

Scientific Note

Cecidomyiidae (Diptera) in the State of Santa Catarina, Brazil

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Abstract. The first checklist of gall midges (Diptera: Cecidomyiidae) in the state of Santa Catarina is organized based on literature review. Species distribution, discussion regarding endemism, and a list of host plants in the state are provided for the first time. We compare the composition of cecidomyiid species with other states of Brazil. Twenty-three species of gall midges occur in Santa Catarina, all gall-inducers. They are distributed in 14 genera, being *Lopesia* Rübsaamen, 1908 and *Bruggmannia* Tavares, 1906 the best represented. The most speciose genera of Cecidomyiidae in Santa Catarina are among the most speciose in Brazil, so this result matches the Brazilian pattern. Cecidomyiids are associated with 18 host plant species distributed in 12 families. Although Santa Catarina comprises a low percentage of the Brazilian fauna of Cecidomyiidae (8.7%), two species are known only from the state. The Sorensen's index showed that the fauna of Santa Catarina and São Paulo are the most similar to each other. The similarity of gall-inducing insects can be related to the host plant composition and phytogeographic domain.

Keywords: gall-inducers, Atlantic Forest, host plants, geographic distribution, plant-insect interaction.

Cecidomyiidae (Diptera) comprise insects that are predominantly gall-inducers, with representatives in all zoogeographic regions. About 6,655 species have already been described, which makes this family one of the most diverse in the order Diptera (Gagné & Jaschhof 2021). Although most cecidomyiids are gall-inducers, the family includes also fungivorous, predaceous, free-living phytophagous, and species that live obligatorily in galls induced by other insects (Gagné & Jaschhof 2021).

In Brazil, Cecidomyiidae are represented by 265 species (Maia 2021). The faunas of Rio de Janeiro (RJ) and Minas Gerais (MG) states are the most investigated, concentrating the highest number of insect gall inventories and described cecidomyiids. In the beginning of the 20th century, E. H. Rübsaamen, J. J. Kieffer and J. S. Tavares described eight species from Santa Catarina (SC) (Rübsaamen 1908; Kieffer 1913; Tavares 1925). After this period, no new data was added to this faunistic knowledge until 2018, when Melo-Júnior et al. (2018) reported cecidomyiid species in some municipalities of the state.

Santa Catarina is one of the smallest states of Brazil, with a territorial area of about 96 thousand km². It is situated in the Southern region of the country, being fully inserted in the Atlantic Forest. Santa Catarina holds the highest percentage of remaining vegetation cover in this phytogeographic domain (Instituto do Meio Ambiente de Santa Catarina) and hosts a rich flora with about 3,784 tracheophyte species (Reis et al. 2011).

This paper aims to present the first checklist of gall midge species in SC, show their distribution in the state, discuss possible scenarios of endemism, provide a list of host plant species, and compare the composition of cecidomyiids with other states of Brazil.

We retrieved data on Cecidomyiidae species with records in SC from Maia 2021, using the "find" tool. To understand the representativeness of gall midges in the state, we presented the species richness of each recorded genus in the world and in Brazil based on Gagné & Jaschhof (2021) and Maia (2021), respectively.

We quantified the number of host plant families, genera, and species, as well as the number of Cecidomyiidae species on them. We highlighted hosts that are vulnerable and endemic to Brazil (Flora do Brasil 2020).

We estimated the similarity of the cecidofauna of SC with the fauna of all states of the Southeast region - Minas Gerais (MG), Espírito

Santo (ES), Rio de Janeiro (RJ), and São Paulo (SP) - and Bahia (BA, Northeastern Brazil). These states were chosen due to the greatest amount of available taxonomic information about cecidomyiids. We adopted the Sorensen's Index and UPGMA analysis to quantify this similarity: $SI = 2c/a+b$ (c = number of species in common; a = number of species in community 1; b = number of species in community 2), using the software Past 4.03.

