	- VI.2013	5A
Myrcia splendens	Cecidomyiidae	leaf vein	globoid	green or brown	absent	IN, TP VI/ VIII.2013	5B
Myrcia splendens	not det.	bud	globoid	green	absent	IN VI.2013	5C
Myrcia splendens	Cecidomyiidae	leaf	marginal roll	green	absent	TP VI.2013	5D

continuation...

Myrcia sp.	not det.	bud	fusiform	green	absent	BU, TP I/ VIII.2013	5E
Myrcia sp.	not det.	bud	globoid	brown	abent	LV IVI.2013	5F
Myrcia sp.	Cecidomyiidae.	stem	fusiform	brown	absent	BU VIII.2013	5G
Myrcia sp.	not det.	leaf	marginal roll	green	and glabrous	IN, TP VIII.2013	-
Myrcia sp.	Lasiopteridi (Cecidomyiidae)	leaf	globoid	green	absent	BU, TP VIII.2013	-
Myrcia sp.	Thysanoptera	bud	amorphous	reddish	absent	TP VIII.2013	-
Psidium guineense	Hymenoptera	stem	globoid	green or brown	absent	LV, TP VI/X.2013	5H
Psidium laruotteanum	not det.	stem[3]	fusiform	brown	absent	BU, TP I/ IV.2013	5I
Myrtaceae (not det.)	not det.	leaf	lenticular	green	absent	TP IV.2013	5J
Guapira opposita	*Bruggmannia* sp. (Cecidomyiidae)	leaf	globoid	green	absent	TP I.2013	5K
Guapira opposita	*Bruggmannia robusta* Maia and Couri, 1993 (Cecidomyiidae)	leaf, petiole, stem	globoid	reddish	present	TP VIII.2013	5L
Neea acuminata[2]	Cecidomyiidae	stem bud[3]	fusiform	brown	absent	BU, TP I/ IV/X.2013	
Neea sp.	not det.	stem	fusiform	brown	absent	TP IV/X.2013	5N
Neea sp.	not det.	leaf	lenticular	brown	absent	TP VI.2013	5O
Chaunochiton sp.[1]	not det.	stem	fusiform	green	absent	- VI.2013	5P
Ludwigia sp.	not. det.	leaf vein petiole	globoid	green	absent	TP VIII.2013	5Q
Piper aduncum	Cecidomyiidae	leaf vein	fusiform	green	absent	TP VI.2013	5R
Piper tuberculatum	Cecidomyiidae	leaf	globoid	green	absent	LV, TP I/IV/VI. 2013	5S
Piper vicosanum[2]	*Zalepidota* sp. nov. (Cecidomyiidae)	bud	globoid	yellow or brown	absent	IN, TP IV/ VIII.2013	5T
Piper vicosanum	not det.	leaf	globoid	brown	absent	IN VIII.2013	5U
Piper sp.	Cecidomyiidae	leaf	toroid	green or brown	absent	BU, LV, TP I/ IV.2013	5V
Piperaceae (not det.)	not det.	leaf	lenticular	green	absent	- VIII.2013	-
Piperaceae (not det.)	not det.	leaf	conical	hairy	present	TP VIII.2013	-
Borreria verticillata	Cecidomyiidae	stem[3]	fusiform	green	absent	LV I.2013	5W
Diodia sp.	Cecidomyiidae	stem	fusiform	green	absent	- VI.2013	5X
Psychotria nuda[2]	not det.	leaf	globoid	green or yellow	present	IN I.2013	5Y
Rubiaceae (not det.)	not det.	flower bud	globoid	green or purple	present	LV IV.2013	5Z
Casearia arborea	*Lopesia* sp. (Cecidomyiidae).	stem	fusiform	brown	absent	- IV.2013	6A
Cupania racemosa	not det.	leaf[3]	globoid	green or yellow	present	IN I.2013	6B
Cupania racemosa	Cecidomyiidae	leaf vein	fusiform,	green	absent	IN, LV, TP IV/ VIII/X. 2013	6C
Matayba sp.	not det.	stem	globoid	brown	absent	BU I.2013	6D
Paullinia glomerulosa	not det.	stem	globoid	brown	absent	TP IV.2013	6E
Paullinia glomerulosa	not det.	leaf vein	fusiform	green	glabrous	TP VI/VIII.2013	6F
Paullinia sp.	not det.	leaf[3]	globoid	green	present	BU I.2013	6G

continuation...

