



ECOSYSTEMS

Gall midges (Insecta, Diptera, Cecidomyiidae) associated with Clusiaceae in Brazil: richness and distribution

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Abstract: A literature compilation was done to gather information about Cecidomyiidae galls on Clusiaceae in Brazil. Botanical names were verified in the site “Flora do Brasil” as well as data on plant distribution and origin. Two herbaria were visited in order to examine galled specimens of Clusiaceae and retrieve new locality records. Thirteen gall morphotypes have been recorded on three genera (*Clusia*, *Garcinia*, and *Tovomita*) and eight species. *Clusia* showed the greatest number of galled species. *Tovomita brevistaminea* is the super host species. Only three gallers, *Parazalepidota clusiae*, *Clusiamyia granulosa* and *C. nitida*, were identified at species level, which highlights how the taxonomy of the gall midges is still poorly known. The examination of galled exsiccates resulted in the expansion of their distribution area. The low gall richness as well as the low number of galled plants on Clusiaceae can be related to the presence of resinous sticky sap and waxy cuticle. The known occurrence of gallers associated with Clusiaceae is restricted to the Atlantic Forest as their host plants. The gallers distribution is less wide than that of the host plants, indicating that their geographic limits can be further extended.

Key words: insect gall, host plant, insect-plant interaction, Atlantic Forest.

INTRODUCTION

Cecidomyiidae are one of the most speciose families of Diptera with more than 6,500 described species throughout the world (Gagné & Jaschhof 2017). Most are gall-inducers, being associated with several plant families. They are the most common gallers in all zoogeographic region and each species is generally monophagous. About 92% of Brazilian species are species-specific (Carneiro et al. 2009). Furthermore, each species induces a gall morphotype with peculiar shape, size, color, and indumentum (Isaias et al. 2013, 2014). This specificity allows that gall morphotype plus host plant species to be used as indicative of the galler's presence (Carneiro et al. 2009).

Clusiaceae Lindl. (Malpighiales) comprise 14 genera and about 800 species of predominantly tropical distribution (Stevens 2001). In Brazil, there are 11 genera and 131 species, of which 46 are endemic (BFG 2015). *Clusia* is the most diverse genus of Clusiaceae with about 300 species of predominantly Neotropical distribution, occurring from Central America to southern Brazil (Stevens 2001). In Brazil, the genus occurs in the Amazon Forest, Caatinga, Cerrado, and Atlantic Forest, being found in several types of vegetation, such as Campinarana, Altitude Fields, Rupestrian Fields, Gallery Forest, Floodplain (Várzea) Forest, Restinga and Amazonian Savana (BFG 2015).

In several Brazilian inventories, galls have been reported on Clusiaceae. Nevertheless, these records are scattered in literature, so the gall

richness on this plant family is not yet known as well as the distribution of gall midges associated with it.

Information on the geographic distribution of most galling insects is scarce and mostly limited to the localities where species were originally sampled (Gagné & Jaschhof 2014). This results in a Wallacean shortfall which affects most practical decisions about how to conserve biodiversity as they are taken at regional and even local scales (Whittaker et al. 2005).

The present work is the first attempt to gather and upgrade data on gall-inducing species associated with Clusiaceae. This paper aimed to answer the following questions - (1) how many cecidomyiid gall morphotypes have been recorded on Clusiaceae in Brazil? (2) which plant genera and species are the most galled? (3) what is known about the taxonomy of these gallers? and (4) what is known about their geographic distribution?

MATERIALS AND METHODS

A literature review was done using the most recent world catalog of Cecidomyiidae published by Gagné & Jaschhof 2017 as the first step. Based on this catalog, a list of gall midge species associated with Clusiaceae was elaborated. The next step was to verify the morphology of each gall in the papers with the original descriptions of the gallers. Then, botanical names were verified in the site “Flora do Brasil” in order to check their correct spelling and synonyms, as well as their geographic distribution in Brazil.

A search for articles was performed on the database Google Scholar using “Brazil”, “Clusiaceae”, “Guttiferae” (an old name for Clusiaceae) and “gall” as keywords in order to retrieve geographic records of the gallers and/or gall morphotypes. Phytogeographic domains

were verified based on the map of biomes of Brazil (IBGE 2004). Only host plants identified at species level were included in the present study.

Furthermore, new locality records were retrieved from galled exsiccates of two herbaria: R - Museu Nacional/UFRJ and RB - Jardim Botânico of Rio de Janeiro. Galled specimens were photographed, as well as their labels and gall morphotypes. New records were established by comparing literature and herbarium data. The geographic distribution of all gall-inducing species was updated.