Twenty-three species of gall midges have been recorded in SC, all gall-inducers. This value corresponds to about 9% of the Brazilian species richness of Cecidomyiidae. Two of them are known only from SC, *Bruggmannia micrura* (Kieffer, 1913) and *Bruggmannia ruebsaameni* (Kieffer, 1913). The gall-inducing species are distributed in 14 genera, being *Lopesia* Rübsaamen, 1908 ($n = 6$ spp.) and *Bruggmannia* Tavares, 1906 ($n = 4$ spp.) the best represented, with about 29% and 23% of the total of species reported in Brazil. The other genera included one to two species each (Tab. 1).

Cecidomyiids are associated with 12 plant families and among these Nyctaginaceae stand out for hosting the greatest number of gall midge species ($n = 7$), followed by Calophyllaceae with four. The other plant families host one to two gall midge species each (Tab. 2). Cecidomyiids are distributed in 18 plant species. Among them, both *Calophyllum brasiliense* Cambess. (Calophyllaceae) and *Guapira opposita* (Vell.) Reitz (Nyctaginaceae) host the greatest richness of gall midge species ($n = 3$).

Three host plant species are endemic to Brazil: *Psidium cattleyanum* Sabine (Myrtaceae), *Mikania trinervis* Hook. & Arn. (Asteraceae) and *Monteverdia obtusifolia* (Mart.) Biral (Celastraceae). *Lantana camara* L. (Verbenaceae) is naturalized, while all others are native to Brazil.

Most cecidomyiid species ($n=15$; 65.2%) have been recorded only in the coast of SC, while six (26.1%) exclusively in the interior (Pedras Grandes: $n=1$; Joinville: $n=1$; Tubarão: $n=4$) and two without reference to localities. Gall midge records totaled six localities in the state, four in the North (Babitonga, Itapoá, Joinville, and São Francisco do Sul), and two in the South (Pedras Grandes and Tubarão). Babitonga (a restinga ecosystem) comprises 52% of all recorded species. Only *Dasineura gigantea* Angelo & Maia, 1999 was registered in two different locations (Babitonga and Itapoá) (Fig. 1).

Table 1. Species richness of Cecidomyiidae (Diptera) by genus in the world (Gagné & Jaschhof 2021), Brazil (Maia 2021), and in Santa Catarina state (South, Brazil).

Genus of Cecidomyiidae	Number of species	Brazil	Santa Catarina
<i>Asphondylia</i>	308	23	1
<i>Bruggmannia</i>	19	14	4
<i>Clinodiplosis</i>	109	20	1
<i>Cordiamyia</i>	1	1	1
<i>Dasineura</i>	483	11	1
<i>Iatrophobia</i>	1	1	1
<i>Liodiplosis</i>	3	3	1
<i>Lopesia</i>	30	26	6
<i>Machaerobia</i>	2	2	1
<i>Mayteniella</i>	1	1	1
<i>Pisphondylia</i>	2	1	1
<i>Proasphondylia</i>	3	3	2
<i>Schismatodiplosis</i>	1	1	1
<i>Sphaeramyia</i>	1	1	1

Table 2. Richness of host plants and gall midge species in Santa Catarina state (South, Brazil).

Host plant family	Number of host genus	Number of host species	Number of gall midges
Asteraceae	1	3	1
Boraginaceae	1	1	2
Calophyllaceae	1	1	4
Celastraceae	1	1	1
Euphorbiaceae	1	2	1
Fabaceae	2	3	2
Lamiaceae	1	1	1
Melastomataceae	1	1	1
Meliaceae	1	1	1
Myrtaceae	1	1	1
Nyctaginaceae	2	2	7
Verbenaceae	1	1	1