Serjania lethalis	not det.	leaf[3]	toroid	brown	absent	LV I.2013	6H
Serjania sp.	Cecidomyiidae	leaf vein	fusiform	green	absent	BU, TP IV.2013	6I
Serjania sp.	Cecidomyiidae	leaf	globoid	green	absent	IN VIII.2013	6J
Simarouba amara	not det.	leaf	conical	green	absent	BU VIII.2013	-
Siparuna guianensis	Cecidomyiidae	leaf	cylindrical	green	absent	BU, IN I.2013	6K
Siparuna guianensis	*Bruggmanniella* sp. (Cecidomyiidae)	stem	fusiform	green	absent	IN IV/VIII.2013	6L
Siparuna sp.	Cecidomyiidae	leaf	lenticular	green	absent	LV I.2013	6M
Solanum campaniforme	*Clinodiplosis* sp. (Cecidomyiidae)	leaf vein petiole	globoid	green	absent	TP IV.2013	6N
Solanum sp.	*Asphondylia* sp. (Cecidomyiidae)	leaf stem	globoid	green or brown	present	TP IV/VIII.2013	6O
Solanum sp.	Cecidomyiidae	stem	fusiform	brown	absent	BU VIII.2013	6P
Solanum sp.	*Asphondylia* sp. (Cecidomyiidae)	leaf vein	globoid	green	absent	TP VI.2013	6Q
Solanaceae (not det.)	not det.	leaf vein	fusiform	green	absent	TP VIII.2013	6R
Pourouma sp.	Cecidomyiidae (Diptera)	leaf vein	fusiform	brown	absent	IN I.2013	6S
Pourouma sp.	not det.	leaf	lenticular	brown	absent	IN VIII.2013	-
Lantana camara	*Schismatodiplosis lantanae* Rübsaamen, 1907 (Cecidomyiidae)	leaf	globoid	green	present	TP, LV VI/ VIII.2013	6T
Lantana camara	*Neolasioptera* sp. (Cecidomyiidae)	stem	fusiform	green,	absent	BU, LV, TP IV/ VI/VIII. 2013	-

Other gall dwellers were found in 39 morphotypes (25.5%) (Table 3). They comprised parasitoids, inquilines (phytophagous insects that occupy galls when they are still being used by gallers), and successors. The first were the most frequent dwellers being obtained from 29 gall morphotypes, and represented by seven families of Hymenoptera: Braconidae, Eulophidae, Eurytomidae, Ichneumonidae, Pteromalidae, Scelionidae, and Torymidae. Among these, the families Torymidae, Eurytomidae and Eulophidae predominated, being found in seven, seven and four gall morphotypes, respectively. The other families occurred in a single gall morphotype each. Four parasitoid genera were identified: *Eurytoma* Illiger, 1807 and *Rileya* Ashmead, 1888 (Eurytomidae), *Horismenus* Walker,1843 (Eulophidae), and *Platygaster* Latreille, 1809 (Platygastridae). The first two were associated with two galled plants each (*Inga edulis* and *Varronia curassavica*, and *Guarea kunthiana* and *Piper vicosanum*, respectively), whereas the other two genera had a single galled plant each. As inquilines we recorded Diptera (Sciaridae and Muscomorpha), Hemiptera and Lepidoptera in 13 gall morphotypes. Among these Hemiptera and Diptera were the most frequent, being observed in six and five plant species, respectively, followed by Lepidoptera obtained from three plant species. Two genera of Sciaridae were identified: *Corynoptera* Winnerty, 1867 and *Pterothrix* Mohrig, 2004. Sucessores included Psocoptera (Caeciliusidae), Formicidae and Acari (mites), obtained from four gall morphotypes. No predators were found.

