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(REVIEW ARTICLE)

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Familia Phoridae (Diptera) as a parasitoid of termites, ants, bees, tick and triatomines

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Abstract

The Objective of this work is to investigate the biology, ecology, habitat, geographic distribution, Taxonomy, life cycle, phenology, control, parasitoidism and reproduction work carried out on the Phoridae Family (Insecta: Diptera). The research was carried out in studies related to quantitative aspects taxonomic and conceptual aspects. A literature search was carried out containing articles published from 1983 to 2021. The mini review was prepared in Goiânia, Goiás, from September to October 2021, through the Online Scientific, internet, ResearchGate, Academia.edu, Frontiers, Biological Abstract, Publons, Qeios, Dialnet, World, Wide Science, Springer, RefSeek, Microsoft Academic, Science, ERIC, Science Research.com, SEEK education, Periodicals CAPES, Google Academic, Bioline International, VADLO, Scopus, Web of Science, LILACS, Medline, LIS and Portal of Scientific Journals in Health Sciences.

Keywords: *Megaselia*; Fly; Phroid; Insecta; Parasitoidism

1 Introduction

Phoridae are a family of small flies that resemble fruit flies but have a characteristic hump. Phroid flies can often be identified by their habit of running quickly across the surface, rather than taking off when they want to flee from a threat.

Figure 1 Female (left) and male (right) adult *Megaselia scalaris* (Loew, 1866) (Diptera: Phoridae) from reared colony; (Source: https://www.researchgate.net/figure/Female-left-and-male-right-adult-M-scalaris-Loew-from-reared-colony_fig1_230658029)

One of its popular English language names, scuttle fly, is a reference to this behavior. About 4000 species in 230 genera were catalogued. The best-known species, with a cosmopolitan distribution, is *Megaselia scalaris* (Loew, 1866) (Diptera:

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Phoridae). The rank of smallest fly in the world, which previously belonged to *Euryplatea nanaknihali* Brown, 2012 with 0.4mm, is now occupied by the species *Megapropodiphora*, with 0.395mm, found in the Amazon (Figures 1and 2) [1,2].

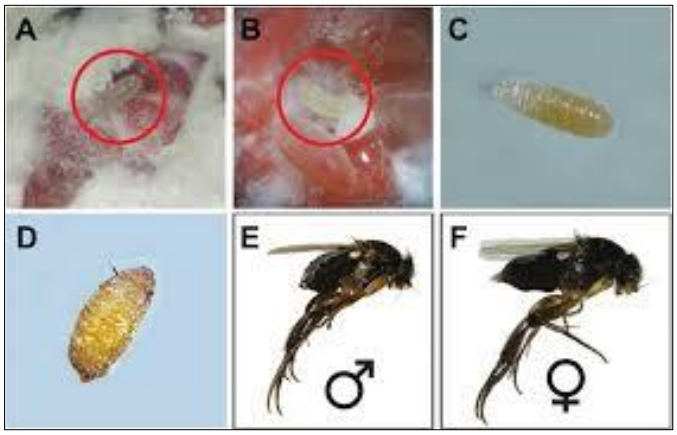

Figure 2 (A) Egg inside the ovisac (B) Just hatched larva by eggs (C) Larvae (D) Pupa Adult male. (F) Adult female; (Source: Photos: K. Muñoz)

Figure 3 Diptera-Phoridae-Scuttle Flies; (Source: Salvador Vitanza)

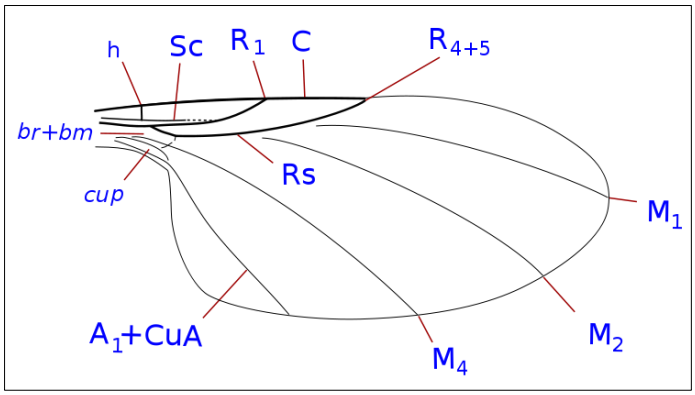

Figure 4 Longitudinal veins: C: costa; Sc: subcosta; R: radius; M: media; Cu: cubitus; A: anal. Crossveins: h: humeral. Cells: *br*: 1st basal; *bm*: 2th basal; *cup*: cell cup. Nervature longitudinali: C: costa; Sc: subcosta; R: radio; M: media; Cu: cubito; A: anale. Nervature transversely: h: omerale. Cellule: *br*: 1ª basale; *bm*: 2ª basale; *cup*: cellula cup; (Source: https://commons.wikimedia.org/wiki/File:Phoridae_wing_veins-2.svg)

The Phoridae (Diptera), characteristic for their reduced wing venation, curved shield and for their rapid and intermittent locomotion, to which their popular English name, scuttle flies, refers. Phoridae comprises several morphological and ecological superlatives. The family is considered one of the richest in diversity of larval habits among

insects, containing predatory, parasitic, parasitoid, herbivorous, saprophagous and fungivorous species (Figure 3, 4, and 5) [3,4,5].