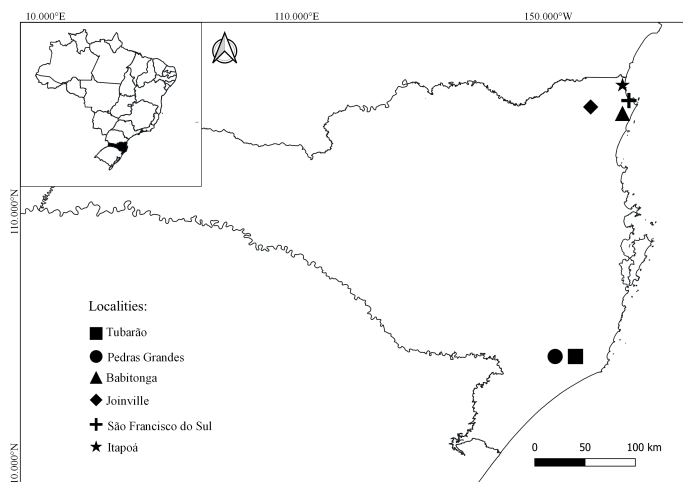


Figure 1. Map of Santa Catarina, showing the localities with records of Cecidomyiidae (Diptera).

The Sorensen's index showed that the faunas of Santa Catarina and São Paulo are the most similar to each other (38%) (Tab. 3; Fig. 2), with 15 species in common, namely: *Asphondylia cordiae* Möhn, 1959, *Bruggmannia elongata* Maia & Couri, 1993, *Cordiamyia globosa*

Maia, 1996, *Dasineura gigantea* Angelo & Maia, 1999, *Iatrophobia brasiliensis* Rübbsaamen, 1908, *Liodiplosis cylindrica* Gagné, 2001, *Lopesia caulinaris* Maia, 2003, *Lopesia conspicua* Maia, 2003, *Lopesia elliptica* Maia, 2003, *Lopesia grandis* Maia, 2001, *Lopesia linearis* Maia, 2003, *Machaerobia machaerii* Kieffer, 1913, *Pisphondylia brasiliensis* Couri & Maia, 1992, *Proasphondylia guapirae* Maia, 1994, and *Sphaeramyia flava* Maia, 2007. The similarity between the faunas of SC and RJ, SC and ES, and SC and MG ranged from 23% to 27%, while the lowest similarity was reported between SC and BA, about 18% only.

The list of gall midge species and their host plants in the state of SC is presented below in alphabetical order. All reported localities in the state are informed.

Table 3. Number of gall midge species (Cecidomyiidae) in Bahia (BA), Espírito Santo (ES), Minas Gerais (MG), Rio de Janeiro (RJ) and São Paulo (SP) (Gagné & Jaschhof 2021; Maia 2021), number of shared species with Santa Catarina (SC) and Sorensen's Index.

Brazilian state	Number of species	Number of shared species with SC	Sorensen's Index
BA	43	6	0.18
ES	36	8	0.27
MG	44	9	0.27
RJ	128	17	0.23
SP	56	15	0.38

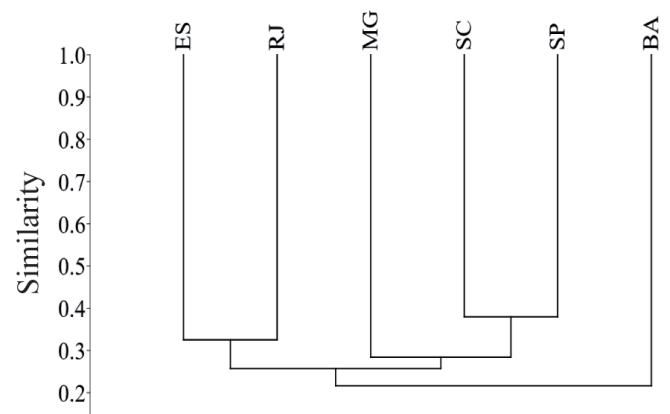


Figure 2. Grouping diagram (UPGMA) for similarity of galling insect species between the states sampled in the study. ES - Espírito Santo, RJ - Rio de Janeiro, MG - Minas Gerais, SC - Santa Catarina, SP - São Paulo, BA - Bahia.