Discussion

One hundred and fifty-three gall morphotypes were found in REBIO União. Only two previous Brazilian inventories have been performed in areas of Ombrophilous Forest, the first in Santa Teresa, Espírito Santo (Maia et al. 2014), and the second in Parque Nacional de Itatiaia (PNI), Southeast Brazil (Maia & Mascarenhas 2017). The authors recorded 265 and 406 gall morphotypes in these areas, respectively. The average number of morphotypes per plant species was 1.42 in REBIO União, compared to 1.87 in Santa Teresa and 2.18 in PNI. Although the total number of gall morphotypes and the average number of morphotypes per plant were lower in REBIO União, it is important to emphasize that periodicity of field work and the size of the sampling area were very different among these sites. Parque Nacional do Itatiaia was investigated from February 2014 to December 2015 with a total of 13 trails in Ombrophilous Forest physiognomy, while Santa Teresa was investigated for two years — seasonally during the first year and monthly during the second year — and included surveys of three protected areas: Parque Natural Municipal São Lourenço (with a single trail), Estação Biológica de Santa Lúcia (with three trails), and Reserva Biológica Augusto Ruschi (single trail). Therefore, the sampling effort was higher in PNI and Santa Teresa than in REBIO União, which could have influenced the present results. The Sorensen´s index revealed little similarlity among these three areas both in terms of host plant species

(REBIO União X PNI = 0.05; REBIO União X Santa Teresa = 0.04; PNI X Santa Teresa = 0.03) and insect gall morphotypes (REBIO União X Santa Teresa = 0.06; REBIO União X PNI = 0.05; PNI X Santa Teresa = 0.03). Since these areas exhibited few galled plant species in common, the same was expected with respect to gall morphotypes due the galler specificity.

The botanical families with the greatest gall richness in REBIO União were Asteraceae, Bignoniaceae, Fabaceae, and Myrtaceae. All have been previously indicated as superhosts by other Brazilian Ombrophilous Forest inventories except Bignoniaceae. Asteraceae, Fabaceae, and Myrtaceae are three of the ten most speciose families of the Atlantic Forest (Jardim Botânico do Rio de Janeiro 2016), adding evidence in support of the plant species richness hypothesis, which predicts a positive correlation between galling insect richness and plant taxon (families or genera) size (Fernandes 1992).

Mikania (Asteraceae) and *Myrcia* (Myrtaceae) were the plant genera with the greatest richness of galls in REBIO União. Both were previously highligthed as superhosts in Santa Teresa and PNI. The former contains 450 species (Holmes 1996), 171 of which are recorded for Brazil (King & Robinson 1987), while the latter contains 753 species (Govaerts *et al.* 2015), with 282 recorded in Brazil (Flora do Brasil 2018). Their great species richness may be related to their great gall richness, again adding evidence in support of the taxon size hypothesis (Fernandes 1992).

Table 3. Host plant species, gallers, gall characterization and associated fauna in Reserva Biológica União (state of Rio de Janeiro, Brazil). 1. Parasitoid, 2.Inquiline, 3. Successor.

