BIOTA AMAZÔNIA

ARTICLE

DOI: http://dx.doi.org/10.18561/2179-5746/biotaamazonia.v11n1p17-21

New biological data on *Eugeniamyia dispar* (Diptera, Cecidomyiidae), a pest on *Eugenia uniflora* L. (Myrtaceae)

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ABSTRACT

Eugeniamyia dispar (Cecidomyiidae, Diptera) is one of the most harmful pests of *Eugenia uniflora* (Myrtaceae) in Brazil. In this study, new data on its biology and negative effects on the host plant are reported. This study was carried out from September, 2017 to August, 2018 in the Quinta da Boa Vista Park (municipality of Rio de Janeiro, Rio de Janeiro state, Brazil). We looked for plant individuals, measured their height and choose one to be studied, based on the exclusive presence of spongy galls. This individual was examined four times a month. The number of galls in early development, closed mature and open galls was counted to verify their abundance. The greatest peaks of galls in early development were observed from late December, 2017 to early March, 2018. Closed mature galls were found from September to October, 2017, from December, 2017 to March, 2018 and in August, 2018. Peaks of open galls occurred about a week after those of mature galls. Dried galls were observed throughout the study period. We observed different gall stages in a single leaf, indicating an overlap of generations. Aborted galls were observed. Leaves with a great number of galls easily detached from the plant. The leaf area loss is related to the presence of galls. At the beginning of this study, *E. uniflora* hosted only galls of *E. dispar*. Later, other gall midge, *Clinodiplosis profusa,* colonized the host plant. The presence of a second galler increases the impact of herbivory on the plant.

Keywords: Damage; gall; host plant; crop.

Novas informações biológicas sobre *Eugeniamyia dispar* (Diptera, Cecidomyiidae), uma praga de *Eugenia uniflora* L. (Myrtaceae)

RESUMO

Eugeniamyia dispar (Cecidomyiidae, Diptera) é uma das pragas mais nocivas de *Eugenia uniflora* (Myrtaceae) no Brasil. Neste estudo, novos dados sobre sua biologia e efeitos negativos na planta hospedeira são relatados. Este estudo foi realizado no período de setembro de 2017 a agosto de 2018 no Parque Quinta da Boa Vista (município do Rio de Janeiro, estado do Rio de Janeiro, Brasil). Procuramos indivíduos vegetais, medimos sua altura e escolhemos um a ser estudado, com base na presença exclusiva de galhas esponjosas. Este indivíduo foi examinado quatro vezes por mês. O número de galhas em desenvolvimento inicial, galhas maduras fechadas e abertas foi contado para verificar sua abundância. Os maiores picos de galhas no início do desenvolvimento foram observados do final de dezembro de 2017 ao início de março de 2018. Galhas maduras fechadas foram encontradas de setembro a outubro de 2017, de dezembro de 2017 a março de 2018 e em agosto de 2018. Os picos de galhas abertas ocorreram cerca de uma semana após os picos das galhas maduras. Galhas secas foram observadas ao longo do período de estudo. Observamos diferentes estágios de galhas em uma única folha, indicando uma sobreposição de gerações. Galhas abortadas foram observadas. Folhas com grande número de galhas destacam-se facilmente da planta. A perda de área foliar está relacionada à presença de galhas. No início deste estudo, *E. uniflora* hospedava apenas galhas de *E. dispar*. Mais tarde, outro cecidomiídeo galhador, *Clinodiplosis profusa*, colonizou a planta hospedeira. A presença de um segundo galhador aumenta o impacto da herbivoria na planta.

Palavras-chave: Danos, fel, planta hospedeira, colheita.

Introduction

Eugeniamyia dispar Maia, Mendonça & Romanowski, 1996 (Diptera, Cecidomyiidae) is a monophagous gall midge species which induces spongy leaf galls on *Eugenia uniflora* L. (Myrtaceae) (Maia et al., 1996), a native plant in Brazil, commonly known as "pitangueira" (FLORA DO BRASIL, 2020). The fruits are edible and also used for the production of jelly, juice, and ice cream. The leaves are used to make tea (indicated for treatment of diarrhea, head colds, influenza, chest colds, coughs and fever), while the stems are used in carpentry. Moreover, this plant acts as insect repellent (SANTOS et al., 2009; USEFUL TROPICAL, 2014).

In Brazil, *E. uniflora* has been recorded in Mato Grosso do Sul state (Midwest Region), Bahia state (Northeast Region), and in all states of the Southeast and South regions (FLORA DO BRASIL, 2020). Nevertheless, galls of *E. dispar* have been recorded only in the states of São Paulo (Southeast Region), Santa Catarina, and Rio Grande do Sul (South Region) (MAIA, 2018).