List of gall midge species in the state of Santa Catarina

- 1) *Asphondylia cordiae* Möhn, 1959. Locality: Babitonga. Host plant: *Varronia curassavica* Jacq. (Boraginaceae) (native to Brazil).
- 2) *Bruggmannia depressa* (Kieffer, 1913). Locality: unstated municipality. Host plant: *Neea* sp. (Nyctaginaceae).
- 3) *Bruggmannia elongata* Maia & Couri, 1993. Locality: Babitonga. Host plant: *Guapira opposita* (Vell.) Reitz (Nyctaginaceae) (native to Brazil).
- 4) *Bruggmannia micrura* (Kieffer, 1913). Locality: unstated municipality. Host plant: *Neea* sp. (Nyctaginaceae).
- 5) *Bruggmannia ruebsaameni* (Kieffer, 1913). Locality: Pedras Grandes. Host plant: *Neea* sp. (Nyctaginaceae).
- 6) *Clinodiplosis iheringi* (Tavares, 1925). Locality: Joinville. Host plant: *Aegiphila integrifolia* (Jacq.) Moldenke (Verbenaceae) (native to Brazil).
- 7) *Cordiamyia globosa* Maia, 1996. Locality: Babitonga. Host plant: *Varronia curassavica* Jacq. (Boraginaceae) (native to Brazil).
- 8) *Dasineura gigantea* Angelo & Maia, 1999. Locality: Babitonga, Itapoá. Host plant: *Psidium cattleyanum* Sabine (Myrtaceae) (endemic to Brazil).
- 9) *Iatrophobia brasiliensis* Rübbsaamen, 1908. Locality: Tubarão (Atlantic Forest). Host plants: *Manihot caerulescens* (native to Brazil) and *Manihot* sp. (Euphorbiaceae).
- 10) *Liodiplosis cylindrica* Gagné, 2001. Locality: Babitonga. Host

plants: *Mikania glomerata* Spreng. (native to Brazil) (Cerrado and Atlantic Forest), *Mikania cf. biformis*, *Mikania trinervis* Hook. & Arn. (endemic to Atlantic Forest) (Asteraceae).

- 11) *Lopesia brasiliensis* Rübsaamen, 1908. Locality: Tubarão. Host plant: *Ossaea* sp. (Melastomataceae).
- 12) *Lopesia caulinaris* Maia, 2003. Locality: Babitonga. Host plant: *Calophyllum brasiliense* Cambess. (Calophyllaceae) (native to Brazil).
- 13) *Lopesia conspicua* Maia, 2003. Locality: São Francisco do Sul. Host plant: *Calophyllum brasiliense* Cambess. (Calophyllaceae) (native to Brazil).
- 14) *Lopesia elliptica* Maia, 2003. Locality: Babitonga. Host plant: *Calophyllum brasiliense* Cambess. (Calophyllaceae) (native to Brazil).
- 15) *Lopesia grandis* Maia, 2001. Locality: Babitonga. Host plants: *Dalbergia ecastophyllum* (L.) Taub. (native to Brazil) and *Dalbergia frutescens* (Vell.) Britton (native to Brazil) (Fabaceae).
- 16) *Lopesia linearis* Maia, 2003. Locality: Babitonga. Host plant: *Calophyllum brasiliense* Cambess. (Calophyllaceae) (native to Brazil).
- 17) *Machaerobia machaerii* Kieffer, 1913. Locality: Tubarão. Host plants: *Machaerium* sp. and *Machaerium hirtum* (Vell.) Stelfeld (Fabaceae) (native to Brazil).
- 18) *Mayteniella distincta* Maia, 2001. Locality: Babitonga. Host plant: *Monteverdia obtusifolia* (Mart.) Biral (Celastraceae) (endemic to Brazil).
- 19) *Pisphondylia brasiliensis* Couri & Maia, 1992. Locality: Babitonga, São Francisco do Sul. Host plant: *Guapira opposita* (Vell.) Reitz. (Nyctaginaceae) (native to Brazil).
- 20) *Proasphondylia formosa* Maia, 1994. Locality: Babitonga. Host plant: *Guapira opposita* (Vell.) Reitz. (Nyctaginaceae) (native to Brazil).
- 21) *Proasphondylia guapirae* Maia, 1994. Locality: Babitonga. Host plant: *Guapira opposita* (Vell.) Reitz. (Nyctaginaceae) (native to Brazil).
- 22) *Schismatodiplosis lantanae* (Rübsaamen, 1908). Locality: Tubarão. Host plant: *Lantana camara* L. (Verbenaceae) (naturalized).
- 23) *Sphaeromyia flava* Maia, 2007. Locality: São Francisco do Sul. Host plant: *Guarea macrophylla* Vahl (Meliaceae) (native to Brazil).