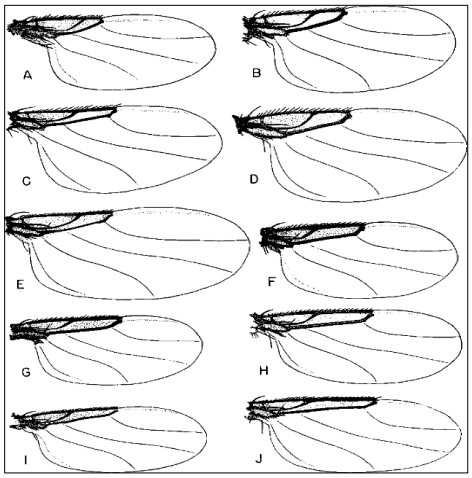

Figure 5 Wings. A, *Conicera (Tritoconkera) hawaiiensis*, n. sp., cf. B, *Gymnoptera orientalis* (de Meijere) C, *Gymnoptera longicostalis* Schmitz, D, *Gymnoptera* simplex (Brues), d\ E, *Gymnoptera vitripennis* (Meigen); (Source: emanticscholar.org/paper/A-New-Species-of-Conicera-(Diptera%3A-Phoridae)-from-Colyer/471d36a3195c1e00160905232563ac9c8f80de1b)

1.1 Parasitism and Predatism

Diversity is also considerable within each category of eating habits. Among the parasitoid phorids, for example, there is the exploitation of a myriad of different hosts, mainly arthropods, or the use of different resources from the same host. As an extreme example of parasitism, the smallest dipteran in the world is a phorid, which attacks ants in Thailand. Phoridae also encompasses genera with several other interactions with social insects, highlighting the relationship of tenantism and kleptoparasitism with termites and ants. These interactions likely had independent appearances in the evolution of the family and were accompanied by convergent changes in female morphology, which may spend part or all their lives within the host's nests (Figure 6, 7, 8, 9, 10, 11 and 12) [4,5,6,7].

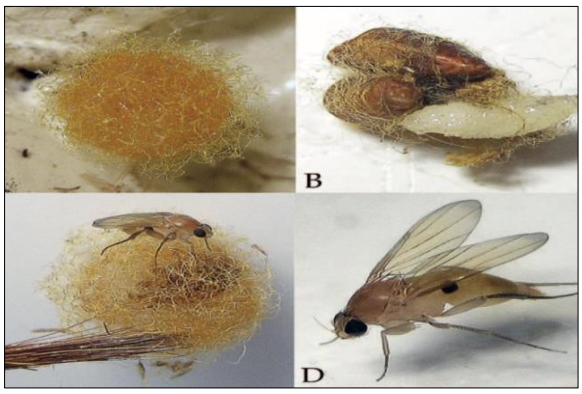

Figure 6 *Phalacrotophora epeirae* (Brues, 1902) (Phoridae) development on spider egg sac; (Source: https://www.researchgate.net/figure/Phalacrotophora-epeirae-Phoridae-development-on-spider-egg-sac_fig5_315758000)

Figure 7 In nature there is a species of fly that uses the body of an ant as a host for oviposition, these flies are from the parasitic family Phoridae, genus *Apocephalus*. They are called "Ant-decapitating flies", as females of this species land on the host and lay eggs on the head, chest, or abdomen. The deposited larvae feed on the living tissue of the host's body; (Source: https://antzbrazil.wordpress.com/category/parasitas/)

Figure 8 Parasitism: Flies and Ants (Females lay eggs on the ant); (Source: https://antzbrazil.wordpress.com/category/parasitas/)

Figure 9 Females lay eggs on the ant; (Source: https://antzbrazil.wordpress.com/category/parasitas/)

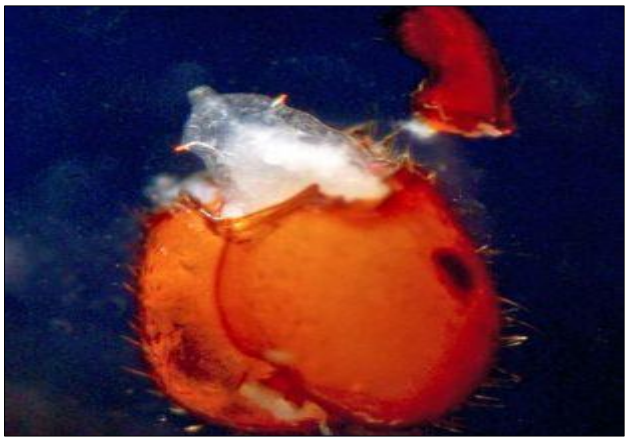

Figure 10 The larva feeds on the tissues; (Source: https://antzbrazil.wordpress.com/category/parasitas/)

Figure 11 It hatches and is in the adult stage; (Source: https://antzbrazil.wordpress.com/category/parasitas/)

However, the ants of the *Atta cephalotes* (L., 1758) (Formicidae: Myrmicinae) species protect themselves, when a large worker called "medium" is carrying the leaves to cultivate the fungus; a smaller worker is carried along with this leaf fragment to defend against this predatory fly.

Figure 12 I had taken this photo on the farm, and I thought: "Oh, look at this worker who is a profiteer, but after I read the article. Therefore, the fly does not attack the average; (Source: Photos: http://news.nationalgeographic.com/news/bigphotos/72740266.html)

1.2 Importance

Megaselia scalaris, a synanthropic and cosmopolitan species, joins the list of superlatives as the most versatile saprophages ever known, feeding on a huge variety of decaying organic matter and even unusual substrates such as blue paint and wax (Figures 13, 14, 15, 16 and 17) [8,9,10].