Host plant species	Galler	Gall characterization				Associated fauna
		Galled organ	Shape	Color	Trichomes	
Mikania gleasonii	*Asphondylia* sp. (Cecidomyiidae)	leaf vein	globoid	green	absent	*Platygaster* sp.[1] (Platygastridae, Hymenoptera)
Mikania sp.3	*Asphondylia* sp. (Cecidomyiidae)	leaf vein	globoid	green	absent	Hymenoptera[1]
Mikania sp.4	Lasiopteridi (Cecidomyiidae)	stem	fusiform	brown	absent	Hymenoptera[1]
Mansoa sp.	Neolasioptera sp. (Cecidomyiidae)	stem leaf vein	fusiform	green brown	absent	Torymidae[1] (Hymenoptera)
Varronia curassavica	*Cordiamyia globosa* Maia, 1996 (Cecidomyiidae)	leaf	globoid	green	present	Hymenoptera[1] Muscomorpha[2] Lepidoptera[2]
Varronia curassavica	Lepidoptera	leaf vein	fusiform	green	present	Hymenoptera[1] Caeciliusidae[3] (Psocoptera)
Boraginaceae (not det.)	Cecidomyiidae	bud	globoid	green brown	absent	*Eurytoma* sp.[1] (Eurytomidae) Eulophidae[1] Torymidae[1] (Hymenoptera)
Boraginaceae (not det.)	Cecidomyiidae	bud	globoid	green	present	Hymenoptera[1]
Ipomoea sp.	Cecidomyiidae	stem	fusiform	green brown	absent	Hymenoptera[1]
Dodecastigma sp.	not det.	stem petiole leaf vein	globoid	brown,	absent	Hymenoptera[1] Hemiptera[2]
Euphorbiaceae (not det.)	not det.	stem	fusiform	brown	absent	Braconidae[1] (Hymenoptera)
Inga capitata	Cecidomyiidae	stem.	fusiform	brown	absent	Hymenoptera[1]
Inga edulis	Cecidomyiidae	leaf vein	fusiform	green	absent	*Eurytoma* sp.[1] (Eurytomidae, Hymenoptera)
Martiodendron sp.	Schizomyiina (Cecidomyiidae)	stem	conical	reddish green	present	Sciaridae[2] (Diptera)
Myroxylon peruiferum	not det.	leaf	lenticular	greenishyellow	absent	Lepidoptera[2]
Senegalia serra	not det.	petiole	globoid	brown	absent	Pteromalidae[1] (Hymenoptera)
Aegiphila integrifolia	not det.	leaf	globoid	green	absent	Hemiptera[2]

continuation...

Ocotea sp.	not det.	leaf vein	fusiform	green	absent	Caeciliusidae[3] (Psocoptera)
Lecythis pisonis	Lasiopteridi (Cecidomyiidae)	leaf	globoid	brown	absent	Lepidoptera[2]
Miconia prasina	Cecidomyiidae	leaf vein	fusiform or globoid	greenish-yellow	absent	Hymenoptera[1]
Miconia pusilliflora	Cecidomyiidae.	stem, bud, leaf3	globoid	green	absent	Torymidae[1] (Hymenoptera) Hymenoptera[1]
Miconia pusilliflora	not det.	leaf vein	globoid	green or brown	absent	Eurytomidae[1] (Hymenoptera)
Guarea kunthiana	Cecidomyiidae. Associated fauna:	leaf vein	fusiform	green	absent	Rileya sp.[1] (Eurytomidae) Eulophidae[1] Torymidae[1] (Hymenoptera)
Guarea kunthiana	Cecidomyiidae	leaf	lenticular	green	absent	Hymenoptera[1]
Myrcia splendens	Cecidomyiidae	leaf vein	globoid	green or brown	absent	Hymenoptera[1]
Myrcia splendens	Cecidomyiidae	leaf	marginal roll	green	absent	Hymenoptera[1] Formicidae[3]
Myrcia sp.	Lasiopteridi (Cecidomyiidae)	leaf	globoid	green	absent	Torymidae[1] (Hymenoptera) Hemiptera[2]
Psidium guineense	Hymenoptera	stem	globoid	green or brown	absent	Hymenoptera[1] Sciaridae[2] (Diptera) Lepidoptera[2]
Piper tuberculatum	Cecidomyiidae	leaf	globoid	green	absent	Eurytomidae[1] (Hymenoptera)
Piper vicosanum[2]	*Zalepidota* sp. (Cecidomyiidae)	bud	globoid	yellow or brown	absent	Rileya sp.[1] (Eurytomidae) Torymidae sp.1[1] Torymidae sp. 2[1] Lepidoptera[2]
Piperaceae (not det.)	not det.	leaf	conical	hairy	present	Sciaridae[2] (Diptera)
Diodia sp.	Cecidomyiidae	stem	fusiform	green	absent	Ichneumonidae[1] (Hymenoptera)
Cupania racemosa	Cecidomyiidae.	leaf vein	fusiform,	green	absent	Hemiptera[2]
Siparuna guianensis	*Bruggmanniella* sp. (Cecidomyiidae)	stem	fusiform	green	absent	Eulophidae[1] (Hymenoptera)
Solanum campaniforme	*Clinodiplosis* sp. (Cecidomyiidae)	leaf vein petiole	globoid	green	absent	Eulophidae[1] (Hymenoptera Hemiptera[2] mites[3]
Solanum sp.	Cecidomyiidae	stem	fusiform	brown	absent	Hymenoptera[1]
Lantana camara	*Schismatodiplosis lantanae* Rübsaamen, 1907 (Cecidomyiidae)	leaf	globoid	green	present	Hemiptera[2]
Lantana camara	*Neolasioptera* sp. (Cecidomyiidae)	stem	fusiform	green,	absent	Scelionidae[1] Torymidae[1] (Hymenoptera) Sciaridae[2] (Diptera)

