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(REVIEW ARTICLE)

Mini review of the aspects conceptual and taxonomic of Cecidomyiidae Family (Insect: Diptera)

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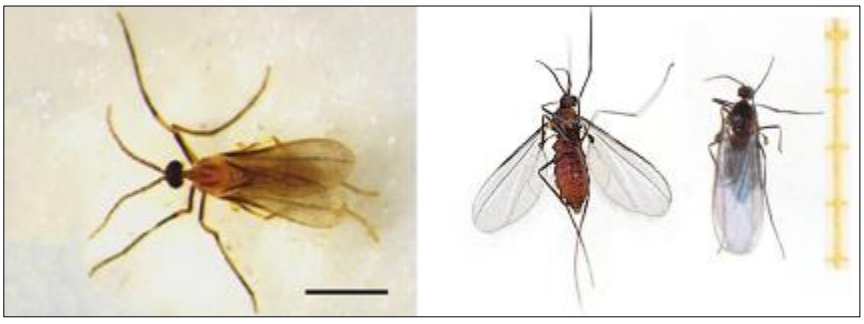
Abstract

Cecidomyiidae (sometimes misspelled Cecidomyidae) is a family of dipterous known as cecidomids or gall flies, because the larvae of most species feed on plant tissue creating an abnormal growth known as gall. The family has a cosmopolitan distribution, with more than 6,000 species. These insects should not be confused with gall wasps (Cynipidae), which also form galls. The purpose of this article is to obtain information on the characteristics of the Cecidomyiidae (Insecta: Diptera). To this end, a bibliographic survey of Cecidomyiidae was carried out in the years 1961 to 2021. Only complete articles published in scientific journals and expanded abstracts presented at national and international scientific events, Doctoral Thesis and Master's Dissertation were considered. Data were also obtained from platforms such as: Academia.edu, Frontiers, Qeios, Pubmed, Biological Abstract, Publons, Dialnet, World, Wide Science, Springer, RefSeek, Microsoft Academic, Science and ERIC.

Keywords: Gall; Plant; Damage; Mites; Aphids

1. Introduction

Cecidomyiidae (sometimes misspelled Cecidomyidae) is a family of dipterous known as cecidomids or gall flies, because the larvae of most species feed on plant tissue creating an abnormal growth known as gall. The family has a cosmopolitan distribution, with more than 6,000 species. These insects should not be confused with gall wasps (Cynipidae), which also form galls (Figure 1) [1].



Source: https://www.diptera.info/forum/viewthread.php?thread_id=99882

Figure 1 Specimens of Cecidomyiidae

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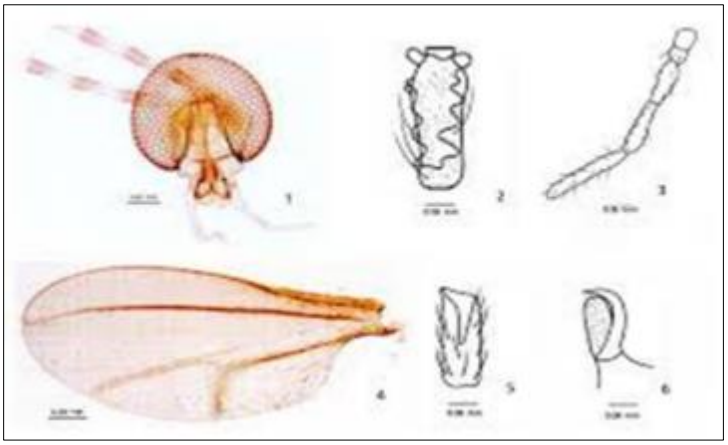
1.1. Description

They are delicate insects, 2-3 mm long, although some are less than 1 mm long. They are characterized by having velvety wings, which is not common in the order Diptera, and by the presence of long antennae (Figures 2, 3 and 4) [1,2,3].

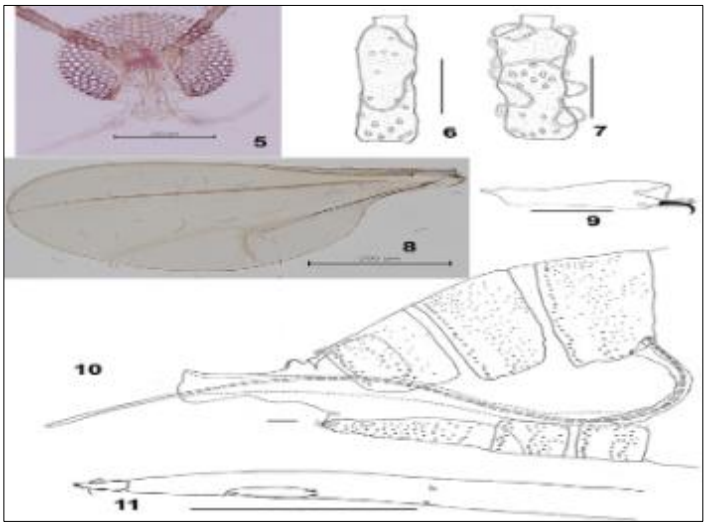
Source: https://www.researchgate.net/figure/Adult-female-left-and-male-right-of-Herbomyia-robusta_fig8_309155026