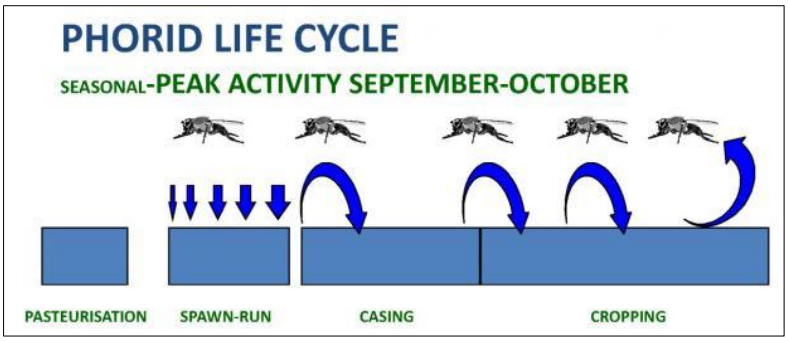

Figure 13 After mating, adult females are developing to mushroom mycelia in spawned compost. The compost remains attractive to adult females throughout the entire spawn-run period and is particularly susceptible during the second week. Mycelial development, which occurs following casing, renews attraction to adult females. Each female can lay up to 50 eggs near developing mycelia. Duration of the life cycle is temperature dependent and will vary in relation to the environmental conditions associated with cropping periods. Increased air temperatures associated with spawn-run and case-run periods facilitate life cycle completion in 24-26 days. The lower temperatures following breaking and during cropping periods may extend the life cycle to 40-50 days; (Source: https://www.afbini.gov.uk/articles/insect-pests-mushrooms-phoridae)

Figure 14 Phorid egg; (Source: https://www.afbini.gov.uk/articles/insect-pests-mushrooms-phoridae)

Figure 15 Phorid larva; (Source: https://www.afbini.gov.uk/articles/insect-pests-mushrooms-phoridae)

Figure 16 Phorid pupa; (Source: https://www.afbini.gov.uk/articles/insect-pests-mushrooms-phoridae)

Figure 17 Adult female Phorid; (Source: https://www.afbini.gov.uk/articles/insect-pests-mushrooms-phoridae)

1.3 Habitat

Phoridae comprises several morphological and ecological superlatives. The family is considered one of the richest in diversity of larval habits among insects, containing predatory, parasitic, parasitoid, herbivorous, saprophagous and fungivorous species. Diversity is also considerable within each category of eating habits. Among the parasitoid phorids, for example, there is the exploitation of a myriad of different hosts, mainly arthropods, or the use of different resources from the same host. As an extreme example of parasitism, the smallest dipteran in the world is a phorid, which attacks ants in Thailand [10,11,12].

1.4 Description

Phoridae also encompasses genera with several other interactions with social insects, highlighting the relationship of tenantism and kleptoparasitism with termites and ants. These interactions likely had independent appearances in the evolution of the family and were accompanied by convergent changes in female morphology, which may spend part or all their lives within the host's nests [10,11,12,13].

Females in the Metopinae-group of genera of the Metopininae subfamily, for example, have reduced eyes, modified legs, and can be apters or brachypters. Those of the subfamily Termitoxeniinae have similar modifications, but with an extremely aberrant morphology, with the physiogastric abdomen, mimetic to termite nymphs. Females of the subfamily Aenigmatiinae also have the adaptations to life in nests, but with limuloid bodies as defense, also quite characteristic (Figure 18) [12,13].

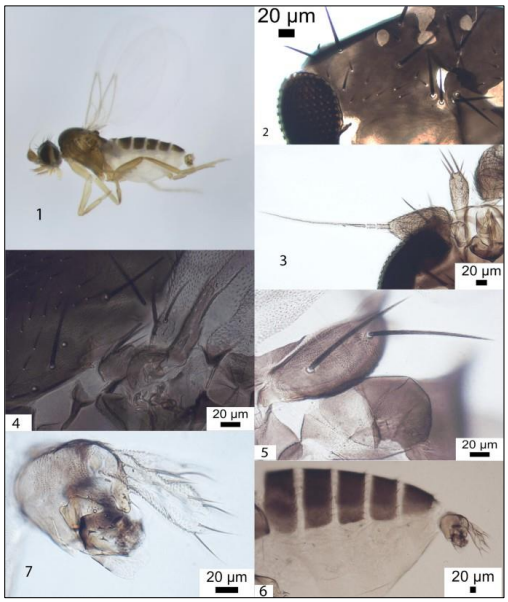

Figure 18 *Iranphora sharafkhaneensis* sp. n., male. 1 Whole fly; 2 frons; 3 antenna and palp; 4 notopleuron; 5 scutellum; 6 abdomen; 7 left face of hypopygium; (Source: https://link.springer.com/article/10.1007/s11756-021-00762-5)

1.5 Biology

More rarely phorids can be pollinators, cause myases in humans, or damage mushroom and corn crops. The family also stands out for containing one of the largest genera ever defined, *Megaselia* Rondani, which currently has approximately 1600 described species. In just one location in Sweden, 330 species of this genus were found (Bonet, 2006) (Figure 19) [15].

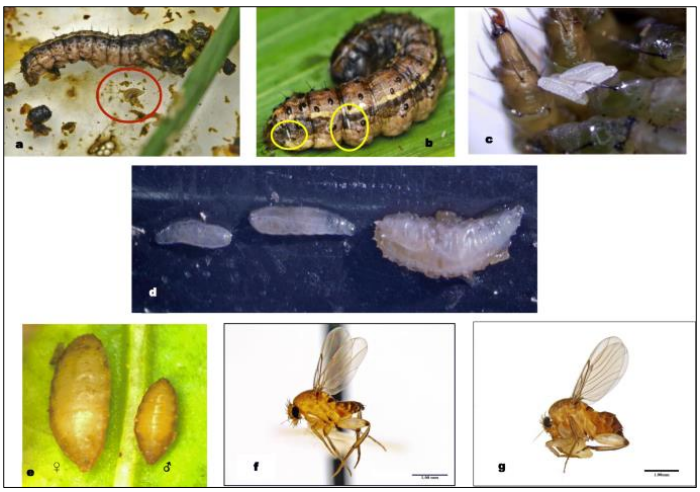

Figure 19 Developmental stages of *Megaselia scalaris* (Loew, 1866). a. Maggots emerging out of infested larva. b Eggs laid on later instar larva. c Eggs laid on pre-pupa. d Three instars of maggot. e Female and male pupa. f Adult male. g Adult female; (Source: First record of a parasitoid, Megaselia (M) scalaris (Diptera: Phoridae) of fall armyworm, Spodoptera frugiperda (Smith, 1797) (Lepidoptera: Noctuidae) from India)

Phoridae is an excellent indicator of the conservation status of an area, as it has varied habits and life strategies, featuring parasitic, parasitoid, predatory and saprophagous species. Phoridae can be considered a potential biological control agent, as it has leaf-cutting ant parasitic species, mainly from the genus *Atta* (Hymenoptera: Formicidae) [15,16].