Most host plant species were native, and together they hosted more than 90% of the gall morphotypes. We expect that the gallers that are associated with these plants are also native, based on high host specificity.

In concordance with other Brazilian inventories in areas of Ombrophilous Forest, leaves were the most galled plant organ in REBIO União, which can be explained by the fact that leaves represent an abundant and common resource (Maia 2001). There was a predominance of globoid and fusiform galls at REBIO União, as was the case for Santa Teresa and PNI. Furthermore, most leaf galls were globoid, whereas most stem and vein galls were fusiform. These shapes are also highligthed in other Atlantic Forest physiognomies, such as Restinga (Maia 2001) and Tableland Forest (Maia & Carvalho-Fernandes 2016). According to Isaias et al. (2013), the high frequency of these shapes is related to the patterns of cell growth and differentiation of these plant organs. Most galls were glabrous, as in all other Brazilian inventories (Maia & Mascarenhas 2017). According to Inbar et al. 2010, trichomes can act as structural defenses against loss of water or against predators and parasitoids, as they impair their feeding and mobility. As the REBIO União is a mesic environment, and the frequency of parasitism was low, the presence of trichomes appears to be unnecessary. Green and brown galls predominated, being the same colors of the most frequent galled plant organs, leaves and stems, respectively, whereas yellow, red and purple galls were rare. Inbar et al. 2010 proposed that galls that exhibit a combination of high levels of defensive compounds with conspicuousness — size, shape, bright coloration and possibly odor — are aposematic. Galls are manipulated by gallers to form all the components of aposematism (chemical defenses and warning coloration or odor). The components of the aposematic phenotype are expressed externally in the gall tissue, protecting the galling insects and not the host plant that produces them, as the hosts have no interest in protecting their parasites. Advertisement of chemically-defended galls may reduce predation by mammalian herbivores, avian insectivores and frugivores and various arthropods. In contrast, galls that exhibit the same color of the host organ are cryptic and probably poor in chemical defenses. Cryptic coloration can also protect the galler against predation. In REBIO União, 57 plant species have been recorded as food sources for the golden-lion tamarin (*Leontopithecus rosalia* Linnaeus, 1766). Four of these plant species are known to host galls — *Inga edulis*, *Myrcia* sp., *Pourouma* sp., and *Simarouba amara* (Lapenta 2002) — all of which are cryptic, except for one morphotype on *Myrcia* sp., which is reddish. We observed color change in a single gall morphotype, which changed from green to yellow. According to Stone et al. 2002, some galls may change color during their development in association with exposure to light or plant defenses.