Although *E. dispar* is a potential pest, it is still little studied (Bierhals et al., 2012). This gall midge was described by Maia et al. (1996) based on material from the state of Rio Grande do Sul (RS), Southern Brazil. Later, Mendonça & Romanovski (2002a, b) studied the life history and the natural enemies of this galler in RS, and reported these galls in the state of Santa Catarina. Maia et al. (2008) extended the geographic distribution of *E. dispar* to the state of São Paulo, Southeastern Brazil. Diez-Rodríguez et al. (2011) and Bierhals et al. (2012) studied parasitoids, population dynamics and gall distribution in an Embrapa area of cultivation of *Eugenia uniflora* in Pelotas (RS).

Besides *E. dispar*, three other cecidomyiids induce galls on leaves of *E. uniflora*, namely *Clinodiplosis profusa* Maia, 2001, *Neolasioptera eugeniae* Maia, 1993 and *Eugeniamyia triangularis* Maia & Nava, 2011 (Diptera, Cecidomyiidae). The first has been recorded in the states of Rio de Janeiro (RJ) and RS, while the two others have a more restricted distribution, being recorded only in RJ (MAIA, 2018). As each species induces a morphologically distinct gall on its host plant, the gall morphotype can be used as a surrogate of the gall-inducing species (CARNEIRO et al. 2009).

The present study aimed to record the presence of *E. dispar* in RJ and provide data on its life history and gall abundance in an urban area of the state of Rio de Janeiro.

Macapá, v. 11, n. 1, p. 17-21, 2021
Disponível em http://periodicos.unifap.br/index.php/biota
Submetido em 19 de Março de 2020 / Aceito em 17 de Dezembro de 2020

Material and Methods

This study was carried out in the Quinta da Boa Vista Park (22°90'58'S- 43°22´65"W), situated in the municipality of Rio de Janeiro, state of Rio de Janeiro, Southeastern Brazil. It is one the biggest urban parks of the city, over 155 thousand square meters, with green areas, centenary trees and lakes, as well as the National Museum and the Zoological Garden (Centro de Arquitetura e Urbanismo do Rio de Janeiro, 2000). In the 16th and 17 centuries, the Quinta da Boa Vista Park was a Jesuists farm. Later, it became the residence of the Imperial Family. In 1869, Auguste Glaziou, a French civil engineer and botanist, designed the landscaping project of the Quinta da Boa Vista, with Brazilian and exotic plants.

This Park (Figure 1) was investigated from September, 2017 to August, 2018.

Figure 1. Panoramic view of Quinta da Boa Vista Park in São Cristóvão, Rio de Janeiro (RJ), Brazil.

First, we look for individuals of *E. uniflora* and measured their height using a measuring tape. Seven individuals were found, one beside the Imperial Palace, and all others in the Botanical Garden (Table 1), an area of about 40,700m^2, which includes the Museu Nacional Library, and buildings of the Botanic and Vertebrates Departaments, "Coral Vivo Project", "Casa de Pedra" (Stone House) and a cultived area of about 20,000 m^2, with exotic and native plants. Their height ranged from 0.83 to 2.10m.

Five individuals were galled. One of them sheltered three distinct gall morphotypes at the same time, all on leaves: conical galls induced by *Clinodiplosis profusa*, lenticular galls induced by *Neolasioptera eugeniae*, and spongy globoid galls induced by *Eugeniamyia dispar*. Two individuals sheltered at the same time galls of *Clinodiplosis profusa* and *Neolasioptera eugeniae*, one presented only galls of *Clinodiplosis profusa* and the other only galls of *Eugeniamyia dispar*.

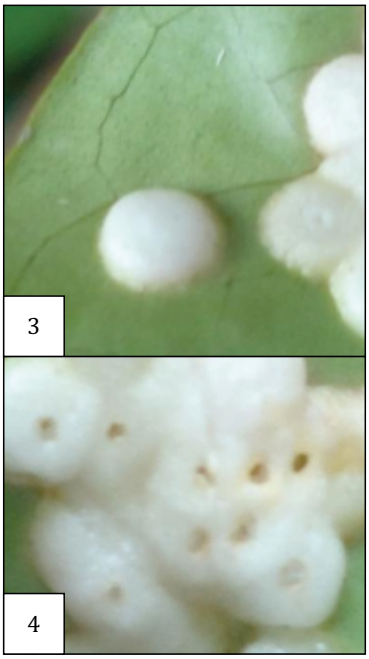
Table 1. List of individuals of *Eugenia uniflora* L. (Myrtaceae) found in the Quinta da Boa Vista Park, Rio de Janeiro (RJ, Brazil): height, gall-inducing species and sites of occurrence.

