

Original Article

Insect galls from the Botanical Garden of the Museu Nacional (Rio de Janeiro, RJ, Brazil)

Galhas de insetos do Horto Botânico do Museu Nacional (Rio de Janeiro, RJ, Brasil)

V. C. Maia^{a,b*} , B. Mascarenhas^a  and C. Koschnitzke^b 

^aUniversidade Federal do Rio de Janeiro – UFRJ, Museu Nacional, Departamento de Entomologia, Rio de Janeiro, RJ, Brasil

^bUniversidade Federal do Rio de Janeiro – UFRJ, Museu Nacional, Departamento de Botânica, Rio de Janeiro, RJ, Brasil

Abstract

The Botanical Garden of the Museu Nacional/Universidade Federal do Rio de Janeiro (Rio de Janeiro, RJ, Brazil) was investigated monthly from October, 2017 to December, 2019 in a total of 27 collections, each lasting four hours, following the methodology of random walking. Vegetative and reproductive organs of herbs, bushes and trees (up to 2 m high) were examined by two people. Voucher material was deposited in the Entomological Collection of the Museu Nacional (MNRJ)/Universidade Federal do Rio de Janeiro. We found 13 insect gall morphotypes in nine host plant species of four families. All host plants are native of Brazil, except *Ficus microcarpa* L.f. (Moraceae), which is naturalized. Myrtaceae and Moraceae were the plant families with the greatest richness of gall morphotypes. *Eugenia* L. (Myrtaceae) and *Ficus* L. (Moraceae) were the plant genera with the highest number of gall morphotypes. In several inventories in the Atlantic forest, Myrtaceae and *Eugenia* stand out for harboring a great variety of galls, while Moraceae and *Ficus* were never stood out for this reason. Most plant species mentioned in the present study were already known as hosts of gall-inducing insects in Brazil. However, for the first time, insect galls are reported on *Ficus crocata* (Miq.) Miq. (Moraceae). We found two new morphotypes on *Eugenia florida* DC. (Myrtaceae). Leaves, stems and buds were the galled organs. Cecidomyiidae were the most frequent inducers. Galls of Thysanoptera were also found. Inquilines were observed in leaf galls on *Eugenia florida*. They promoted differences in gall morphology and killed the gall-inducing larva.

Keywords: Cecidomyiidae, gall-inducers, host plants, insect-plant interaction, Thysanoptera.

Resumo

O Horto Botânico do Museu Nacional/Universidade Federal do Rio de Janeiro (Rio de Janeiro, RJ, Brasil) foi investigado mensalmente de outubro, 2017 a dezembro, 2019 em busca de galhas de insetos. O material-testemunha foi depositado na Coleção de Entomologia do Museu Nacional (MNRJ)/Universidade Federal do Rio de Janeiro. Nós encontramos 13 morfotipos de galhas de insetos em nove espécies de plantas hospedeiras de quatro famílias. Todas as plantas hospedeiras são nativas do Brasil, exceto *Ficus microcarpa* L.f. (Moraceae), que é naturalizada. Myrtaceae e Moraceae foram as famílias vegetais com a maior riqueza de morfotipos de galhas. *Eugenia* L. (Myrtaceae) e *Ficus* L. (Moraceae) foram os gêneros com maior número de morfotipos de galhas. Em vários inventários na Mata Atlântica, Myrtaceae e *Eugenia* destacam-se por apresentar uma grande variedade de galhas, enquanto Moraceae e *Ficus* nunca se destacaram por tal razão. A maioria das plantas mencionadas no presente estudo já eram conhecidas como hospedeiras de insetos galhadores no Brasil. Contudo, esta é a primeira vez que galhas de insetos são registradas em *Ficus crocata* (Miq.) Miq. (Moraceae). Nós encontramos dois novos morfotipos de galhas em *Eugenia florida* DC. (Myrtaceae). Folhas, caules e gemas foram os órgãos hospedeiros de galhas. Cecidomyiidae foram os indutores mais frequentes. Galhas de Thysanoptera também foram encontradas. Nós identificamos cinco espécies cecidógenas, três pertencentes a Cecidomyiidae (Diptera) e duas a Thysanoptera. Inquilinos foram observados em galhas foliares em *Eugenia florida*. Eles promoveram diferenças na morfologia da galha e mataram a larva indutora.

Palavras-chave: Cecidomyiidae, indutores de galhas, plantas hospedeiras, interação inseto-planta, Thysanoptera.

1. Introduction

Several inventories of insect galls were performed in areas of the Atlantic forest, especially in the State of Rio de Janeiro (Maia and Siqueira, 2020). However, the knowledge is concentrated in some localities. Of the 92 municipalities of the State, only 26 have insect gall records (Maia, 2021a), and systematic inventories were performed in 15 of them.