In the present study, the highest gall richness was recorded in June and August, the period when most plants are sprouting, which increases the availability of oviposition sites since new tissues have high differentiation capacity and plasticity (Gonçalves et al. 2005, Rohfritsch 1992).

We noticed that the longer trails had higher gall richness, while shorter trails had lower gall richness, indicating that the gall richness is positively related to trail length. This is probably a result of the longer paths encompassing a greater number of plant species and, consequently, a greater number of possible hosts. The Sorensen `s index revealed little similarity among the studied trails, so each contributes to the gall richness of REBIO União.

We recorded gallers of five orders: Diptera (Cecidomyiidae), Lepidoptera, Hymenoptera, Hemiptera, and Thysanoptera. Thus, all galling insect orders were represented at REBIO União with the exception of Coleoptera. Maia et al. 2014 and Maia & Mascarenhas 2017 found galls induced by other insect taxa in their inventories of Ombrophilous Forest, such as Tephritidae (Diptera) and Coleoptera. Cecidomyiidae were the most frequent gallers at REBIO União, following a global pattern. As several galls were found empty, parasitized or occupied by more than one insect taxon, we could not determined their gallers.

Among the gallers, *Alycaulus globulus* Gagné, 2001, *Arrabiadaeamyia serrata* Maia, 2001, *Asphondylia cfr. cordiae* Möhn, 1959, *Brugmannia robusta* Maia and Couri, 1993, *Cordiamyia globosa* Maia, 1996, *Dasineura byrsonimae* Maia, 2010, *Liodiplosis conica* Gagné, 2001, and *Schismatodiplosis lantanae* Rübsaamen, 1908 were recorded for the first time in REBIO União, thus expanding their known distribution. *Alycaulus globulus, Cordiamyia globosa*, *Liodiplosis conica* and *Schismatodiplosis lantanae* had been previously recorded from Ombrophilous Forest (Gagné et al. 2001, Maia et al. 2014, Maia & Mascarenhas 2017, Proença & Maia 2014), while *Asphondylia cfr. cordiae*, *Brugmannia robusta* and *Dasineura byrsonimae* were previously recorded from Restinga and Tableland Forest (Maia & Silva 2016, Maia & Carvalho-Fernandes 2016), and *Arrabiadaeamyia serrata* from just Restinga. So, the last four species were recorded for the first time in Ombrophilous Forest.

At least seven genera of gall midges were recorded in REBIO União in the present study, with those of the genera *Asphondylia* and *Neolasioptera* being the most diverse. These genera have been recorded in other Brazilian inventories, in restingas of the states of Rio de Janeiro and São Paulo (Maia 2001, Oliveira & Maia 2005, Maia & Oliveira 2010, Monteiro et al. 1994, 2004, Maia et al. 2008), in Ombrophilous Forest in Southeast Brazil (Maia & Mascarenhas 2017) and in Cerrado in Minas Gerais (Maia & Fernandes 2004), which is evidence of their adaptability to different environmental conditions.

The present study provided new data on insect-plant interactions, including: *Asphondylia* on *Mikania gleasonii* (Asteraceae) and *Pyrostegia* (Bignoniaceae); *Neolasioptera* on *Anemopaegma chamberlaynii*, *Lundia* and *Mansoa* (Bignoniaceae); *Bruggmanniella* on Siparunaceae; *Clinodiplosis on Davilla rugosa* (Dilleniaceae) and *Solanum campaniforme* (Solanaceae); and *Lopesia* on Salicaceae. These new data reinforce the importance of inventories.