Individual	Height	Gall - inducing species (Diptera: Cecidomviidae)			Site
		Clinodiplosis profusa	*Neolasioptera eugeniae*	*Eugeniamyia dispar*	
1	2.10m	X	X	-	Botanical Garden
2	2.30m	X	X	-	Botanical Garden
3	0.83m	X	X	X	Botanical Garden
4	2.20m	X	-	-	Botanical Garden
5	2.15m	-	-	-	Botanical Garden
6	0.95m	-	-	-	Botanical Garden
7	0.92m	-	-	X	Palace area

We choose this last individual to be studied, based on the exclusive presence of spongy galls. We adopted this procedure to guarantee that all leaf damage could be attributed to *Eugeniamyia dispar*. This individual (Figure 2) was examined four times a month. All leaves were observed and those with galls were photographed, adaxial and abaxially, using a digital camera. Both leaf surfaces were photographed since galls grow on both surfaces.

Figure 2. *Eugenia uniflora* L. (Myrtaceae) in the Palace area of Quinta da Boa Vista Park in São Cristóvão, Rio de Janeiro (RJ), Brazil.

The photographies of the abaxial surface reveal if the gall is still closed (Figure 3) or if it exhibits the hole through the larva escapes (Figure 4). The number of galls in early development, mature galls but still closed and open galls was counted to verify their abundance throughout the year.



Figures 3-4. Galls of *Eugeniamyia dispar* (Diptera, Cecidomyiidae) on *Eugenia uniflora* (Myrtaceae): 3. closed mature galls, 4. open galls.

Some galls were removed from the plant, dried and deposited in the Entomological Collection of the Museu Nacional (MNRJ), Universidade Federal do Rio de Janeiro as voucher material.

Results

In September, 2017 there were no galls. In October and in the first three weeks of December, some galls in early development (Figure 5) were observed (n<20 per month).

Figure 5. Galls of *Eugeniamyia dispar* (Diptera, Cecidomyiidae) on *Eugenia uniflora* (Myrtaceae) in early development.

From the last week of December, 2017 to the first two weeks of March, 2018, there were three peaks of galls in early development, with the galls number ranging from about 200 to about 300. In late March and early April, the amount of galls in early development significantly decreased (n<20). From then until the end of July, no gall in early development was found. They appeared again in late July and there was another peak in mid-August (Figure 6).

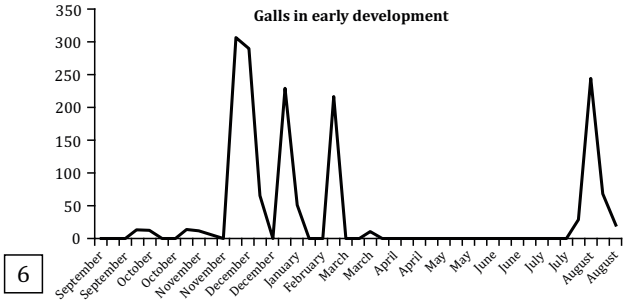


Figure 6. Number of *Eugeniamyia dispar* (Diptera, Cecidomyiidae) galls in early development during the period of September, 2017 to August, 2018.

Mature galls still closed were found in several months, from September to October, 2017, from December, 2017 to March, 2018 and in the last three weeks of August, 2018. They were not observed only in November, 2017 and from mid-March, 2018 to early August. The greatest peak was found in January, 2018 (about 200) and in August, 2018 (about 180). Less significant peaks occurred in September, October, and December, 2017 with about 75 galls each, and the smallest in March, 2018 with about 50 galls (Figure 7).

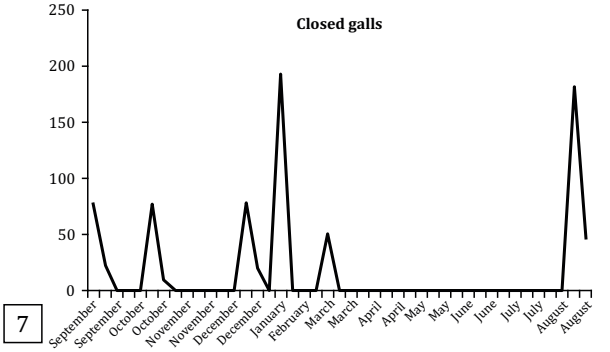


Figure 7. Number of closed mature galls of *Eugeniamyia dispar* (Diptera, Cecidomyiidae) during the period of September, 2017 to August, 2018.