Of the others 11, there are some scattered records. In the municipality of Rio de Janeiro, systematic inventories were carried out only in the Municipal Natural Park of Grumari (Oliveira and Maia, 2005) and in the *Restinga* of Marambaia in Barra de Guaratiba (Maia and Silva, 2016). Nevertheless, this municipality harbors one national park (ICMBIO, 2023),

*e-mail: maiavid@acd.ufrj.br

Received: October 16, 2023 – Accepted: December 26, 2023



This is an Open Access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

five state parks (INEA, 2023), and more than 20 municipal parks (Rio de Janeiro, 2023). So the richness of insect galls is still less known, due to the lack of local studies.

The Botanical Garden of the Museu Nacional/Universidade Federal do Rio de Janeiro is completely inserted in the Atlantic forest domain. It is located within the Quinta da Boa Vista Park (22° 54' 12.59" S and 43° 13' 16.80") (Figure 1), which is one of the largest urban parks in the municipality of Rio de Janeiro (RJ, Brazil) (Riotur, 2023). The Botanical Garden of the Museu Nacional has a green area with ca. 20,000 m², where plants of several Brazilian ecosystems as well as exotic are found. It harbors 40 identified species of trees and shrubs, and six species of herbs. Among the former, *Ficus* L. (Moraceae) and *Eugenia* L. (Myrtaceae) are the best represented genera (UFRJ, 2023). This area is a refuge of biodiversity, conservation and scientific research. Some insect galls were observed in this area, however they are not reported in the literature. The main objective of this study is to inventory the insect galls from this area and identify their inducers in order to know which gall-inducing species were able to colonize this small green spot located in an urban environment.

2. Material and Methods

The vegetation of the Botanical Garden of the Museu Nacional (Figure 2) was investigated monthly from October, 2017 to December, 2019 by VCM and BM. We adopted the methodology of random walking (Julião et al., 2002). Each visit to the site lasted four hours. Herbs, bushes and trees (up to 2 m high) were examined. Leaves, buds, stems, tendrils, aerial roots, flowers, bud flowers, and fruits were investigated for galls.

All host plants and galls were photographed. Galled branches were collected, packed and transported in labelled plastic bags to the laboratory, where galls were morphotyped. Each morphotype was characterized by host organ, shape, color, presence/absence of trichomes, and number of internal chamber, according to Isaias et al. (2014), and separated from one to another. Samples of each gall morphotype were dissected under a stereomicroscope in order to obtain immature stages of the gall-inducing species. Other samples were kept in plastic pots padded with paper towel, covered by organza at room temperature, in order to obtain adults. These pots were examined every day (except weekends) for emergence.

Whenever adults were observed, these pots were kept for few minutes in the refrigerator to provoke their lethargy. Then, adults were collected with a wet brush, placed in a labeled microvial with 70% ethanol and later identified by the VCM at the lowest possible taxonomic level. Specimens of Cecidomyiidae were prepared and mounted on microscope slides by VCM, following the methods outlined in Gagné (1994). The gall-inducers identification was based on insect morphology, gall morphology and host plant species. Voucher material was deposited in the Entomological Collection of the Museu Nacional (MNRJ)/Universidade Federal do Rio de Janeiro. Plant species were identified by CK and their origin was verified in Flora e Funga do Brasil website (JBRJ, 2023).

3. Results and Discussion

We found 13 insect gall morphotypes in nine host plant species of four families (Table 1, Figures 3-17). All host plants are native of Brazil, except *Ficus microcarpa* L.f. (Moraceae), which is naturalized (Pederneiras et al., 2023). Among native species, *Ficus enormis* Mart ex. Miq is endemic to Brazil and harbors one gall morphotype induced by Cecidomyiidae (Diptera). Considering the species-specificity of the gall-inducing insects, we can state that this gall midge species is endemic too. Therefore, the Botanical Garden of the Museu Nacional is home to one endemic cecidogenous species that was not yet been undescribed.

Myrtaceae were the plant family with the greatest richness of gall morphotypes (n=6), followed by Moraceae (n=4) (Table 1), while *Eugenia* L. (Myrtaceae) and *Ficus* L. (Moraceae) were the botanical genera with the highest number of gall morphotypes (n=5 and n=4, respectively). In several inventories in the Atlantic forest, Myrtaceae and *Eugenia* stood out for harboring a great variety of galls (Maia, 2019; Carvalho-Fernandes et al., 2016; Maia and Souza, 2013; Rodrigues et al., 2014), while Moraceae and *Ficus* were never stood out for this reason.



1



2

Figures 1-2. Study area: 1. Quinta da Boa Vista Park (Rio de Janeiro, RJ, Brazil); 2. The Botanical Garden of the Museu Nacional.

Table 1. Insect galls from the Botanical Garden of the Museu Nacional (Rio de Janeiro, RJ, Brazil).