About 25% of the gall morphotypes were occupied by dwellers other than those that created the gall. This rate is similar to that recorded in PNI (27.5%), but lower than the rates recorded for areas of restinga (50% in Bertioga, in the state of São Paulo; 56% in Maricá + Carapebus in the state of Rio de Janeiro; 40% in Mangaratiba also in the state of Rio de Janeiro). This finding is probably due to the harsh abiotic conditions of restingas, which include intense lumination and strong winds, which could favor gall formation and occupation as a protective strategy.

Parasitoids, being represented by seven families of Hymenoptera, were more frequent and diverse than inquilines and successors. Parasitoids were also reported in all other Brazilian inventories of insect galls as predominant. They are considered the main natural enemies of galling insects, and play an importan role in their populational control (La Salle 1993). These families of Hymenoptera have all previously been reported by Brazilian inventories of insect galls, among which Torymidae, Eurytomidae and Eulophidae are the most frequent families (Maia & Azevedo 2009).

Inquilines included Diptera (Sciaridae and Muscomorpha), Hemiptera and Lepidoptera, all of which have aready been recorded in other Brazilian inventories. Nevertheless, few records of inquilinous Sciaridae and Muscomorpha are known (Maia & Fernandes 2004, Maia et al. 2008, Maia et al. 2014, Rodrigues et al. 2014). Among Sciaridae, we identified two genera, *Corynoptera* Winnerty, 1867 and *Pterothrix* Mohrig, 2004, both reported for the first time as gall inquilines. The records of Sciaridae on *Martiodendron* sp. (Fabaceae), *Psidium guianeense* (Myrtaceae) and *Lantana camara* (Verbenaceae) are also new. Muscomorpha were reported for the first time on *Varronia curassavica* (Boraginaceae). Hemiptera and Lepidoptera are frequent inquilines, having been associated with several plants in Brazil, but the records of Hemiptera on *Dodecastigma* (Euphorbiaceae), *Aegiphila integrifolia* (Lamiaceae), *Myrcia splendens* (Myrtaceae), *Cupania racemosa* (Rubiaceae), *Solanum campaniforme* (Solanaceae), and *Lantana camara* (Verbenaceae) are new, as well as the record of Lepidoptera on *Piper vicosanum* (Piperaceae).

Successors were represented by Psocoptera, Hymenoptera (Formicidae) and Acari, all previously recorded in galls. Nevertheless, new associations were observed, namely: Caeciliusidae (Psocoptera) on *Varronia curassavica* (Boraginaceae) and *Ocotea* sp. (Lauraceae); Formicidae (Hymenoptera) on *Myrcia splendens* (Myrtaceae); and Acari on *Solanum campaniforme* (Solanaceae).

Comparing the galled plants of the REBIO União with those of other Brazilian inventories in the Atlantic Forest, we verified that two genera (*Xylopia* L. and *Thunbergia* L.), and five species (*Dicliptera mucronifolia*, *Thunbergia alata*, *Mikania pilosa*, *Adenocalymma subsessilifolium* DC., and *Adenocalymma validum*) were reported for the first time as host plants.

Conclusions

The REBIO União hosts particular insect gall richness with several galls on endemic plants, which showed the importance of this protected area for the conservation of the galling guild. Asteraceae, Fabaceae and Myrtaceae were confirmed as plant families with the greatest gall richness in Ombrophilous Forest areas, while Bignoniaceae was added as a super host. The predominant features of galls of REBIO União were in agreement with the morphological pattern previously observed in Brazil. The geographical distribution of eight gall midge species were expanded and new data on insect-plant interactions were provided. The new records reinforce the importance of such inventories for improving the knowledge of galling guild richness and distribution in Brazil.

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Author Contributions

Valéria Cid Maia: Substancial contribution in the concept and design of the study, contribution to data collection, analysis, interpretation and manuscript preparation.

Eick de Souza Siqueira: contribution to data analysis and interpretation.

Conflicts of interest

The authors declare that they have no conflict of interest related to the publication of this manuscript.

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