Open galls were observed in September to October, 2017, from December, 2017 to March, 2018 and in the last weeks of August, 2018. The greatest peaks occurred in September, 2017 and August, 2018 (with about 100 galls). Other peaks were observed in October, 2017, December, 2017, and March, 2018, but with less galls (about 90, 80 and 50, respectively) (Figure 8).

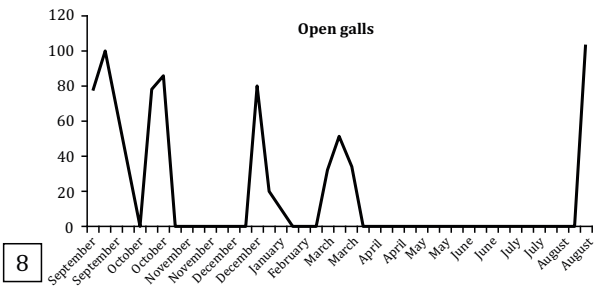


Figure 8. Number of open galls of *Eugeniamyia dispar* (Diptera, Cecidomyiidae) during the period of September, 2017 to August, 2018.

Dried galls:

Dried galls (Figure 9) were observed throughout the study period.

Figure 9. Dried galls of *Eugeniamyia dispar* (Diptera, Cecidomyiidae) on *Eugenia uniflora* (Myrtaceae).

Nevertheless, they were more frequent from December, 2017 to the first two weeks of April, 2018, ranging from about 150 to about 300. And their amount greatly reduced from September to November, 2017, ranging from 0 to 65, and from May to August, 2018, ranging from about 0 to 100 (Figure 10).

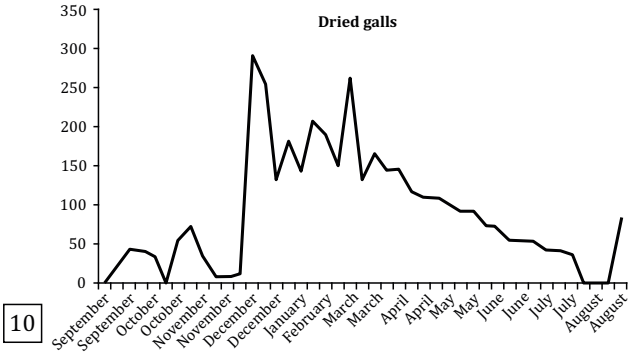


Figure 10. Number of dried galls of *Eugeniamyia dispar* (Diptera, Cecidomyiidae) during the period of September, 2017 to August, 2018.

Other observations:

Although different gall stages were analyzed separately, they overlapped, so that in a single leaf we found from initial galls to decomposing open galls (Figure 11).

Figure 11. Different simultaneous stages of galls of *Eugeniamyia dispar* (Diptera, Cecidomyiidae).

Aborted galls (Figure 12) were found throughout the study period, but they were not frequent. Their percentage varied from 0 to 8.2%.

Figure 12. Healthy gall (green) and aborted gall (brown) of *Eugeniamyia dispar* (Diptera, Cecidomyiidae) on *Eugenia uniflora* (Myrtaceae).

The number of galls per leaf varied from 0 to 42. Many leaves were completely or almost completely occupied by galls (Figure 13).

Although these leaves did not suffer natural abscission, they easily detached from the plant with handling when galls were mature.

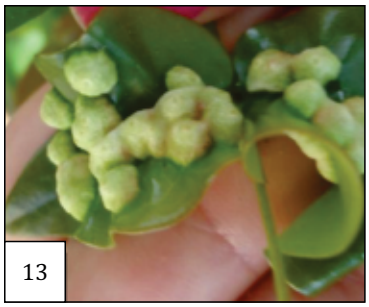


Figure 13. Leaves of *Eugenia uniflora* (Myrtaceae) almost completely occupied by galls of *Eugeniamyia dispar* (Diptera, Cecidomyiidae).

Furthermore, a great amount of torn leaves were observed after the gall dryness. The tear began in the gall tissue (Figure 14), and then extended to the entire galled area, causing great loss of leaf area (Figure 15).

Figures 14-15. Loss of leaf area due to presence of galls of *Eugeniamyia dispar* (Diptera, Cecidomyiidae).

In fact, this phenomenon was very frequent. It occurred in all leaves with mature galls abandoned by the galler, but it was not observed in leaves with aborted galls.