Family	Species	Gall characterization	Gall-inducer
Fabaceae	<i>Adenantha peregrina</i> (L.) Speg.	On leaf/globoid/brown/glabrous/one-chambered (no figure)	Cecidomyiidae (Diptera)
	<i>Machaerium</i> sp.	On bud and leaf/globoid/green (brown when deiscent)/with trichomes/one-chambered (Figure 3)	Cecidomyiidae
Moraceae	<i>Ficus crocata</i> (Miq.) Miq.	On leaf/lenticular/yellow/glabrous/one-chambered (Figure 4)	Cecidomyiidae
		On leaf/globoid/green (brown when deiscent)/with few trichomes/one-chambered (Figure 5)	Cecidomyiidae
	<i>Ficus enormis</i> Mart ex. Miq.	On leaf/lenticular/yellowish/glabrous/one-chambered (Figure 6)	Cecidomyiidae
	<i>Ficus microcarpa</i> L.f.	On leaf/fold/green/glabrous/one-chambered (Figure 7)	<i>Gnaikothrips ficorum</i> (Marchal, 1908) (Thysanoptera)
Myrtaceae	<i>Eugenia florida</i> DC.	On leaf/conical/green/glabrous/one to three-chambered (Figures 8-11)	<i>Bruggmannia</i> sp. (Cecidomyiidae)
		On stem/fusiform/brown/glabrous/one-chambered (Figure 12)	Cecidomyiidae
	<i>Eugenia uniflora</i> L.	On leaf/globoid/whitish/glabrous/one-chambered/spongy (Figure 13)	<i>Maiamyia dispar</i> (Maia, Mendonça and Romanowski, 1997) (Cecidomyiidae)
		On leaf/lenticular/green, yellow or reddish/glabrous/one-chambered (Figure 14)	<i>Neolasioptera eugeniae</i> Maia, 1993 (Cecidomyiidae)
		On leaf/conical/green/glabrous/one-chambered (Figure 15)	<i>Clinodiplosis profusa</i> Maia, 2001 (Cecidomyiidae)
	<i>Myrcia selloi</i> (Spreng.) N.Silveira	Bud gall/amorphous/reddish or green/glabrous (Figure 16)	<i>Holopothrips acrioris</i> Lindner, Ferrari, Mound and Cavalleri, 2018 (Thysanoptera)
Sapindaceae	<i>Serjania</i> sp.	On leaf vein/fusiform/green/glabrous/one-chambered (Figure 17)	Muscomorpha (Diptera)

Most plant species mentioned in the present study were already known as hosts of gall-inducing insects in Brazil. However, for the first time, insect galls are reported on *Ficus crocata* (Miq.) Miq. (Moraceae). The native range of this species is Mexico to Tropical America. In Brazil, it occurs in all phytogeographic domains and states (POWO, 2023).

We found six gall morphotypes which are previous known from Brazil. Nevertheless, the morphotypes on *Adenantha peregrina* (L.) Speg. (Fabaceae) (n=1), *Ficus enormis* Mart ex. Miq. (Moraceae) (n=1) and *Myrcia selloi* (Spreng.) N. Silveira (Myrtaceae) (n=1) are reported for the first time in the State of Rio de Janeiro. Furthermore, we found two new gall morphotypes on *Eugenia florida* DC. (Myrtaceae). Luz et al. (2012) described three other leaf galls on this plant in Minas Gerais.

Although insect galls are previously known on some species of *Machaerium* Pers. (Fabaceae) and *Serjania* Mill. (Sapindaceae), the lack of morphological information about the gall-inducer does not allow us to determine whether it is the same species.

The gall induced by *Gnaikothrips ficorum* (Marchal, 1908) (Thysanoptera) on *Ficus microcarpa* L.f. (Moraceae) has the widest geographic distribution among the