Figure 2 Adult female (left) and male (right)



Source: https://www.scielo.br/j/isz/a/ZTVvwLnBbjsRQHMVQXGF7jM/?lang=en

Figure 3 Male of *Schizomyia tuiuium* Guimarães & Amorim, 2002: 1, head (front view); 2, third flagelomere; 3, palpus; 4, wing; 5, first tarsomere; 6, tarsal claw and empodium



Figure

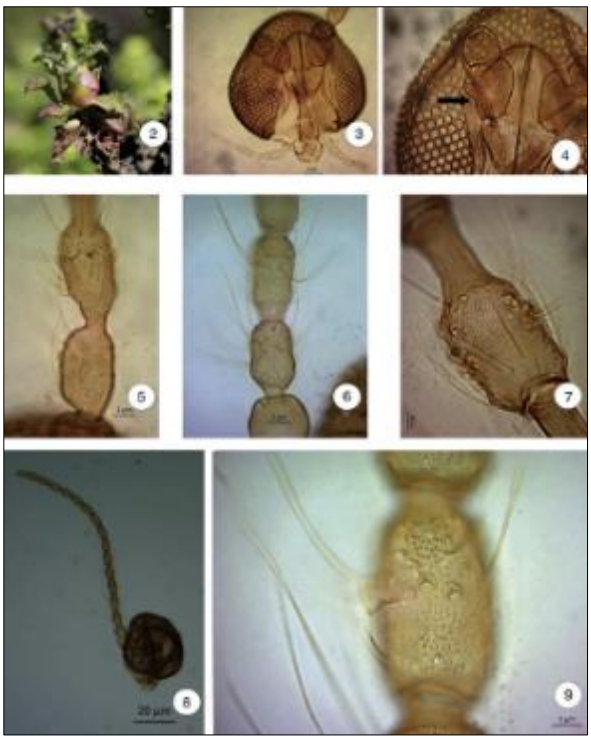
Source: https://zookeys.pensoft.net/article/29679/element/2/11/

Figure 4 5 Head 6 Ventral view of female antennal flagellomere V 7 Ventral view of male flagellomere V 8 Wing 9 Tarsomere V and acromere 10 Terminal part of female abdomen 11 Ovipositor apex. Scale bars: 50 µm (6, 7, 9–11), 200 µm (5, 8)

Some species of this family are economically important and can constitute serious pests, especially the wheat gall fly, the species *Mayetiola destructor* (Say, 1817). Other important pests, among many others belonging to this family, are the flies that attack lentils *Contarinia lentis* Aczél, 1944, the alfalfa gnat (*Dasineuraignota*), which affects several legumes, the cruciferous gnat *Dasineura brassicae* (Winnertz, 1853)) and the gnat pears *Contarinia pyrivora* (Riley, 1886) (Figures 5A and 5B) [1,2,3].

Source: https://www.scielo.br/j/rbent/a/pqV3SRsznm8C83PmMyDKJhH/?lang=en

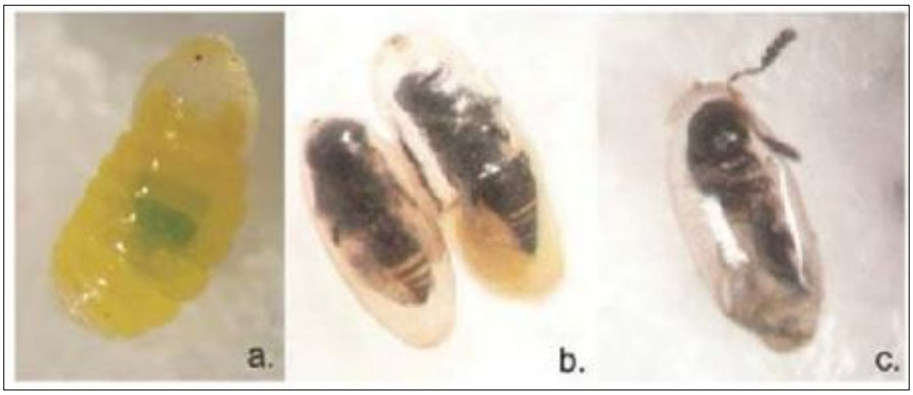
Figure 5A (19) Larva inside gall's chamber; (20 and 21) young and mature pupa inside gall's chamber; (22) undetermined hymenoptera parasitoid in the gall; (23) adult female