At the beginning of this survey, the studied plant hosted only galls of *E. dispar*. Nevertheless, galls of *C. profusa* (Figure 16) appeared from December, 2017 to January, 2018 (n=18) and from July and August, 2018 (n= 104). Galls of *N. eugeniae* were not found.

Figure 16. Simultaneous presence of galls of *Eugeniamyia dispar* and *Clinodiplosis profusa* (Diptera, Cecidomyiidae) on *Eugenia uniflora* (Myrtaceae).

Discussion

Eugeniamyia dispar induces galls on new leaves of *E. uniflora* (MENDONÇA; ROMANOWSKI, 2002a). We observed that all peaks of galls in early development occurred exactly in the periods when the plant was sprouting. The greatest peaks were observed from late December, 2017 to early March, 2018, when the greatest amount of young leaves was found. These facts showed synchronization between oviposition and host plant phenology, a critical event to the success of the next gall midge generation.

Mature galls, but still closed, were found from September to October, 2017 (period without galls in early development), as well as from December, 2017 to March, 2018 and in August, 2018. In these last two periods, they first appeared one week after the observation of galls in early development.

Peaks of open galls occurred about a week after the peaks of mature galls. Dried galls were observed throughout the study period. This broad period of dried galls is related to their long stay in the plant as the same galls were observed for several months. The greatest amount of dried galls was found from December, 2018 to early May, few weeks after the greatest gall abundance.

We observed different gall stages in a single leaf, indicating an overlap of generations. In fact, *E. dispar* is a multivoltine species with life-cycle of about two weeks (MENDONÇA; ROMANOVSKI, 2002a).

In our study, active galls were not found from April to July 2018. Differing from our result, Mendonça and Romanovski (2002a) reported galls from late August to early June in RS. Nevertheless, galls were more abundant during the summer than in other seasons in both studies. Mendonça and Romanovski (2002a) surveyed a population of Rio Grande do Sul (South Region of Brazil), while we studied a population of Rio de Janeiro (Southeast Region of Brazil) therefore the gall-inducing species was under different climatic conditions.

Aborted galls were observed. We attributed them to hypersensitivity reactions, characterized by a brown circular spot around the gall. They constitute a defensive response of the plant that encompasses morphological and histological changes terminating in the death of the attacked tissue, and thus in the localization, containment, inactivation, and eventual death of the herbivore (FERNANDES, 1990). The highest percentage of aborted galls was 8.2%, showing that this strategy was not effective in combating gall induction. Different result was found by Fernandes (1998) that reported a high number of aborted galls induced by *Contarinia* sp. (Diptera, Cecidomyiidae) on leaves of *Bauhinia brevipes* Vogel (Fabaceae) in Minas Gerais state (Brazil), and pointed out that hypersensitive reaction was the most important mortality factor in that galling population (more than 90%). Nevertheless, few studies on hypersensitive reactions against gallers have been documented in Brazil (e.g. FERNANDES, 1998, SOUZA et al., 2006, DETONI et al., 2011).

We observed that leaves with a great number of galls easily detached from the plant. As the gall-inducing larvae pupate in the soil, this abscission does not negatively affect the galler, especially because the galls are already mature, so the larvae are ready to leave the gall. Instead of harming them, the abscission can help the larvae reach faster the soil, reducing the risk of dryness and predation. But the abscission did not occur naturally. It resulted from human handling. But this phenomenon suggests that strong winds could provoke the same effect on the plant.

For the first time, the leaf area loss and its progression were reported and photographed. However, this effect on the host plant has yet to be evaluated. It can represent a harmful loss or it can be a strategy to avoid the costs of maintaining an unproductive area.

At the beginning of this study, *E. uniflora* hosted only galls of *E. dispar*. Nevertheless, *C. profusa* later colonized the host plant. Galls of both gall midges were found even in the same leaf. They may compete for the same resource or they may share it. In any case, the presence of a second gall-inducing species increases the impact of herbivory on the host plant.

Conclusion

The geographic distribution of *E. dispar* was extended to the state of Rio de Janeiro. Peaks of galls in early development and host plant sprout are synchronized. Generation overlap occurs. Life cycle of this species in the state of Rio de Janeiro differs from that of Rio Grande do Sul.

New plant reactions were first reported: hypersensitivity response, abscission of leaves with great abundance of mature galls when handling, and leaf area loss after gall maturity.

E. dispar and *C. profusa* simultaneously induce galls on the host plant, increasing the herbivory impact on it.

Acknowledgments

We are grateful to Karen Diocesano da Cruz and Angelina Pimentel (Museu Nacional, Universidade Federal do Rio de Janeiro) for field assistance, and to Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) (Proc. 301481/2017-2) for financial support.

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