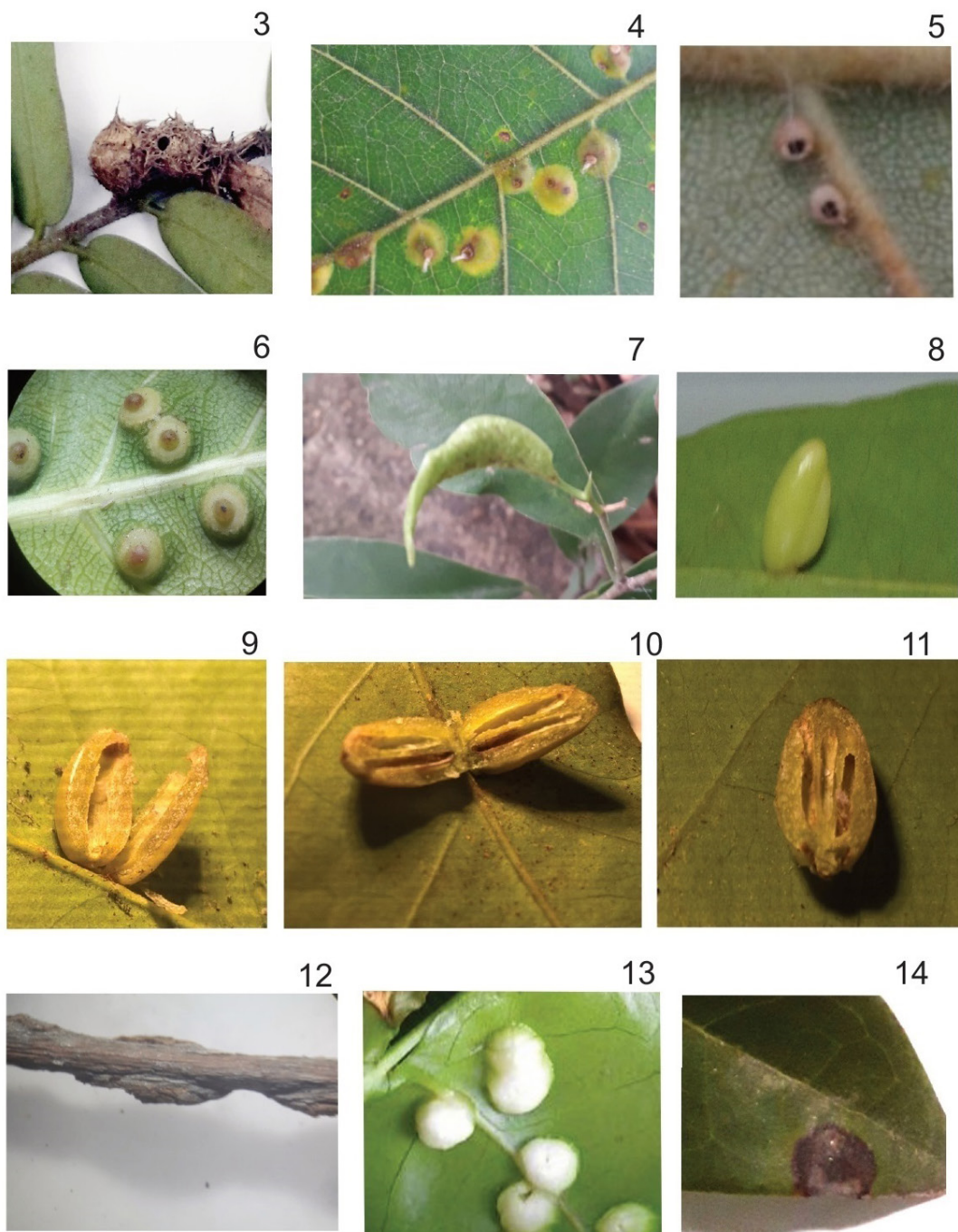
reported galls. It occurs in all zoogeographic regions (Mound and Marullo, 1996). Although the host plant is native of Asia, it was introduced to several areas of the world as it is ornamental.

In the Table 2, we showed data on the geographic distribution of all gall morphotypes reported in the present study in Brazil.

Leaves, stems and buds were the galled organs. However, leaf galls were the most common as they are throughout the world (Felt, 1940). According to Maia (2001), this pattern can be explained because leaves are an abundant and constant resource. Castro et al. (2012) argued that the greater incidence of leaf galls reflects higher levels of nutritional reserves in the leaves, and Isaias et al. (2013) added that leaves are more plastic host organs than stems. We did not find galls on reproductive plant organs. In fact, records of galls on flowers and fruits are rare in all Brazilian inventories, probably because galled and non-galled reproductive organs are externally similar to each other. In addition to being less conspicuous, these galls are also less frequent, since their temporal occurrence is restricted to the period of flowering and fruiting of their host plants.

Cecidomyiidae were the most frequent inducers. Galls of Thysanoptera were also found. We did not find galls of Hemiptera, Coleoptera, Lepidoptera or Hymenoptera. Nevertheless, galls of Hemiptera are the second most frequent in the Neotropical region (Houard, 1933).

We identified five species of Cecidomyiidae and two species of Thysanoptera. The other gall-inducers were identified in broader taxonomic categories due to insufficient material, since for specific identification of gall midges the morphology of the larva, pupa, male and female is necessary.



Figures 3-14. Insect galls from the Botanical Garden of the Museu Nacional, Rio de Janeiro (RJ, Brazil): 3. Deiscent bud galls on *Machaerium* sp. (Fabaceae); 4-7: Leaf galls on Moraceae: 4-5: On *Ficus crocata* (Miq.) Miq.; 4. Lenticular; 5. Globoid (deiscent); 6. Leaf gall on *Ficus enormis* Mart ex. Miq., 7. Leaf gall on *Ficus microcarpa* L.f.; 8-12. Galls on *Eugenia florida* DC. (Myrtaceae): 8-11. Leaf galls: 8. General aspect, 9-11: in longitudinal section: 9. One-chambered gall; 10. Two-chambered gall; 11. Three-chambered gall; 12. Stem galls; 13-14. Leaf galls on *Eugenia uniflora* L. (Myrtaceae): 13. Discoid; 14. Lenticular.

Table 2. Insect galls found in the Botanical Garden of the Museu Nacional (Rio de Janeiro, RJ, Brazil): previous records in Brazil with references and new records.