1.6 Ecology

Add are predators or parasites of earthworms, snails, spiders, centipedes, millipedes, and insect eggs, larvae, and pupae. The adults feed on nectar, honeydew, and the juices exuding from fresh carrion and dung. Some adults feed on the body fluids of living beetle larvae and pupae, others prey on small insects. Several species have the common name coffin fly, because they breed in human corpses with such tenacity, they can even continue living within buried coffins. For this reason, they are important in Forensic Entomology (Figure 20) [15,16].

Figure 20 Phorid Fly (Phoridae) laying eggs on leafcutter ant head, the developing larva will eventually decapitate the ant, Costa Rica; (Source: https://www.naturepl.com/stock-photo-phoridae-nature-image00476960.html)

Most commonly, they feed on decaying organic matter. Because they frequent unsanitary places, including drainpipes, they may transport various disease-causing organisms to food material. The adults are conspicuous because of their fast and abrupt running. In some species, the evils fly in swarms. *Megaselia halterata* (Wood, 1910), the mushroom phorid, is a pest of mushroom cultures. Although it does not cause direct damage, it is an efficient vector of dry mold *Lecanicillium fungicola* (Preuss, 1851) Zare & Gams [synonym: *Verticillium fungicola* (Preuss 1851) Hassebrauk] (1), an ascomycete fungus (Order: Hypocreomycetidae) (Figure 21) [15,16].

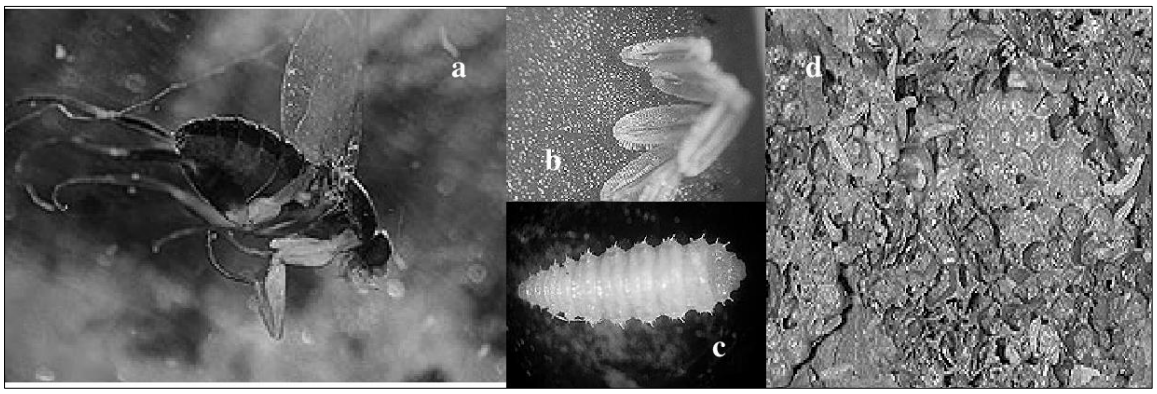

Figure 21 *Pseudohypocera kerteszi* (Enderlein, 1912) female. b: batch of eggs of *P. ker*teszi. c: larva of *P. kerteszi*. d: larvae of *P. kerteszi* feeding on the contents of the brood combs (the comb is destroyed); (Source: https://www.semanticscholar.org/paper/The-behaviour-of-the-kleptoparasite%2C-Pseudohypocera-Jong-Sommeijer/5249a630af33164a1214a3cf993aa08c31242daa/figure/1)

The behavior of the kleptoparasite, *Pseudohypocera kerteszi* (Enderlein, 1912) (Diptera, Phoridae). Some interactions between different organisms can be characterized by opportunism, such as kleptoparasitism. Parasitism is defined as an interaction between a parasitic species that obtains resources through one or several host individuals, causing damage and causing damage to the host species. The term kleptoparasitism ('kleptein', from the Greek: 'steal' 'steal') was introduced to describe the theft of food previously collected or processed by some other individual [15,16].

Source: Garcia GO. Kleptoparasitism as an opportunistic trophic strategy: costs and benefits for parasites and hosts. [Doctoral Thesis] Universidad Nacional de Mar del Plata. 2010.

1.7 Life cycle

Phorid flies develop from eggs into larval and pupal stages before emerging as adults. The female lays from one to 100 tiny eggs at a time in or on the larval food. She can lay up to 750 eggs in her lifetime. The time it takes from egg to adult varies on the species, but the average is about 25 days (Figure 22) [15,16].