Source: https://www.scielo.br/j/rbent/a/9RPTCsrxLfsGcMYDTDqWnbF/?lang=e

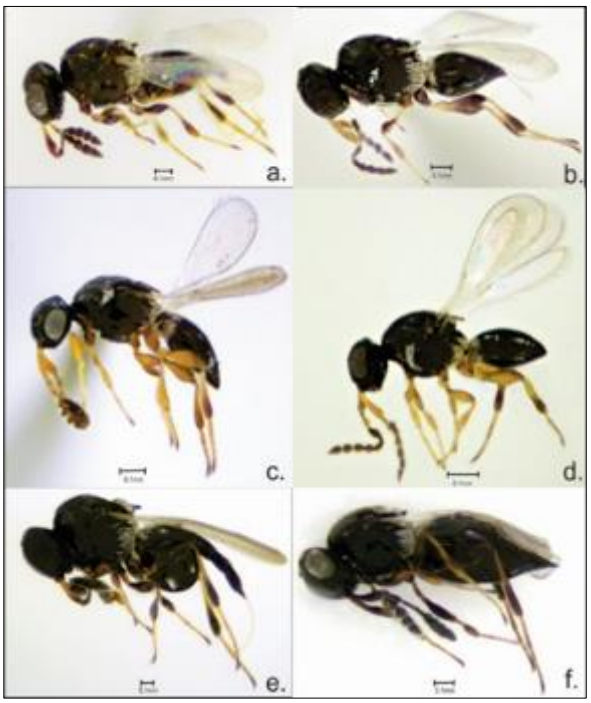
Figure 5B (2) Bud gall on *Haplopappus foliosus* (Asteraceae). Scale bar: 5 mm. (3-9) *Haplopappusmyia gregaria* Maia & Villagra, 2017: (3) adult: male head, frontal; (4) male scape and pedicel; (5) male 1st and 2nd flagellomeres; (6) female 1st and 2nd flagellomeres; (7) male 4th flagellomere; (8) female antenna; (9) female 5th flagellomere

Some other species are natural enemies of crop pests because their larvae are predators or parasitoids of the species causing these pests. The most common prey are aphids of the Aphididae family and mites. As Cecidomyiidae larvae cannot travel long distances, a large population of prey or hosts is often needed for females to lay eggs. This is why they are usually only seen when pest populations reach large numbers. In the United States one species, *Aphidoletes aphidimyza* (Rondani, 1857), is used commercially for the biological control of pests in greenhouses (Figures 5C, 5D, 6 and 7) [1,2,3].



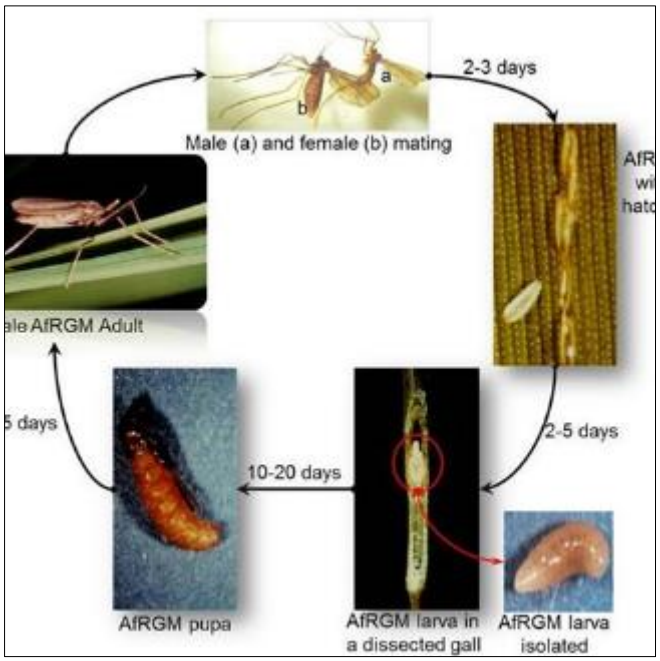
Source: emanticscholar.org/paper/Parasitoids-of-Prodiplosis-longifila-Gagné-and-in-Hernandez-Mahecha-Manzano/f0d5c8ce9d1fa214ab8f86701817535317e1fbfc#references

Figure 5C *Synopeas* Forster (Hymenoptera: Platygasteridae) are parasitoids of gall midges and bug midges (Diptera: Cecidomyiidae) worldwide Symptoms of immature stages of parasitized: a: initial symptom on a parasitized larva, b: parasitoid development on pupae, c: onset of parasitoid emergence



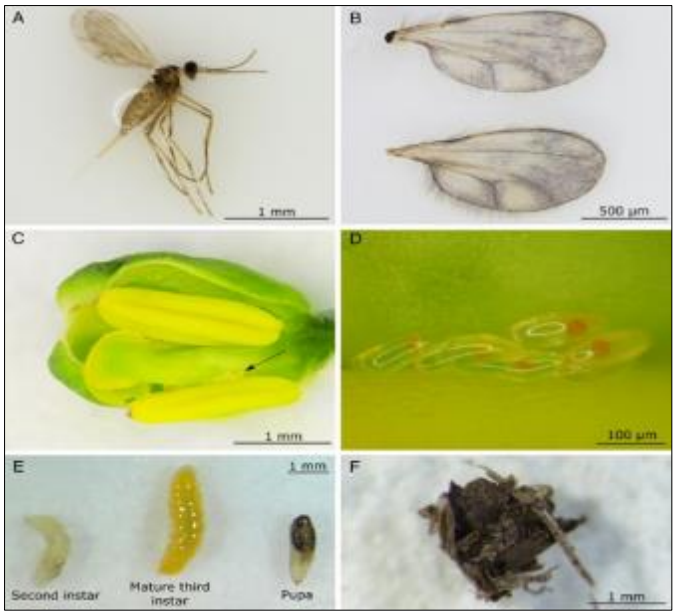
Source: https://www.researchgate.net/figure/Parasitoid-wasp-species-found-Synopeas-varipes-female-a-male-b-Synopeas_fig3_32219309