Host plant species	Previous and new records of insect galls
<i>Adenantha peregrina</i> (L.) Speg.	Same morphotype: Goiás: Santos et al. (2010) Mato Grosso do Sul: Urso-Guimarães et al. (2017), São Paulo: Urso-Guimarães and Scareli-Santos (2006) Rio de Janeiro: new record (presente study)
<i>Machaerium</i> sp.	Similar morphotypes: Minas Gerais: Fernandes et al. (1987) on <i>M. angustifolium</i> , Malves and Frieiro-Costa (2012) on <i>M. aculeatum</i> Raddi Rio de Janeiro: Maia et al. (2016) on <i>M. macaense</i> , Tavares (1916) on <i>Machaerium</i> sp. Santa Catarina: Rübbsaamen (1907) on <i>Machaerium</i> sp.
<i>Ficus enormis</i> Mart ex. Miq.	Same morphotype: São Paulo: Maia et al. (2008) Rio de Janeiro: new record (presente study)
<i>Ficus microcarpa</i> L.f.	Same morphotype: Amazonas, Pará, Bahia, Ceará, Pernambuco, Espírito Santo, Rio de Janeiro, São Paulo, Santa Catarina and Rio Grande do Sul: Lima (2023)
<i>Eugenia florida</i> DC.	Same morphotypes: no previous records Other gall morphotypes: Minas Gerais: Luz et al. (2012)
<i>Eugenia uniflora</i> L.	Same morphotypes: Gall of <i>Clinodiplosis profusa</i> Maia, 2001: Rio de Janeiro: Maia (2021a) Rio Grande do Sul: Goetz et al. (2018) Gall of <i>Maiamyia dispar</i> (Maia, Mendonça and Romanowski, 1997): Rio de Janeiro: Maia (2021a, b) São Paulo: Maia (2021a) Rio Grande do Sul: Maia (2021a) Gall of <i>Neolasioptera eugeniae</i> Maia, 1993: Minas Gerais: Maia (2021a) Espírito Santo: Maia (2021a) Rio de Janeiro Maia (2021a)
<i>Myrcia selloi</i> (Spreng.) N.Silveira	Same morphotype: Rio Grande do Sul: Lindner et al. (2018) First record in Rio de Janeiro
<i>Serjania</i> sp.	Similar gall morphotype: Southeastern Brazil: Maia and Mascarenhas (2017) on <i>S. glutinosa</i> Radlk. Minas Gerais: Fernandes et al. (2001) on <i>S. caracasana</i> (Jacq.) Willd., Maia (2013 and 2014) on <i>Serjania</i> sp. in Mato Grosso do Sul: Urso-Guimarães et al. (2017) on <i>Serjania</i> cf. <i>glabrata</i> Kunth., Julião et al. (2002) on <i>Serjania</i> sp. Rio de Janeiro: Rodrigues et al. (2014) on <i>Serjania</i> sp.

Secondary dwellers were observed in galls on leaves of *Eugenia florida*. These galls, induced by Cecidomyiidae, are invaded by Thysanoptera. Whenever this invasion occurs, the gall-inducing larva dies. Invaded galls are morphologically different from non-invaded galls (Figure 18), as the former are shorter and ovoid, while the latter are longer and conical. Several publications have reported gall invasion by thrips. Some species invade galls soon after the gall-inducer emerged as *Holopothrips chaconi* Zamora, Hanson and Mound, 2015 in Costa Rica (Zamora et al., 2015), a successor in galls of Cecidomyiidae on *Piper* (Piperaceae), but other species invade galls still occupied by the inducer as *Myrciathrips variabilis* Cavalleri, Lindner and Mendonça, 2016 (Cavalleri et al., 2016). Both species feed on gall tissues. The former has no negative effect on the inducer, while the later competes

for space and feeding resources. Additionally, *M. variabilis* promotes changes in structure and size of the gall, acting as a true inquiline (sensu Mani, 1964). Other thrips are predators that invade galls and feeds on the gall-inducer, as *Koptothrips* species (Varadarasan and Ananthakrishnan, 1981), while others, expel or kill the gall-inducer, as *Koptothrips* species, taking over the gall. As in *Eugenia florida*, the original morphology of the gall is modified by the presence of thrips, they can be considered true inquilines. Few records of true inquilines are known in Brazil. Maia (2022) reported some of them in areas of restinga, all represented by Hymenoptera.

Another interesting aspect of the leaf galls on *Eugenia florida* is the variation in the number of internal chambers (from one to three) (Figures 9-11), resulting from the fusion of galls at the beginning of formation.



Figures 15-18. Insect galls from the Botanical Garden of the Museu Nacional, Rio de Janeiro (RJ, Brazil): 15-16: on Myrtaceae: 15. Conical galls on *Eugenia uniflora* L.; 16. Bud gall on *Myrcia selloi* (Spreng.) N.Silveira; 17. Leaf gall on *Serjania* sp. (Sapindaceae); 18. Bud gall modified by inquiline on *Eugenia florida* DC. (Myrtaceae).