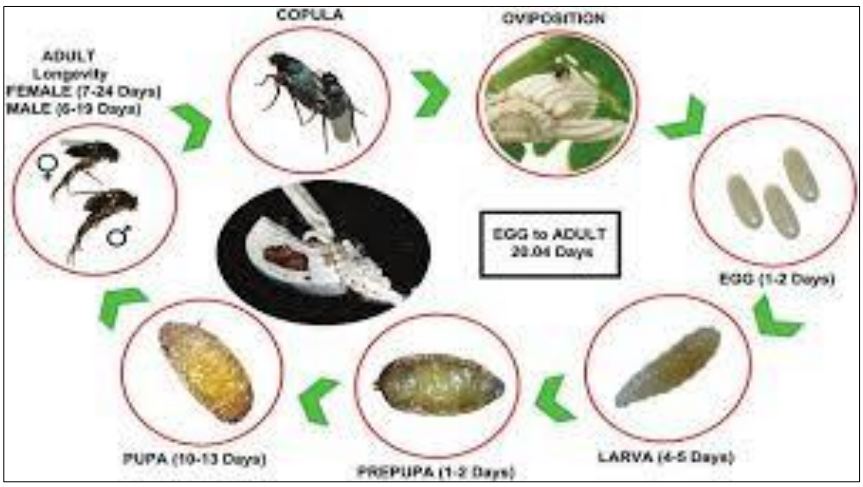

Figure 22 Life cycle of *Syneura cocciphila* Coquillett, 1895, under laboratory conditions (26.6 ± 1.5°C; RH: 62.8 ± 6.17%); (Source: Photos K. Muñoz)

The larvae emerge in 24 hours and feed for a period between 8 and 16 days, before crawling to a drier spot to pupate. The phorid fly's egg-to-adult lifecycle can be as short as 14 days but may take up to 37 days.

Many species of phorid flies are specialist parasitoids of ants, but several species in the tropics are parasitoids of stingless bees. These affected bees are often host to more than one fly larva, and some individuals have been found to contain 12 phorid larvae. Other species, especially those of the giant genus *Megaselia*, develop in various fungi during their larval stage and may be pests of cultivated mushrooms [15,16].

1.8 Taxonomy

Females in the Metopinae-group of genera of the Metopininae subfamily, for example, have reduced eyes, modified legs, and can be apters or brachypters. Those of the subfamily Termitoxeniinae have similar modifications, but with an extremely aberrant morphology, with the physiogastric abdomen, mimetic to termite nymphs. Females of the subfamily Aenigmatiinae also have the adaptations to life in nests, but with limuloid bodies as defense, also quite characteristic. Classification within the family is currently under dispute. Several authors have proposed different divisions of subfamilies over the years [15,16].

The family into four subfamilies: Aenigmatiinae, Metopininae, Phorinae and Thaumatoxeninae and transferred the termitophile phorids known until then to the Termitoxeniidae family. Thaumatoxeninae being distinguished by their extremely modified forms [15,16,17].

Metopininae and Phorinae were composed of the most frequently found phorids and with the most common morphology, distinguishable from each other mainly by the presence of a groove in the anepisternum in Metopininae, absent in Phorinae. Observations, found that females inserted in Alamirinae correspond to the winged stage of females of Termitoxeniinae, having synonymized these two subfamilies. Classification within the family is currently under dispute. Several authors have proposed different divisions of subfamilies over the years [15,16].

Objective

The Objective of this work is to investigate the biology, ecology, habitat, geographic distribution, Taxonomy, life cycle, phenology, control, parasitoidism and reproduction work carried out on the Phoridae Family (Insecta: Diptera).

2 Methods

The method used to prepare this mini review was Marchiori 2021 methodology [17].

3 Studies conducted and selected

3.1 Study 1

Given the gap in knowledge of neotropical phorids and the complete absence of taxonomic and diversity surveys of this family in Rio Grande do Sul, this work aims to identify Phorinae species from the Coastal Plain of Rio Grande do Sul.

Ninety-nine individuals of the Phorinae subfamily were collected, distributed in five genera: *Chaetocnemistoptera* Borgmeier, *Coniceromya* Borgmeier, *Conicera* Meigen, *Diploevra* Lioy and *Dohrniphora* Dahl. The region with the highest number of individuals was region 1 with 38 individuals, followed by region 4 with 34 individuals, region 2 with 15, region 5 with seven and region 3 with five individuals. *Dohrniphora* was the most represented genus both in number of species (eight) and in abundance (63 individuals), which is expected. *Dorhniphora* is the largest genus of the subfamily with more than 175 described species, and after *Megaselia* it is the second most collected genus of Phoridae. The eight species of *Dohrniphora* were *Dohrniphora biseriata* Borgmeier, 1960, *Dohrniphora diplocantha* Borgmeier, 1960, *Dohrniphora dispar* Enderlein, 1912, *Dohrniphora fuscicoxa* Borgmeier, 1923, *Dohrniphora longirostrata* Borgmeier, 1912, *Dohrniphora* sp.1, *Dohrniphora* sp.2 and *Dohrniphora* sp. 3 (Figure 23).

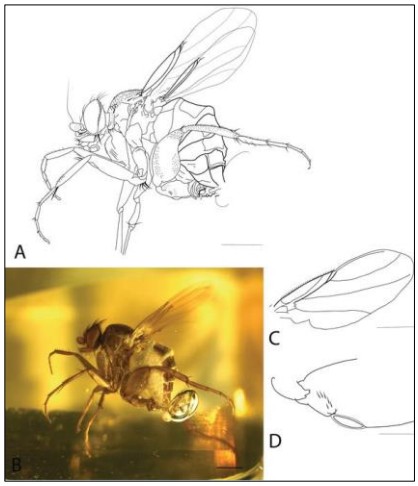

Figure 23 Swarming behavior in *Dohrniphora* females is noted for the first time. Probably, these females were frequently used in large numbers to dead and decaying insects and other animals trapped in resin. Another phorid genus with similar habits, *Puliciphora*, frequently co-occurs in amber pieces containing *Dohrniphora* specimens; (Source: https://brill.com/view/journals/ise/49/3/article-p299_299.xml?language=en)

Due to the current state of knowledge of the genus, it was not possible to determine the abundance of each species, as only males can be identified, as females are cryptic. Thus, of all individuals collected, 34 were female and could not be identified. The male specimens of *Dohrniphora* that could not be identified probably belong to species not yet described, given the little knowledge of the neotropical fauna. The following species and number of individuals represented the other genera: *Coniceromyia anacleti* Borgmeier, 1925 (13), *Conicera* sp. (11), *Diplonevra* sp. (7) and *Chaetocnemistoptera pityropyga* Ament, 2014 (5) [18].