Figure 5D Parasitoid wasp species found: *Synopeas varipes* (Harrington, 1900) (Hymenoptera: Platygastridae) female (a.), male (b.); *Synopeas reticulatifrons* Buhl, 2002: female (c), male (d); *Synopeas* aff. *longiventre*: female (f); *Synopeas* aff. *curvicauda*: female (e)



Source: https://www.researchgate.net/figure/1-African-rice-gall-midge-cycle-of-reproduction-adapted-from-Nwilene-et-al-2006b_fig1_321485327

Figure 6 African rice gall midge cycle of reproduction

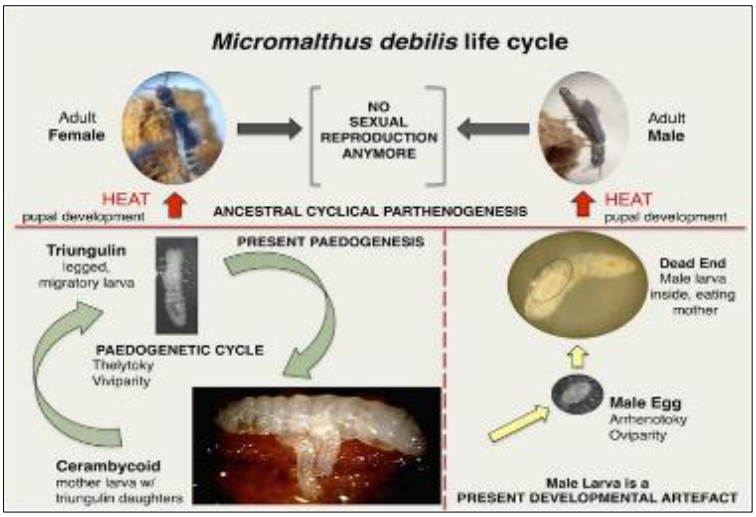


Source: https://www.cambridge.org/core/journals/canadian-entomologist/article/abs/new-species-of-contarinia-rondani-diptera-cecidomyiidae-that-induces-flower-galls-on-canola-brassicaceae-in-the-canadian-prairies/08B2446D2CB021CD1AF73E84E58A0735

Figure 7 Larvae develop in the flowers of canola, which causes swelling and prevents opening, pod formation, and seed set. Mature larvae exit the galls, fall to the soil, and form cocoons. Depending on conditions, larvae will either pupate and eclose in the same calendar year or enter facultative diapause and emerge the following year. Adults emerge from overwintering cocoons in spring and lay eggs on developing canola flower buds. The galls produced by canola (Brassicaceae) were previously attributed to the swede midge

1.2. Biology and Ecology

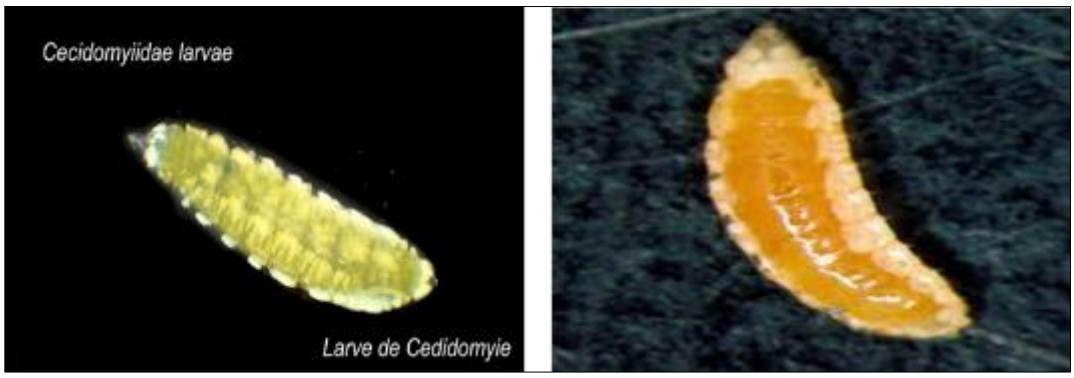
Cecidomyiidae are also known for an interesting phenomenon of infantile reproduction, or paedogenesis, in which the larvae reproduce without reaching the adult stage. Another phenomenon, even stranger, leads in some species to daughter larvae to grow inside the mother and devour her to get out (Figure 8A) [4].