4. Conclusions

The Botanical Garden of the Museu Nacional harbors 13 insect gall morphotypes in nine host plant species of four families. All host plants are native of Brazil, except *Ficus microcarpa* L.f. (Moraceae), which is naturalized. Among them, one species is endemic to Brazil and hosts an undescribed gall midge species. Myrtaceae were the plant family with the greatest richness of gall morphotypes and *Eugenia* L. (Myrtaceae) was the super host genus. We presented the first records of insect galls on *Ficus crocata* (Miq.) Miq. (Moraceae) and two new gall morphotypes on *Eugenia florida* DC. (Myrtaceae). Leaf galls were the most common and Cecidomyiidae were the most frequent inducers as they are throughout the world. Inquiline (thrips) were found in galls on leaves of *Eugenia florida*. They promoted changes in structure and size of the gall and killed the gall-inducer. The present study adds new data to the knowledge of plant-insect interactions and tri-trophic relations involving plants, gall-inducing insects and secondary fauna.

Acknowledgements

VCM thanks Fundação de Amparo à Pesquisa do Estado do Rio de Janeiro (FAPERJ) (Process. E-26/2010.300/2021) for financial support.

References

CARVALHO-FERNANDES, S.P., ASCENDINO, S., MAIA, V.C. and COURI, M.S., 2016. Diversity of insect galls associated with coastal shrub vegetation in Rio de Janeiro, Brazil. *Anais da Academia Brasileira de Ciências*, vol. 88, no. 3, pp. 1407-1418. <http://dx.doi.org/10.1590/0001-3765201620150658>. PMID:27627066.

CASTRO, A.C., OLIVEIRA, D.C., MOREIRA, A.S.F.P., LEMOS-FILHO, J.P. and ISAIAS, R.M.S., 2012. Source-sink relationship and photosynthesis in the horn-shaped gall and its host plant *Copaifera langsdorffii* Desf.(Fabaceae). *South African Journal of Botany*, vol. 83, pp. 121-126. <http://dx.doi.org/10.1016/j.sajb.2012.08.007>.

CAVALLERI, A., LINDNER, M.F. and MENDONÇA JUNIOR, M.S., 2016. New Neotropical Haplithripini (Thysanoptera: Phlaeothripidae) with a key to Central and South American genera. *Journal of Natural History*, vol. 50, no. 21-22, pp. 1389-1410. <http://dx.doi.org/10.1080/00222933.2015.1113316>.

FELT, E.P., 1940. *Plant galls and gall makers*. Ithaca: Comstock Publishing Co., 364 p.

FERNANDES, G.W., JULIÃO, G.R., ARAÚJO, R.C., ARAÚJO, S.C., LOMBARDI, J.A., NEGREIROS, D. and CARNEIRO, M.A., 2001. Distribution and morphology of insect galls the Rio Doce Valley, Brazil. *Naturalia*, vol. 26, pp. 211-244.

FERNANDES, G.W., MARTINS, R.P. and NETO, E.T., 1987. Food web relationships involving *Anadiplosis* sp. galls (Diptera, Cecidomyiidae) on *Machaerium aculeatum* (LEGUMINOSAE). *Revista Brasileira de Botanica. Brazilian Journal of Botany*, vol. 10, pp. 117-123.

GAGNÉ, R.J., 1994. *The gall midges of the Neotropical region*. Ithaca: Cornell University Press, 352 p.

GOETZ, A.P.M., LUZ, F.A., TOMA, T.S.P. and MENDONÇA-JÚNIOR, M., 2018. Gall-inducing insects of deciduous and semideciduous forests in Rio Grande do Sul State, Brazil. *Iheringia. Série Zoologia*, vol. 108, e2018015. <http://dx.doi.org/10.1590/1678-4766e2018015>.

HOUARD, C., 1933. *Les Zooecidies des Plantes de l' Amerique du Sud et de l' Amerique Central*. Paris: Hermann & Cie, 549 p.

INSTITUTO CHICO MENDES DE CONSERVAÇÃO DA BIODIVERSIDADE – ICMBIO [online], 2023 [viewed 23 December 2023]. Available from: <http://www.icmbio.gov.br>

INSTITUTO NACIONAL DO AMBIENTE – INEA [online], 2023 [viewed 23 December 2023]. Available from: <https://www.inea.rj.gov.br>