3.2 Study 2

The objectives of the study were to identify the parasitic fly species found in the termite bodies and in the termite mounds.

A total of 240 larval stages were found in four mounds, divided into the 14 dead larvae found in the heads, and 226 living larvae found in the bodies of the *Mimus gilvus* Vieillot, 1807soldiers from the four mounds. Only one phorid larva was found in an individual soldier termite, with a single exception in which five larvae were found in the head of one soldier. Sixty-seven pupae developed from the larvae under laboratory conditions, but adult flies did not emerge from

them. However, 75 adult Phorid flies were found in the mounds. They showed the rapid bursts and short pauses of movement that are characteristic of the family Phoridae. The numbers and percentages of parasitized soldiers of the two castes for the four mounds (Figure 24) [19].

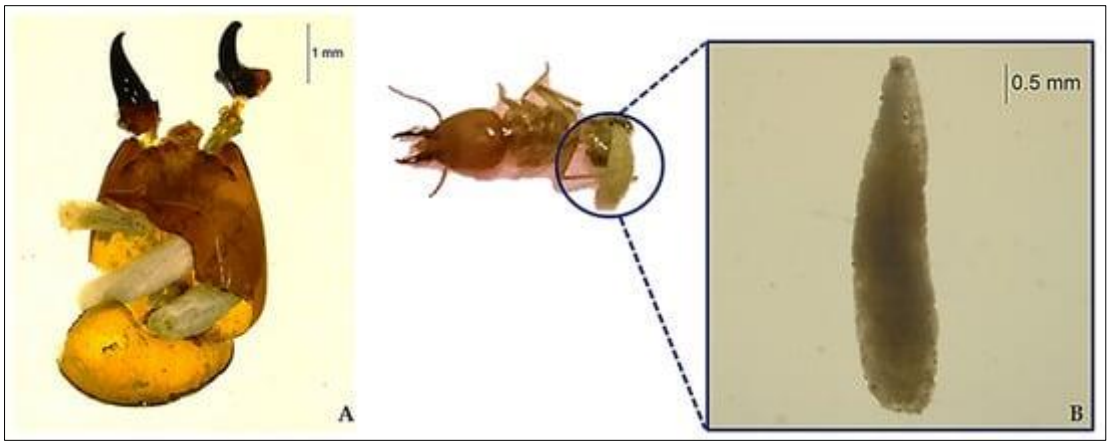

Figure 24 Larvae in the soldier termite head (A) and emerging from the soldier termite body (B); (Source: https://www.mdpi.com/2075-4450/11/5/318/htm)

3.3 Study 3

3.3.1 *Pseudohypocera kerteszi* (Enderlein, 1912) (Diptera, Phoridae)

In honeybee hives, adult comb flies move very quickly between and over the combs, especially in the lateral combs, temporarily hiding inside the comb's alveoli. Its larvae have a whitish-yellow color and a characteristic shape of the order Diptera: the head is not visible, and they do not have legs. In the last instar, they measure 0.8 to 1 cm, so they are much larger than the adult. Once the larval stage is completed, the flies pass to the pupal stage, ending their cycle of metamorphoses and breaking the cocoon to initiate adulthood food, followed, consecutively, by new cycles of infestation (Figure 25, 26 and 27).

Figure 25 *Pseudohypocera kerteszi* (Enderlein, 1912) (Diptera, Phoridae); (Source: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/viewer.html?pdfurl=https%3A%2F%2Fwww.infoteca.cnptia.embrapa.br%2Fbitstream%2Fdoc%2F931952%2F1%2F24346.pdf&clen=4360487)

Figure 26 larvae of *Pseudohypocera kerteszi* (Enderlein, 1912) (Diptera, Phoridae)

However, some species of this family have very peculiar habitats, developing inside active anthills, termite mounds, hornets and even bee nests. Females in species that inhabit anthills and termite mounds often do not have wings, which can also occur in phorids that live permanently with colonies of certain meliponini, such as irapuás or mandaçaias [19].

Figure 27 A dead colony of *Melipona marginata* Lepeletier, 1836 (Hymenoptera: Apidae) infested with larvae of *Pseudohypocera kerteszi* (Enderlein, 1912) (Diptera, Phoridae), most of them walking and feeding on the honey and pollen pots; (Source: Photo by Cristiano Menezes) (In color at www.bulletinofinsectology.org))

3.4 Study 5

The present work decided to investigate this aspect, comparing the attractiveness between red wine vinegars and white wine vinegars. Another point investigated was the possible increase in colony infestation using "phorid hunting" traps.

A total of 633 phorids of the species *Pseudohypocera kerteszi* (Enderlein, 1912) (Diptera, Phoridae), 361 in red vinegar and 270 in white vinegar were captured. The analysis of data obtained through the Wilcoxon test for paired data showed that there was no significant difference in the number of phorids captured in different types of vinegar (white or red) in colonies of *Melipona flavolineata* Friese, 1900 (Z=0.77; N=26 ep=0.44) and *Melipona seminigra* Cockerell, 1919 (Hymenoptera, Apidae, Meliponini) (Z=0.45; N=13 and p=0.65). The results obtained demonstrate that both red wine vinegar and white wine vinegar are equally efficient for the control of phorids (Figures 28, 29 and 30) [20].

Figure 28 Standard 40 ml bottle used as "phorid hunt"; (Source: https://www.apacame.org.br/mensagemdoce/121/artigo3.htm)

In 70 replicates made throughout the experiment, no phorids were captured in the traps placed in empty boxes, which allows us to infer that the traps alone do not attract phorids that are outside the colony into the colony. This suggests that these parasites are attracted to other factors, probably due to the odors of bees and pollen pots that may be open [20].