Source: https://www.nature.com/articles/srep27364

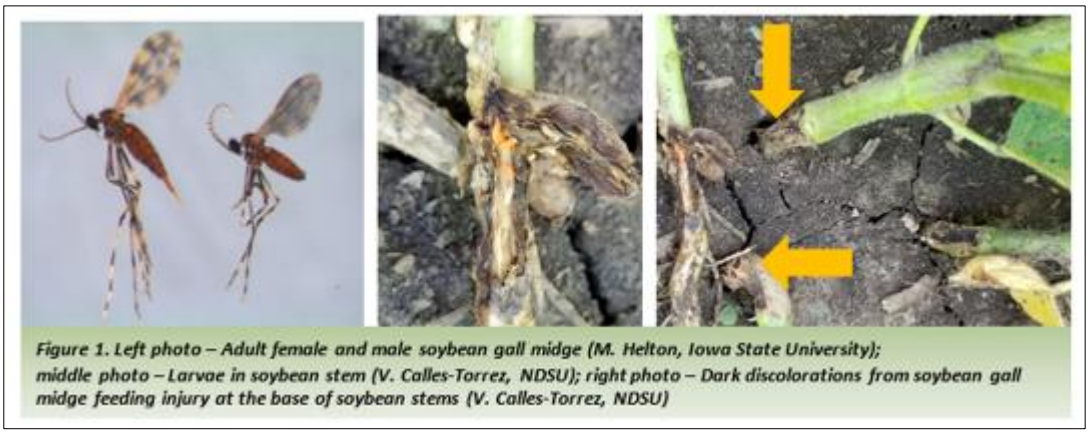
Figure 8A Bottom left: green arrows show the present time obligate paedogenesis life cycle, where viviparous 1st instar female larvae or triungulins are the legged, migratory stage. Bottom right: yellow arrows indicate rare, relic development of a male larva, where the oviparous 1st instar male larva is legless. The male larva is under present conditions a developmental dead end. Top: red arrows show the rare development of adults induced through exposure to extreme heat. Adults are no longer reproductively functional; they were part of the ancestral cycle of sexual and asexual reproduction

These forms galls of growth give rise to structures of defined size and appearance, typical action of Cecidomyiidae: spherical, greenish, with hair short distributed over the entire surface. They have a single chamber where larvae develop. The end of gall growth coincides with end of larval growth, when finally, an insect adult emerges, leaving the pupae half-buried in the output cavity. This is quite a trait widespread among Cecidomyiidae (Figures 8B and 9) [4].



Source: https://bugguide.net/node/view/1307380

Figure 8B Larvae of Cecidomyiidae



Source: https://www.ndsu.edu/agriculture/ag-hub/ag-topics/crop-production/crop-pest-report/entomology/soybean-gall-midge-update-north-dakota

Figure 9 Soybean gall midge larvae feed beneath the epidermis near the base of the stem. Sometimes the base of the stem is necrotic (dark coloration), swollen, deformed and gall-like. Heavily infested soybean plants are stunted, wilted, lodged or dead. Significant yield losses at field edges have been recorded in states with severe infestations

Cecidomyiidae family which are the most common galling insects worldwide. Females of these insects lay their eggs on plants. When the larvae hatch from the eggs, they begin to feed on plant tissues, and in their saliva there is a ecidogenic substance, which probably acts as an auxin, a plant hormone that produces growth by inducing the multiplication and growth of plant cells (Figures 10, 11, 12, 13, 14 and 15 [4].

Source: https://www.museunacional.ufrj.br/hortobotanico/galhas/clinodiplosis.html

Figure 10 Host plant: *Eugenia uniflora* L., (Myrtaceae) Galling insect: *Eugeniamyia dispar* Maia, Mendonça & Romanowski, 1996 2- (Cecidomyiidae)

Source: https://www.museunacional.ufrj.br/hortobotanico/galhas.html

Figure 11 Host plant: *Eugenia uniflora* L. (Myrtaceae): Galling insect: *Clinodiplosis profusa* Maia, 2001 (Cecidomyiidae)

Source: https://www.museunacional.ufrj.br/hortobotanico/galhas.html

Figure 12 Host plant: *Eugenia uniflora* L. (Myrtaceae) Galling insect: Galling insect: *Neolasioptera eugeniae* Maia, 1993 (Cecidomyiidae)

Source: https://www.museunacional.ufrj.br/hortobotanico/galhas.html

Figure 13 Host plant: *Ficus crocata* Mig (Moraceae) Galling insect: Cecidomyiidae sp. 2

Source: https://www.museunacional.ufrj.br/hortobotanico/galhas.html

Figure14 Host plant: *Ficus crocata* Mig (Moraceae) galling insect: Cecidomyiidae sp.1

Source: https://www.museunacional.ufrj.br/hortobotanico/galhas.html

Figure15 Host plant: *Eugenia florida* DC (Myrtaceae) Galling insect: Cecidomyidae