Although SC comprises a low percentage of the Brazilian fauna of Cecidomyiidae, two species have been recorded only in the state. Both induce galls on *Neea* sp. (Nyctaginaceae). According to Costa et al. (2020), only *Neea pendulina* Heimerl (Nyctaginaceae) occurs in SC, so this is probably the host plant of both species. *Neea pendulina* has been also reported in PR, SP and RJ. Therefore, these gall-inducers can also occur in these states.

The most speciose genera of Cecidomyiidae in SC are among the most speciose in Brazil, so this result matches the Brazilian pattern (Maia 2021). On the other hand, the plant families with the greatest richness of gall midge species in SC were Nyctaginaceae and Calophyllaceae, differing from the Brazilian pattern, where Fabaceae, Asteraceae, and Myrtaceae are the highlights. Nevertheless, the two host plant species with the greatest number of gall midge species in the state, *C. brasiliense* and *G. opposita*, are among the three super hosts in Brazil.

Gall-inducers associated with plants endemic to Brazil have been reported in other states. Two of them, *D. gigantea* and *M. distincta*, were proposed as co-endemic by Maia (2021), since they occur exclusively on endemic hosts. However, the gall-inducer associated with *M. trinervis* cannot be considered co-endemic as it induces galls also on *Mikania glomerata*, a plant that is native, but not endemic to Brazil. Therefore, we can list two Brazilian co-endemic species of gall midges occurring in SC.

Most cecidomyiid species have been recorded in the coast of SC, since researches are most frequent in coastal areas. Babitonga comprises the majority of the recorded species because the taxonomy of Cecidomyiidae from restingas is the most studied in comparison to

the fauna from other physiognomies of the Atlantic Forest.

Santa Catarina is more similar to SP than to the other states in gall midge composition. SC is fully inserted in the Atlantic Forest, while SP includes Atlantic Forest and Cerrado areas. However, most gall midge species reported in SP, about 74%, were collected in Atlantic Forest areas, what can explain the similarity. ES and RJ are contiguous states, both fully inserted in the Atlantic Forest. They are more similar to each other in cecidomyiid composition than to SC, SP, MG, and BA. Once again, the similarity of phylogeographic domain is correlated to the similarity of gall midge fauna (Maia 2013).

Minas Gerais is more similar to SC + SP than ES + RJ due to the great number of species reported exclusively in Cerrado areas (about 56%) (Maia 2020), and BA, the least similar in gall midge composition, is the single Brazilian state which includes three different phylogeographic domains, Caatinga, Cerrado and Atlantic Forest, all with records of cecidomyiids (Maia & Silva 2020).

Plant composition and local vegetal formation is once more reported as correlating with the similarity of the gall midge fauna of a given area (Araújo & Guilherme 2012). Since most gall-inducing insects are species-specific, depending on the presence and quality of the host plant for their establishment (Carneiro et al. 2009), this correlation must be due this ecological background, but studies testing a direct interaction of these factors is still lacking.

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Authors' Contributions

ICF: Contribution to the idea, concept and design of the study, data collection, data analysis and interpretation and the manuscript preparation. VCM: Contribution to the concept and design of the study, data collection, data analysis and interpretation and the manuscript preparation.

Conflict of Interest Statement

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

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