Figure 29 Embrapa Eastern Amazon, in Belém - PA, place of the experiments; (Source: https://www.apacame.org.br/mensagemdoce/121/artigo3.htm)

Although the use of traps with vinegar is common, in severe cases of infestation, traps are insufficient to solve the problem; in these cases, a drastic cleaning of the entire colony is recommended, removing all the phorid larvae found, keeping only the pupae discs (lighter discs), the pollen pots closed and not infested [20].

Figure 30 Phorid Collecting Traps (white and red wine vinegar) inside hive of *Melipona flavolineata* Friese, 1900;

(Source: https://www.apacame.org.br/mensagemdoce/121/artigo3.htm)

3.5 Study 6

A potential tick control alternative that is being studied by the researcher is the *Megaselia scalaris* fly.

Embrapa Gado de Corte, in partnership with Unicamp and Unesp, recorded, for the first time, in the region of Campo Grande/MS, the presence of *Megaselia scalaris* (Loew, 1866) parasitizing engorged females of *Boophilus microplus* (Canestrini, 1887) (Arachnida: Ixodidae), impacting the production of eggs of this parasite (Figure 31).

Figure 31 Eggs of *Megaselia scalaris* (Loew, 1866) (Diptera; Phoridae) measuring 0.6 mm long by 0.2 mm in diameter. Note the micro hair region of the face dorsal, called cactus like, so named because it resembles the trunk of the cactus with young leaves, which in Brazil, especially in the Northeast and is popularly known as the palm. In cactus, the leaves evolve into cladodes, which are modified spines. Also note that the ventral side of the egg is smooth

The fly is found in many environments, as it could explore a wide variety of ecological niches. Attracted by the adult female of *B. microplus*, in which it penetrates, in a variable number of larvae, feeding on tissues, reducing egg production. "The presence of *M. scalaris* larvae in tick engorged females affected in different degrees the egg production during the laying period as a function of the number of larvae present inside the parasite (Figures 32, 33, 34 and 35) [21].

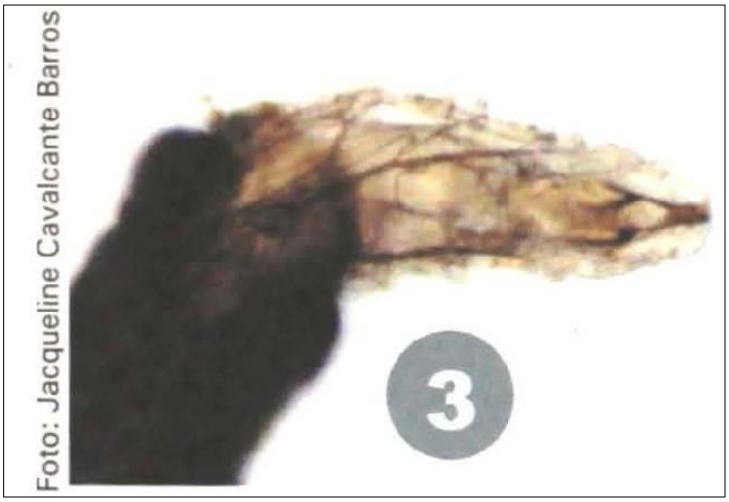

Figure 32 Moment of hatching of the *Megaselia scalaris* (Loew, 1866) (Diptera; Phoridae) larva, already partially outside the membranes that make up the eggshell (chorium and others), which appear only in part; (Source: emanticscholar.org/paper/A-mosca-Megaselia-scalaris-(Loew)-(Diptera%3A-do-uma-Koller.W. Andreotti/32cdcafc996345217f6a6e3addc8cbba84569553)

Figure 33 Partial view of an adult *Megaselia scalaris* (Loew, 1866) (Diptera; Phoridae), highlighting the alar venation, characteristic of the Phoridae family, as well as the head (antennae, palps, proboscides)

Figure 34 Pupae and adults of *Megaselia scalaris* (Loew, 1866) (Diptera; Phoridae), with emphasis on the flat appearance and semi-opaque yellow color of these and the "hump" of the adult; (Source: emanticscholar.org/paper/A-mosca-Megaselia-scalaris-(Loew)-(Diptera%3A-do-uma-Koller.W.-Andreotti/32cdcafc996345217f6a6e3addc8cbba84569553)

Figure 35 Stages of the evolutionary cycle of *Megaselia scalaris* (Loew, 1866) (Diptera; Phoridae), except the egg stage. In this Larva L 1 2.9 mm; L2 - 3.9 mm and L3 5.3 mm; (Source: emanticscholar.org/paper/A-mosca-Megaselia-scalaris-(Loew) -(Diptera%3A-do-uma-Koller.W.-Andreotti/32cdcafc996345217f6a6e3addc8cbba84569553)

Figure 36 *Boophilus microplus* (Canestrini, 1887) (Arachnida: Ixodidae); (Source: http://www.invencoesbrasileiras.com.br/controle-do-carrapato-bovino/)

3.6 Study 7

Megaselia scalaris (Loew, 1866) (Diptera: Phoridae), as a biological control agent of the litter-dwelling darkling beetle *Luprops tristis* (Fabricius, 1801) (Coleoptera: Tenebrionidae), a serious home-invading pest of southern India, is reported. In the laboratory, *M. scalaris* parasitized dormant, aggregated populations of *L. tristis. Megaselia scalaris* completed its life cycle by feeding on the decaying substrate consisting of dead L. tristis and their excreta. *Megaselia scalaris* larvae fed on the viscera of parasitized *L. tristis* within a day and were not deterred by the defensive gland secretion of the host. The scuttle flies preferred *L. tristis* as a food source even when an alternative organic food source was available, and it parasitized only inactive *L. tristis* (Figures 37 and 38) [22].