1.3. Diet

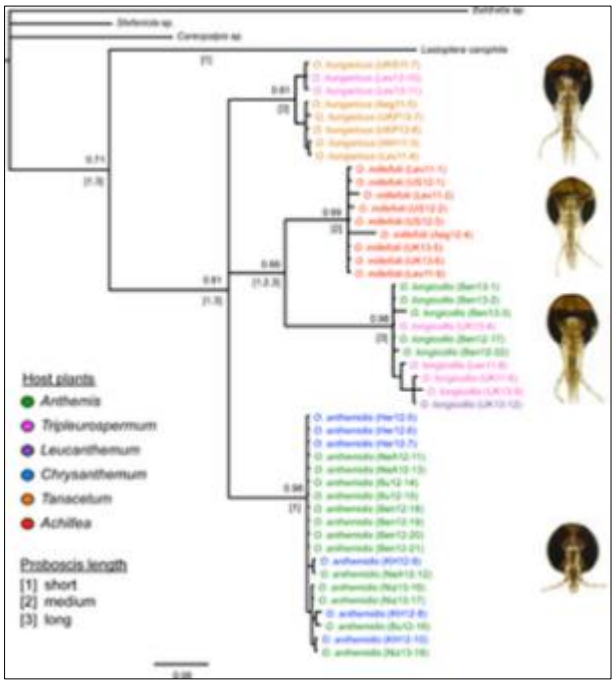
Most cecidomiids have their own mouthparts to feed on liquids. Longer-lived adults do this, using water and nectar. Most gall-causing species probably do not feed in adulthood. The females oviposited on the flowers, in which numerous larvae and pupae were found; in male inflorescences from these trees there is a fungus of the genus *Choanephora*, (fungi), on which these Diptera feed. This is the first case of pollination in which fungi play an indispensable role (Figure 16A) [5,6,7].

Source: Photo, and identified by: Nikolai Vladimirov. Image without touching the website

Figure 16A Female of Cecidomyiidae

Insects use flowers as a breeding site, not for feed on nectar. The flowers present thermogenesis, and post-a Thesis heating seems to benefit the larval development of these dipterans. Studies by other authors have already shown that cecidomiids of the genus *Megommata*, which feed on pollen, are exclusive pollinators of two species of this family (Figure 16B) [5, 6, 7].

1.4. Systematics and Phylogeny



Source: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0130981

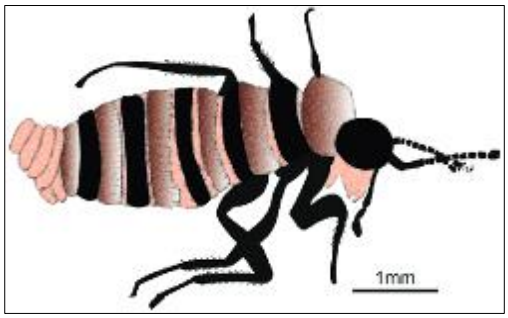
Figure 16B Phylogenetic tree of *Ozirhincus* Rondani based on Bayesian analysis of partial sequence of the cytochrome oxidase subunit I (COI) and ribosomal RNA16S mitochondrial genes. Support values are shown next to nodes, above branches. Character states representing proboscis length as suggested by the ancestral states analysis are shown below branches (in square brackets). Letters and numbers following species name refer to collecting localities and date. Colors correspond to host-plant genera

Asphondylia solidaginis Beutenmüller 1907, pupa on a gall in *Solidago* sp., *Rhopalomyia solidaginis* (Loew, 1862) *Vitisiella* larva. In its present circumscription, the family contains more than 6,000 species. The most numerous subfamily is Cecidomyiinae. The classification of some groups is not yet fully resolved.

Subfamily Cecidomyiinae, Alykaolin. Aphidoletini, Asphondyliini (includes Polystephini and Schizomyiini), Brachineurini, Cecidomyiini, Clinodiplosini, Kiefferini, lasiopterini, Ledomyiini, Lestodiplosini, Mycodiplosini, Oligotrophini, Rhizomyiini and Trotterini.

Subfamily: Lestremiinae, Acoenoniini, Baeonotini, Campylomyzini, Catochini, Catotrichini, Forbesomyin, Lestremini, Micromyini (includes Aprionini, Bryomyiini and Peromyini.

Subamiliy Porricondylinae; Ashnapti, Diallactin Dicerurini, Dirhizini, Heteropezini, Porricondylini (includes Holoneurini) and Winnertzini (Figure 17) [7,8].



Source: https://www.researchgate.net/figure/Line-drawings-of-fossil-gall-midge-Cecidomyiidae_fig5_342795702

Figure 17 Line drawings of fossil gall midge (Cecidomyiidae)

Objective

The Objective of this work is to investigate the characteristics Cecidomyiidae Family (Insecta: Diptera).