RESULTS

Literature compilation

Thirteen gall morphotypes induced by Cecidomyiidae have been recorded on three genera and eight species of Clusiaceae in Brazil. The average number of gall morphotypes per species was 1.6. The host plant genera were *Clusia* L., *Garcinia* L., and *Tovomita* Aubl., the first genus showed the greatest number of galled species (n=5), followed by *Garcinia* and *Tovomita* (with two and one galled species, respectively). *Clusia* and *Tovomita* showed also the greatest richness of gall morphotypes, six and five, respectively, followed by *Garcinia* with two (Table I). The average number of gall morphotype per species was 1.0 in *Garcinia*, 1.2 in *Clusia*, and 5.0 in *Tovomita*. The last genus comprised a single galled species, *T. brevistaminea* Engl. which is indicated as super host, as it showed the highest richness of gall among the other species of Clusiaceae in Brazil.

Although 13 gall morphotypes have been recorded on Clusiaceae, only three gallers (about 23%) were identified at species level. The others records were presented at family level (Table I). Data on their geographic distribution is very scarce, being restricted to few localities (Table I).

All host plant species are native, four of them are endemic of Brazil, occurring exclusively in the

Table I. Galls induced by Cecidomyiidae (Diptera) on Clusiaceae in Brazil.

Host plant	Galler	Gall morphotype	Phytogeographic domain/ Locality	Reference
<i>Clusia insignis</i> Mart.	Cecidomyiidae	Globoid leaf gall	Amazon Forest/ PA: Oriximiná	Almada & Fernandes 2011
<i>Clusia fluminensis</i> Tr. & Pl.	<i>Parazalepidota clusiae</i>	Circular (=lenticular) gall leaf	Atlantic Forest/ RJ: Rio de Janeiro, Maricá, Parque Estadual da Costa do Sol (Arraial do Cabo and Saquarema)	Maia 2001, Oliveira & Maia 2005 Carvalho-Fernandes et al. 2016
<i>Clusia hilariana</i> Schlttdl.	<i>Clusiamyia granulosa</i>	Circular (=lenticular) leaf gall	Atlantic Forest/ RJ: Carapebus, Parque Nacional da Restinga de Jurubatiba, Parque Estadual da Costa do Sol (Arraial do Cabo, RJ) ES: Guarapari	Maia 2001 Monteiro et al. 2004 Bregonci et al. 2010 Carvalho-Fernandes et al. 2016
<i>Clusia lanceolata</i> Camb.	<i>Clusiamyia nitida</i>	Globose leaf gall	Atlantic Forest/ RJ: Maricá	Maia 2001
<i>Clusia nemorosa</i> G. Mey.	Cecidomyiidae	Discoid leaf gall	Atlantic Forest/ PE: Reserva Ecológica Mata de Duas Lagoas (Cabo de Santo Agostinho)	Santos et al. 2012
<i>Clusia nemorosa</i> G. Mey.	Cecidomyiidae	Globoid leaf gall	Atlantic Forest/ PE: Reserva Ecológica Mata de Duas Lagoas (Cabo de Santo Agostinho)	Santos et al. 2012
<i>Garcinia brasiliensis</i> Mart.*	Cecidomyiidae	Spheroid leaf gall	Amazon Forest/ PA: Oriximiná	Almada & Fernandes 2011
<i>Garcinia brasiliensis</i> Mart.*	Cecidomyiidae	Lenticular leaf gall	Cerrado/MS: Corumbá	Julião et al. 2002
<i>Tovomita brevistaminea</i> Engl.	Cecidomyiidae	Spherical leaf gall	Atlantic Forest/ PE: Reserva Ecológica de Saltinho (Tamandaré)	Santos et al. 2012
<i>Tovomita brevistaminea</i> Engl.	Cecidomyiidae	Globoid leaf gall	Reserva Ecológica de Saltinho (Tamandaré, PE)/Atlantic Forest	Santos et al. 2012
<i>Tovomita brevistaminea</i> Engl.	Cecidomyiidae	Conical leaf gall	Atlantic Forest/ PE: Reserva Ecológica de Saltinho (Tamandaré)	Santos et al. 2012
<i>Tovomita brevistaminea</i> Engl.	Cecidomyiidae	Elliptical leaf gall	Atlantic Forest/ PE: Reserva Ecológica de Saltinho (Tamandaré)	Santos et al. 2012
<i>Tovomita brevistaminea</i> Engl.	Cecidomyiidae	Globoid stem gall	Atlantic Forest/ PE: Reserva Ecológica de Saltinho (Tamandaré)	Santos et al. 2012

*In Julião et al. 2002, the host plant was identified as *Rheedia brasiliensis* (Mart.) Pl. & Tr., an homotypic synonym of *Garcinia brasiliensis* Mart.