- ISAIAS, R.M.S., CARNEIRO, R.G.S., OLIVEIRA, D.C. and SANTOS, J.C., 2013. Illustrated and annotated checklist of Brazilian gall morphotypes. *Neotropical Entomology*, vol. 42, no. 3, pp. 230-239. <http://dx.doi.org/10.1007/s13744-013-0115-7>. PMID:23949804.
- ISAIAS, R.M.S., OLIVEIRA, D.C., CARNEIRO, R.G.S. and KRAUS, J.E., 2014. Developmental anatomy of galls in the Neotropics: arthropods stimuli versus host plant constraints. In: G. FERNANDES and J. SANTOS, eds. *Neotropical insect galls*. Dordrecht: Springer, pp. 15-34.
- JARDIM BOTÂNICO DO RIO DE JANEIRO – JBRJ [online], 2023 [viewed 12 February 2023]. *Flora e funga do Brasil* [online]. Available from: <https://floradobrasil.jbrj.gov.br/FB8703>
- JULIÃO, G.R., AMARAL, M.E.C. and FERNANDES, G.W., 2002. Galhas de insetos e suas plantas hospedeiras no pantanal Sul-Mato-Grossense. *Naturalia*, vol. 24, pp. 47-74.
- LIMA, E.F.B., 2023 [viewed 23 December 2023]. Phlaeothripidae. In: JARDIM BOTÂNICO DO RIO DE JANEIRO – JBRJ. *Catálogo taxonômico da fauna do Brasil* [online]. Rio de Janeiro: JBRJ. Available from: <http://fauna.jbrj.gov.br/fauna/faunadobrasil/42682>
- LINDNER, M.F., FERRARI, A., MOUND, L.A. and CAVALLERI, A., 2018. *Holopothrips* diversity: a Neotropical genus of gall-inducing insects (Thysanoptera, Phlaeothripidae). *Zootaxa*, vol. 4494, no. 1, pp. 1-99. <http://dx.doi.org/10.11646/zootaxa.4494.1.1>. PMID:30313728.
- LUZ, G.R., FERNANDES, G.W. and SILVA, J.O., 2012. Galhas de insetos em habitats xérico e méxico em região de transição Cerrado-Caatinga no norte de Minas Gerais, Brasil. *Neotropical Biology and Conservation*, vol. 7, no. 3, pp. 171-187. <http://dx.doi.org/10.4013/nbc.2012.73.04>.
- MAIA, V.C. and MASCARENHAS, B., 2017. Insect galls of the Parque Nacional do Itatiaia (Southeast Region, Brazil). *Anais da Academia Brasileira de Ciências*, vol. 89, no. 1, suppl., pp. 505-575. <http://dx.doi.org/10.1590/0001-3765201720160877>. PMID:28562824.
- MAIA, V.C. and SILVA, L.O., 2016. Insect galls of restinga de Marambaia (Barra de Guaratiba, Rio de Janeiro, RJ). *Brazilian Journal of Biology = Revista Brasileira de Biologia*, vol. 76, no. 3, pp. 787-795. <http://dx.doi.org/10.1590/1519-6984.05314>. PMID:27097094.
- MAIA, V.C. and SIQUEIRA, E.S., 2020. Insect galls of the Reserva Biológica União, Rio de Janeiro, Brazil. *Biota Neotropica*, vol. 20, no. 1, e20190758. <http://dx.doi.org/10.1590/1676-0611-bn-2019-0758>.
- MAIA, V.C. and SOUZA, C.S., 2013. Insect galls of the xeric vegetation of Ilha do Cabo Frio (Arraial do Cabo, RJ, Brazil). *Biota Neotropica*, vol. 13, no. 3, pp. 278-288. <http://dx.doi.org/10.1590/S1676-06032013000300030>.
- MAIA, V.C., 2001. The gall midges (Diptera, Cecidomyiidae) from three restingas of Rio de Janeiro State, Brazil. *Revista Brasileira de Zoologia*, vol. 18, no. 2, pp. 305-656. <http://dx.doi.org/10.1590/S0101-81752001000200028>.
- MAIA, V.C., 2013. Insect galls of São Tomé das Letras (MG, Brazil). *Biota Neotropica*, vol. 13, no. 4, pp. 164-189. <http://dx.doi.org/10.1590/S1676-06032013000400017>.
- MAIA, V.C., 2014. Insect galls of Itamonte (Minas Gerais, Brazil): characterization and occurrence. *Biota Neotropica*, vol. 14, no. 1, pp. 1-17. <http://dx.doi.org/10.1590/S1676-06033839>.
- MAIA, V.C., 2019. Insect galls on Myrtaceae: richness and distribution in Brazilian restingas. *Biota Neotropica*, vol. 19, no. 1, e20180526.
- MAIA, V.C., 2021a. Cecidomyiidae (Diptera, Insecta): richness of species and distribution in Brazil. *Biota Neotropica*, vol. 21, no. 2, e20201038. <http://dx.doi.org/10.1590/1676-0611-bn-2020-1038>.
- MAIA, V.C., 2021b. New biological data on *Eugeniomyia dispar* (Diptera, Cecidomyiidae), a pest on *Eugenia uniflora* L. (Myrtaceae). *Biota Amazônia*, vol. 11, no. 1, pp. 17-21.
- MAIA, V.C., 2022. Review of the inquiline fauna associated with insect galls in Brazilian restingas. *Brazilian Journal of Biology = Revista Brasileira de Biologia*, vol. 82, e235395. <http://dx.doi.org/10.1590/1519-6984.235395>. PMID:34105660.