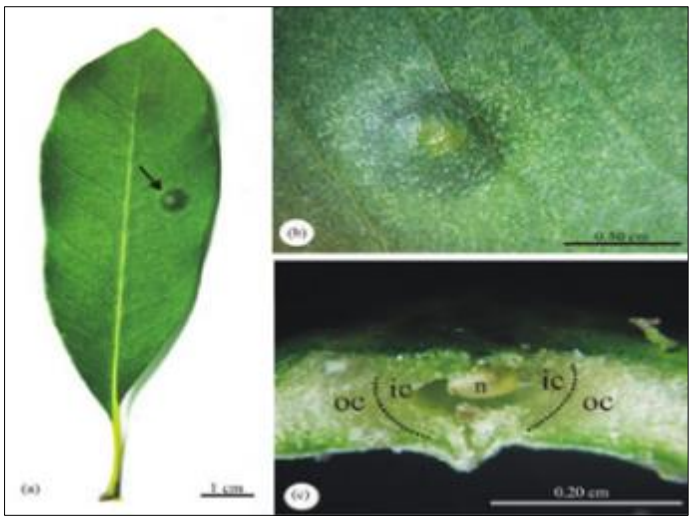
2. Methods

The method used to prepare this mini review was Marchiori 2021 methodology [9].

3. Studies conducted and selected

3.1. Study 1

Galls represent a fascinating phenomenon in the natural world, reflecting the intimate interactions of organisms, shaped over thousands of years by organic evolution (Figures 18, 19 and 20).



Source: https://www.sciencedirect.com/science/article/pii/S0168945210000324

Figure 18 Galls (Apocynaceae)

Source: researchgate.net/figure/FIGURES-122-129-Adults-of-Primocerioides-and-Sphiximorpha-species-overall-appearance_fig17_310619479

Figure 19 Adults of *Primocerioides* and *Sphiximorpha* species, overall appearance, and lateral view. 122 *Primocerioides regale* Violovich, 1985 male holotype of *Sphiximorpha hiemalis* Ricarte, Nedeljković & Hancock, 2012, 123 *P. regale* female, *Cyprus* 124 *Sphiximorpha garibaldii* Rondani, 1860 male, holotype 125 mm. *S. garibaldii* female, (holotype of *Ceria tridens* Loew, 1872, 126 *Sphiximorpha euprosopa* Rondani, 1860 male, holotype 127 *Sillaphilecta* female Greece 129, *Sphiximorpha subsessilis* (Illiger, 1807) female, Greece. Scale line = 1 mm

Source: file:///C:/Users/User/Downloads/2009_FernandesCarneiro.pdf

Figure 20 Galls induced by different organisms: (A) Gall induced by insects; (B) Mite-induced gall; (C) *Ambrosia* gall (induced by a symbiotic fungus of an insect); (D) Fungus-induced gall (witches' broom); (E) Nematode-induced gall; and (F) Loranthaceae-induced gall (little grass)

The insect is capable of modifying the growth patterns of the host plant, changing the nature of the plant tissue and leading the host to the formation of a food rich in nutrients and free from defensive chemical compounds, as well as a structure that isolates it from the environment.

Galls are also known and used for their pharmacological properties recognized since antiquity. "Aleppo galls" contain 50% to 60% of galactotanic acid, in addition to significant amounts of gallic and ellagic acids, substances used in the treatment of diarrhea, buccal inflammation and buccal inflammation and hemorrhoids.

Most of the described species of cecidomiids are associated with plants inducing or living as lodgers in galls, while few species are predators. The species of the Porrycondilinae subfamily feed on fungi, a condition considered ancestral in relation to the habit of inducing galls (Figure 21).

Source: https://pt-br.facebook.com/Baccharis/

Figure 21 Asteraceae Family

Cecidomyiidae are little known in the Neotropical Region with 500 species and 170 recorded genera. In Brazil there are 159 described species and 75 genera. Several species described in Brazil are from restinga vegetation in the State of Rio de Janeiro where 95 species and 47 genera have been reported. However, records of cecidomiids in the vegetation of the Cerrado and other Brazilian regions have increased considerably in recent years [10,11,12,13,14,15,16,17,18,19].

3.2. Study 2

3.2.1. Cecidomyiidae family

Family Representative

Rabdophaga saliciperda (Dufour, 1841) [20].

They are very small and delicate Diptera, ranging from 1 mm to 5 mm in length, with relatively long antennae and legs, and reduced alar nerves. The larvae of most species live in plants where they usually form galls, which can be found in all parts of the plant and are commonly characteristic of each species of Cecidomyiidae (Figures 22 and 23).

Source: ainfo.cnptia.embrapa.br

Figure 22 Adult of *Rabdophaga saliciperda* (Dufour, 1841)

Other larvae occur under the bark of trees, in decaying plants, in fungi, or can be predators. The larvae are tiny, have a reduced head and jaws very small. In most species, in their last larval stage, on the ventral side of the prothorax, there is a sclerotized structure called a spatula. Many larvae have vivid coloring such as red, orange or yellow.