Atlantic Forest: *Clusia fluminensis* Tr. & Pl., *Clusia hilariana* Schltld., *Clusia lanceolata* Camb., and *Garcinia brasiliensis* Mart. (Flora do Brasil).

Herbarium data

Galled exsiccates of *Clusia fluminensis* (n=18), *C. hilariana* (n=14), and *C. lanceolata* (n=68) were found, totaling 112 (Figures 1a, b, c). The distribution area of *Parazalepidota clusiae*, *Clusiamyia granulosa* and *C. nitida* was extended. Their current distribution is represented in the Figures 2a, b, c. Two new state records and 18 new municipality records were reported in the present study (Table II).

DISCUSSION

Comparing the total number of galls on Clusiaceae in Brazil (n=13) with that on Myrtaceae (n=54) and Asteraceae (n=29) in a single phytophysiognomy of Atlantic Forest in the Southeast Region (Maia 2013), we can realize that Clusiaceae host low gall richness and few galled plant genera (n=3) and species (n=8), whereas Myrtaceae comprise 15 galled species of seven genera and Asteraceae 12 galled species of five genera. The average number of gall morphotypes per species of Clusiaceae (1.6) is lower than that of Myrtaceae (3.6) and Asteraceae (2.4). The low gall richness as well as the low number of galled plants on Clusiaceae can be related to the presence of resinous sticky sap and waxy cuticle, features that prevent herbivory (Rasmann & Agrawal 2009). According to Da Camara et al. 2018, the latex stores different classes of secondary compounds which protect the plant against natural enemies, more precisely, microorganisms and herbivores.

Only 23% of gallers associated with Clusiaceae are identified at species level, which highlights how the taxonomy of the gall midges is still poorly known. In fact, the number of described species

is much lower than the number of reported gall morphotypes in Brazil, indicating how taxonomic studies are necessary.

The occurrence of gallers associated with Clusiaceae is restricted to the Atlantic Forest since their host plants are restricted to the same biome. Although Julião et al. 2002 recorded the presence of *G. brasiliensis* in Mato Grosso do Sul, this occurrence was not confirmed in the site Flora do Brasil (2019). The gallers distribution is less wide than that of the host plants (Figures 2a, b, c), indicating that their geographic limits can be further extended.

The monophagy of the gall-inducers indicates that species associated with endemic plants are also endemic. So, the family Clusiaceae hosts three described endemic species of gall midges: *Parazalepidota clusiae*, *Clusiamyia granulosa* and *Clusiamyia nitida*.

CONCLUSIONS

The family Clusiaceae hosts few gall-inducing insects, which can be explained by the presence of resinous sticky sap and waxy cuticle, features that prevent herbivory. The host plant genera are *Clusia*, *Garcinia* and *Tovomita*, the first includes the greatest number of galled species and the last the highest medium average of gall morphotypes per species. The taxonomic knowledge of the gall midge species is still poorly known since only 23% have been described. Although several new locality records were reported in the present study, their geographic distribution can be wider since their host plants have a wider distribution limits. *Parazalepidota clusiae*, *Clusiamyia granulosa* and *C. nitida* are endemic of Brazil and restricted to the Atlantic Forest, as their host plants.