- MAIA, V.C., MAGENTA, M.A.G. and MARTINS, S.E., 2008. Ocorrência e caracterização de galhas de insetos em áreas de restinga de Bertioiga (São Paulo, Brasil). *Biota Neotropica*, vol. 8, no. 1, pp. 167-197. <http://dx.doi.org/10.1590/S1676-0603200800100020>.
- MAIA, V.C., WILSON, V.A.C. and MONTEIRO, R.F., 2016. A new species of *Machaerobia* Rubsaaenen, 1915 (Diptera, Cecidomyiidae) from Brazil. *Revista Brasileira de Entomologia*, vol. 60, no. 3, pp. 227-230. <http://dx.doi.org/10.1016/j.rbe.2016.05.002>.
- MALVES, K. and FRIEIRO-COSTA, F.A., 2012. List of plants with galls induced by insects from the UNILAVRAS/Boqueirão Biological Reserve, Ingaí, state of Minas Gerais, Brazil. *Check List*, vol. 8, no. 3, pp. 426-431. <http://dx.doi.org/10.15560/8.3.426>.
- MANI, M.S., 1964. *Ecology of plant galls*. The Hague: Dr. W. Junk, 434 p. <http://dx.doi.org/10.1007/978-94-017-6230-4>.
- MOUND, L.A. and MARULLO, R., 1996. The thrips of Central and South America: an introduction. *Memoirs on Entomology*, vol. 6, pp. 1-488.
- OLIVEIRA, J.C. and MAIA, V.C., 2005. Ocorrência e caracterização de galhas de insetos na restinga de Grumari (Rio de Janeiro, RJ, Brasil). *Archivos do Museu Nacional*, vol. 63, no. 4, pp. 669-676.
- PEDERNEIRAS, L.C., MACHADO, A.F.P. and SANTOS, O.D.A., 2023 [viewed 12 November 2023]. *Ficus*. In: JARDIM BOTÂNICO DO RIO DE JANEIRO – JBRJ. *Flora e funga do Brasil* [online]. Rio de Janeiro: JBRJ. Available from: <https://floradobrasil.jbrj.gov.br/FB594385>
- PLANTS OF THE WORLD ON LINE – POWO [online], 2023 [viewed 23 December 2023]. Available from: <https://powo.science.kew.org/>
- RIO DE JANEIRO. Fundação Parques e Jardins – FPJ, 2023 [viewed 23 December 2023]. *Parques urbanos* [online]. Available from: <https://www.rio.rj.gov.br/web/fpj/parques-urbanos>
- RIOTOR [online], 2023 [viewed 24 September 2023]. Available from: <https://riotur.io>
- RODRIGUES, A.R., MAIA, V.C. and COURI, M.S., 2014. Insect galls of restinga areas of Ilha da Marambaia, Rio de Janeiro, Brazil. *Revista Brasileira de Entomologia*, vol. 58, no. 2, pp. 173-197. <http://dx.doi.org/10.1590/S0085-56262014000200010>.
- RÜBSAAMEN, E.H., 1907. Beitrage zur Kenntnis aussereuropäischer Zoocedien. III. Beitrag: gallen aus Brasilien und Peru. *Marcellia*, vol. 6, pp. 110-173.
- SANTOS, B.B., FERREIRA, H.D. and ARAÚJO, W.S., 2010. Ocorrência e caracterização de galhas entomógenas em uma área de floresta estacional semidecídua em Goiânia, Goiás, Brasil. *Acta Botanica Brasílica*, vol. 24, no. 1, pp. 243-249. <http://dx.doi.org/10.1590/S0102-33062010000100026>.
- TAVARES, J.S., 1916. Cecidomyias novas do Brazil. *Brotéria. Série Zoológica*, vol. 14, pp. 36-57.
- UNIVERSIDADE FEDERAL DO RIO DE JANEIRO – UFRJ. Museu Nacional, 2023 [viewed 23 December 2023]. *Horto Botânico* [online]. Available from: <https://museunacional.ufrj.br/hortobotanico>
- URSO-GUIMARÃES, M.V. and SCARELI-SANTOS, C., 2006. Galls and gall-makers in plants from the Pé-de-Gigante Cerrado Reserve, Santa Rita do Passa Quatro, SP, Brazil. *Brazilian Journal of Biology = Revista Brasileira de Biologia*, vol. 66, no. 1B, pp. 357-369. <http://dx.doi.org/10.1590/S1519-69842006000200018>. PMID:16710528.
- URSO-GUIMARÃES, M.V., CASTELLO, A.C.D., KATAOKA, E.Y. and KOCH, I., 2017. Characterization of entomogen galls from Mato Grosso do Sul, Brazil. *Revista Brasileira de Entomologia*, vol. 61, no. 1, pp. 25-42. <http://dx.doi.org/10.1016/j.rbe.2016.08.002>.

- VARADARASAN, S.M. and ANANTHAKRISHNAN, T.N., 1981. Population dynamics and prey-predator/parasite relationships of gallforming thrips. *Proceedings of the Indian National Science Academy*, vol. 47, pp. 321-340.
- ZAMORA, S., HANSON, P. and MOUND, L.A., 2015. *Holopothrips chaconi* sp.n. (Thysanoptera: Phlaeothripinae) from leaf-vein galls on *Piper* species (Piperaceae) in Costa Rica. *Revista de Biología Tropical*, vol. 63, no. 4, pp. 1035-1042. <http://dx.doi.org/10.15517/rbt.v63i4.16787>.