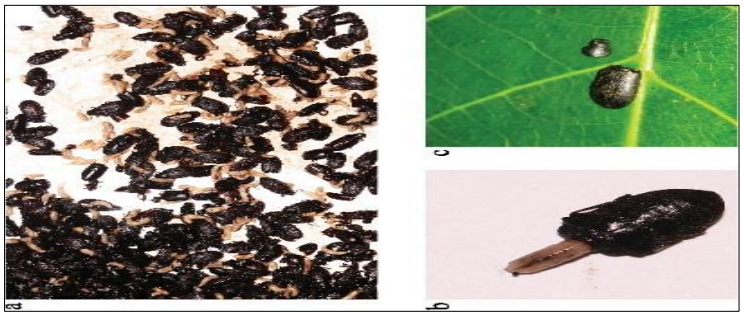

Figure 37 Biological Control Potential of the Scuttle Fly, *Megaselia scalaris* (Loew, 1866) (Diptera: Phoridae), on the Home-Invading Pest *Luprops tristis* (Fabricius1801) (Coleoptera: Tenebrionidae); (Source: https://bioone.org/journals/the-coleopterists-bulletin/volume-74/issue-2/0010-065X-74.2.331/Biological-Control-Potential-of-the-Scuttle-Fly-Megaselia-scalaris-Loew/10.1649/0010-065X-74.2.331.short)

In this note, we present the first report of *M. scalaris* infesting colonies of *Triatoma brasiliensis* Neiva, 1911, the most important Chagas disease vector in the semiarid zones of northeastern Brazil.

The triatomine bugs were identify and the samples of *M. scalaris* were identify. Specimens of *M. scalaris* invaded the quadrangular plastic containers (10×10×10 cm) with perforated lids where two years-old colonies of *T. brasiliensis* (X = 40 samples) were being reared under laboratory conditions (temperature: min. 21.5ºC, max. 32ºC, X = 27.63ºC, relative humidity: min. 52%, max. 96%, X = 77.5%). Two weeks later, some triatomines with atypical darker color with stretched out proboscis and legs, were found moving slowly at the bottom of the containers. All the developmental stages of *M. scalaris* were found inside the containers of the triatomine colonies. Dead insects with these symptoms presented a strong putrid odor (Figure 39) [23].

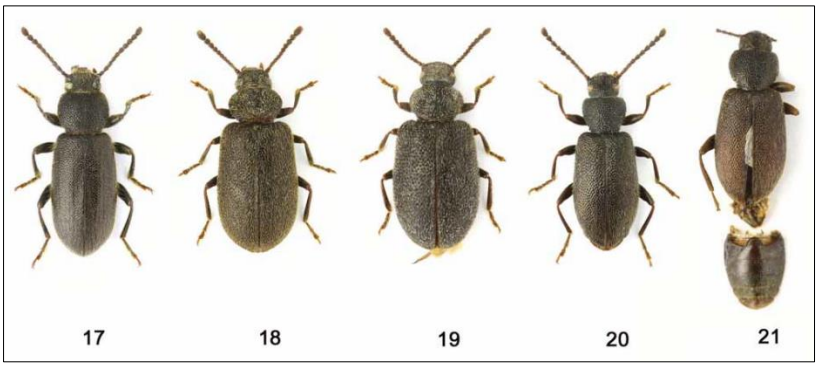

Figure 38 Habitus: 17. *Luprops rugosissimus* Kaszab, 1980; 18. *Luprops tristis (*Fabricius, 1801); 19. *Luprops curticollis* Fairmaire, 1896; 20. *Luprops gracilior* Fairmaire, 1896; 21. *Luprops devagiriensis* sp; (Source: https://treatment.plazi.org/id/03886A7BFFF39B37FF0105E4AEB2FC62)

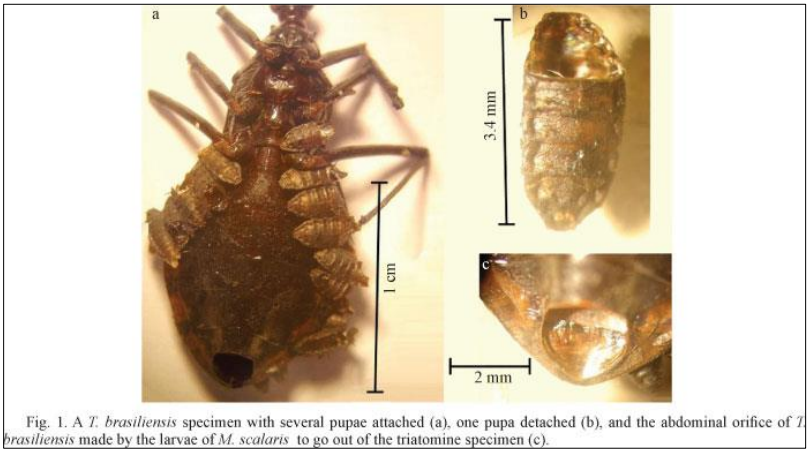

Fig. 1. A *T. brasiliensis* specimen with several pupae attached (a), one pupa detached (b), and the abdominal orifice of *T. brasiliensis* made by the larvae of *M. scalaris* to go out of the triatomine specimen (c).

Figure 39 one of the specimens found at the bottom of the container after being infested by *Megaselia scalaris* (Loew, 1866); (Source: https://www.scielo.br/j/ne/a/tKDgNzBxcZFFJpbWPVm5mFP/?lang=en)

4 Conclusion

The Phoridae (Diptera), characteristic for their reduced wing venation, curved shield and for their rapid and intermittent locomotion, to which their popular English name, scuttle flies, refers. Phoridae comprises several morphological and ecological superlatives. The family is considered one of the richest in diversity of larval habits among insects, containing predatory, parasitic, parasitoid, herbivorous, saprophagous and fungivorous species.

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