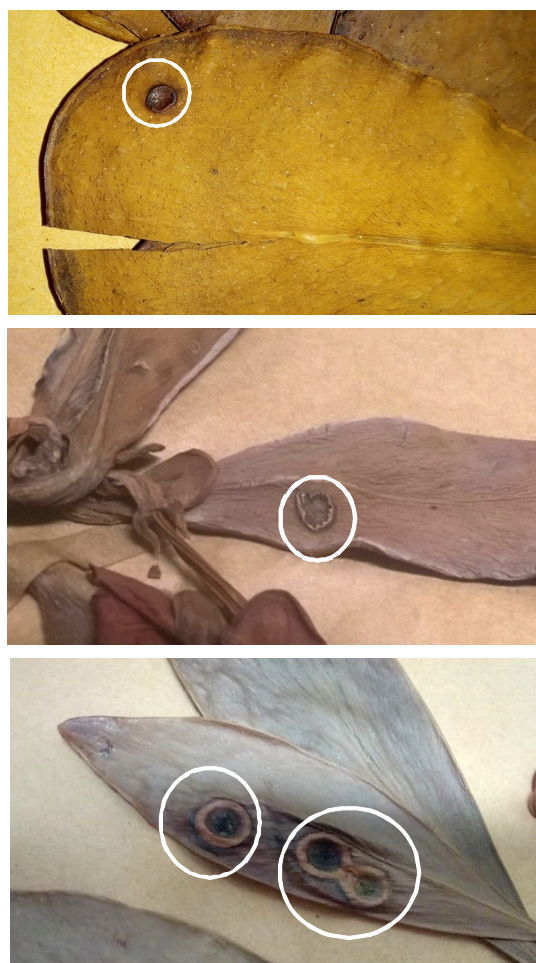


Figure 1. Exsiccatates of Clusiaceae with galls induced by Cecidomyiidae (Diptera). a. Gall induced by *Parazalepidota clusiae* on *Clusia fluminense*, b. Gall induced by *Clusiamyia granulosa* on *Clusia hilariana*, c. Gall induced by *Clusiamyia nitida* on *Clusia lanceolata*.

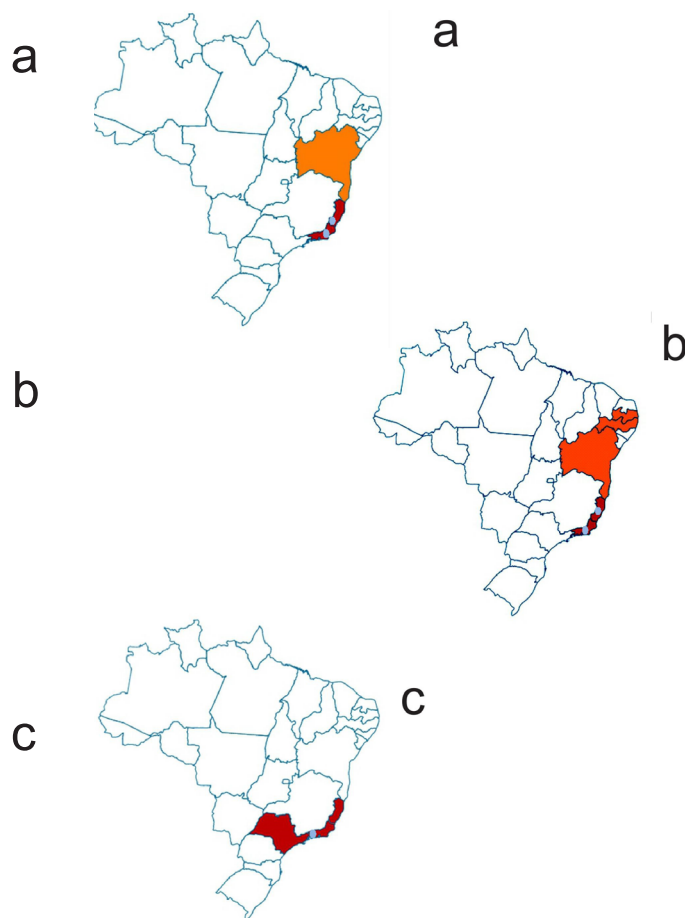


Figure 2. Maps of Brazil, showing the host plant distribution (colored area) and that of the gall-inducing species (Diptera, Cecidomyiidae) (colored circles). a. *Clusia fluminense* and *Parazalepidota clusiae*, b. *Clusia hilariana* and *Clusiamyia granulosa*, c. *Clusia lanceolata* and *Clusiamyia nitida*.

Table II. Localities of occurrence of *Parazalepidota clusiae*, *Clusiamyia granulosa*, and *C. nitida* retrieved from herbarium examination.

Gall-inducing species	New state records	New municipality records	Phytogeographic domain
<i>Parazalepidota clusiae</i>	E.S. (Vila Velha)	Quissamã, Macaé, Cabo Frio, Araruama, São Gonçalo, Rio de Janeiro, Petrópolis, Mauá (RJ)	Atlantic Forest
<i>Clusiamyia granulosa</i>	E.S. (Santa Maria de Jetibã and Linhares)	Casimiro de Abreu (RJ)	Atlantic Forest
<i>Clusiamyia nitida</i>	-	Quissamã, Macaé, Silva Jardim, Rio de Janeiro, Paraty (RJ)	Atlantic Forest

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