The presence of this group can be basically noticed by the swelling and the occurrence of galls in the most varied parts of the plants. How to recognize the family:

Larva characteristics: vermiform; reduced head, conical, with tiny jaws; presence of a sclerotized structure on the ventral side of the prothorax (spatula); showy coloring: red, orange, yellow, pink; pupa with antennal appendages in the

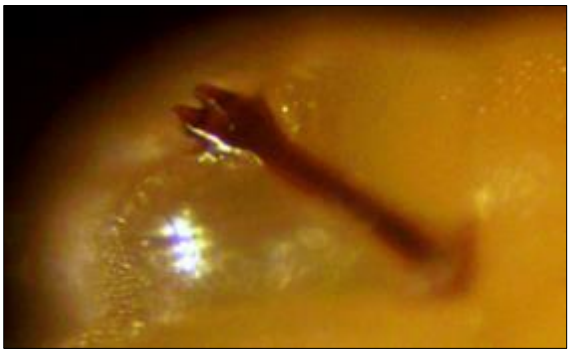
form of horns. Adult characteristics: miniature size: 1mm to 5mm; long legs; reduced alar venation (less than seven longitudinal ribs); long antennas (Figures 24, 25 and 26) [20].

Source: http://www.dorsetnature.co.uk/pages-gall/g-267.html

Figure 23 Larvae of *Rabdophaga saliciperda* (Dufour, 1841)

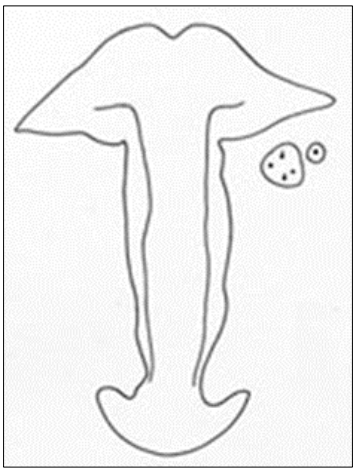
Source: http://www.dorsetnature.co.uk/pages-gall/g-267.html

Figure 24 Diptera: Cecidomyiidae - gall midge *Rabdophaga saliciperda* (Dufour, 1841)



Source:https://bladmineerders.nl/parasites/animalia/arthropoda/insecta/diptera/nematocera/cecidomyiidae/cecidomyiinae/lasiopteridi/oligotrophini/rabdophaga/rabdophaga-saliciperda/

Figure 25 Spatula 0.34-0.37 mm (n = 2) in length and two well-developed triangular apical teeth



Source:https://bladmineerders.nl/parasites/animalia/arthropoda/insecta/diptera/nematocera/cecidomyiidae/cecidomyiinae/lasiopteridi/oligotrophini/rabdophaga/rabdophaga-saliciperda

Figure 26 Prosternum with spatula

3.3. Study 3

The objective of this work was to list the species of Cecidomyiidae found in insect survey studies carried out in Restinga areas in the Atlantic Forest Biome (Figures 27, 28 and 29).

Source: https://www.shutterstock.com/pt/search/atlantic+forest+brazil

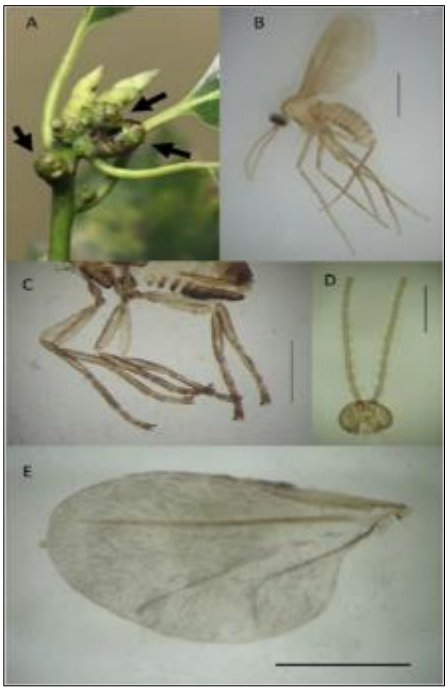
Figure 27 Atlantic Forest Biome

A total of 68 gall morphotypes were recorded, induced by 68 species of Cecidomyiidae, distributed in 35 host plant species belonging to 21 botanical families. The most frequent gall morphotypes were globose (N= 16), ovoid (N= 10), fusiform (N= 08) and circular (N= 07). The leaf was the most attacked plant organ (72%), followed by the stem (14%) and yolk (8%). Only the Restinga da Barra de Maricá (RBM) showed fruit gall, induced by *Bruggmanniella maytenuse* (Maia & Couri, 1992) in *Maytenus obtusifolia* Mart. (Celastraceae).

Source: https://advambiental.com.br/restinga-area-de-preservacao-permanente/

Figure 28 Restinga areas

The host plant families with the greatest gall richness were: Asteraceae (N=16), Myrtaceae (N= 14) and Clusiaceae (N= 7). The Neotropical region, the five botanical families with the greatest richness of galls are: Fabaceae, Asteraceae, Melastomataceae, Myrtaceae and Solanaceae. Among these, only two are suggested as super hosts in restinga areas [21].



Source: https://www.sciencedirect.com/science/article/abs/pii/S1226861518306605#!

Figure 29 *Bruggmanniella*

4. Conclusion

Some species of this family are economically important and can constitute serious pests, especially the wheat gall fly. Other important pests, among many others belonging to this family, are the flies that attack lentils the alfalfa gnat which affects several legumes, the cruciferous gnat and the gnat pears.

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