

Family Pipunculidae (Diptera) as endoparasitoids of the cicada: Agricultural pest (Homoptera)

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Abstract

The Pipunculidae Family are obligate endoparasitoids of Homoptera, notably Cicadellidae, Cercopidae, Delphacidae, Membracidae, Issidae, Cixiidae and Flatidae. They mainly attack their nymphs in different stages of development. It has been also recorded the development of some species of *Neph rocerus* Ikon, 1873 in Tipulids (Diptera: Tipulidae). Female flies usually look for suitable prey and introduce eggs into the host's hemocoel via a penetrating ovipositor. A host attacked by pipunculides is usually in the late nymphal stages; flies of the genus *Verralia* affect only the imaginal stage of the host (Cercopidae, whose nymphs live in foam masses and are therefore protected from pipunculids). The aim of this study is to report the characteristics of the family Pipunculidae endoparasitoids of cicada (Order Homoptera (Insecta: Homoptera)). For this, a bibliographic survey of Scoliidae was carried out in the years 1919 to 2021. Only complete articles published in scientific journals and expanded abstracts presented in national and international scientific events were considered.

Keywords: Biocontrol; Scarabaeidae; Larvae; Wasp; Host

1. Introduction

1.1. Description

The Family Pipunculidae is small flies, 2-8 mm, dark coloration. Head semiglobosa, huge compound eyes, occupying most of the head. Proboscis short and smooth, pad-like. Short antennae, with a dorsal edge. Wings long and slender, with M1 vein ending in the costa vein very close of vein R4+5, cell r4+5 open, anal cell closed. The large size of the head in relation to the body characterizes this family (Figures 1, 2, 3, 4, 5A and 5B) [1,2,3,4].



Source: <https://en.wikipedia.org/wiki/Pipunculidae>

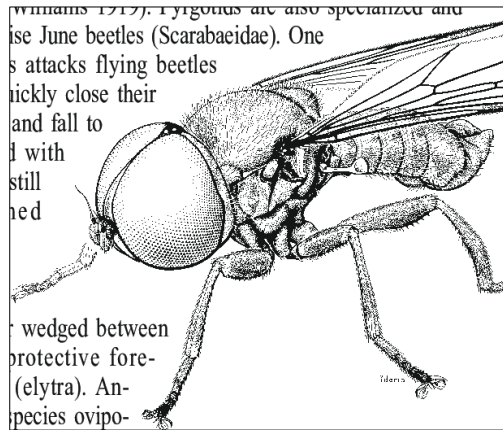
Figure 1 Specimen of Pipunculidae (dorsal view)

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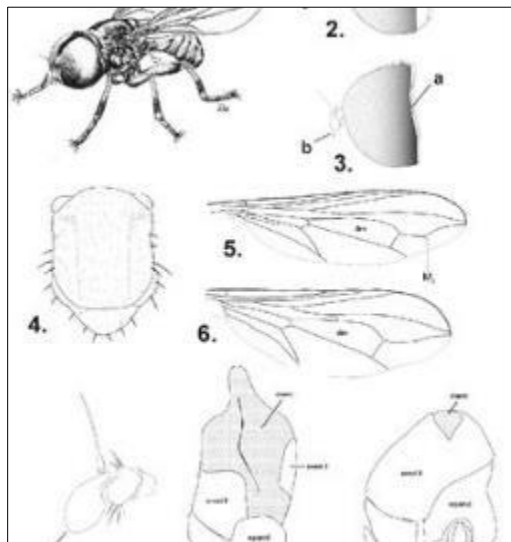
Source: <https://en.wikipedia.org/wiki/Pipunculidae>

Figure 2 Specimen of Pipunculidae (Side view)



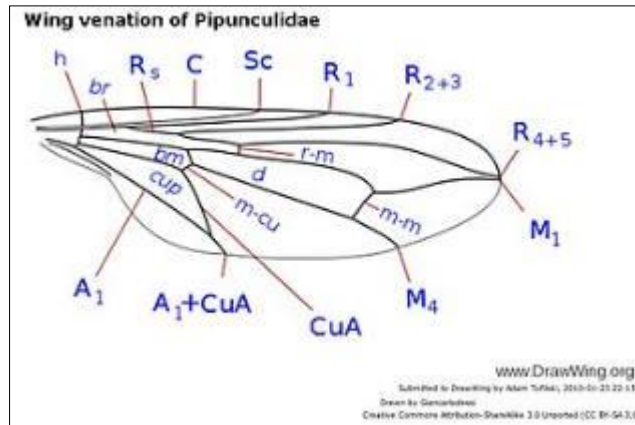
Source: from McAlpine et al 1987, p. 745 -misidentified as *Pipunculus ater* and (Illustration courtesy of AAFC)

Figure 3 Big-headed flies (Pipunculidae) such as *Pipunculus luteicornis* Cresson 1911, are internal parasitoids of various *Auchenorrhyncha* (Homoptera) families, especially leafhoppers (Cicadellidae), delphacid planthoppers (Delphacidae) and spittlebugs (Cercopidae)



Source: https://www.researchgate.net/publication/277005066_Pipunculidae

Figure 4 Abstract A review on the knowledge of the species of Pipunculidae present in Argentina is presented, with a key for the identification of genera and subgenera. A catalog of the 44 species of the country and its geographic information is also provided. Abstract A review of the current knowledge of bigheaded flies from Argentina is presented, with an identification key for genera and subgenera. A checklist of 44 species and their geographical information are also provided



Source: <https://en.wikipedia.org/wiki/Pipunculidae>

Figure 5 A Typical wing venation of Pipunculidae

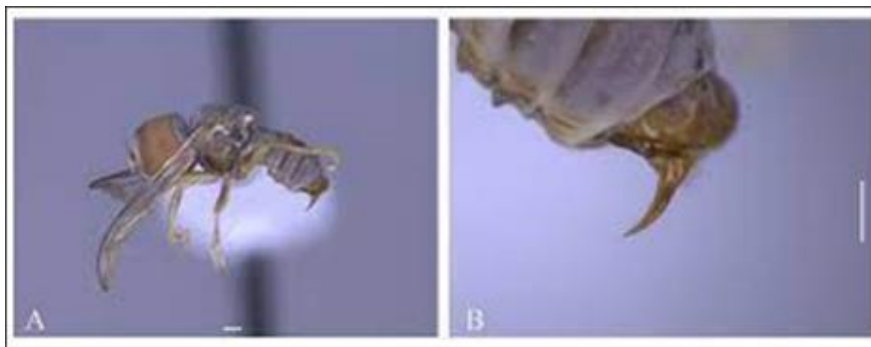


Source: <https://www.flickr.com/photos/niconguyen/41460293650>

Figure 5 B Big headed fly - Pipunculidae

1.2. Biology

With an acute ovipositor, female pipunculids pierce the integument of cicadas and some other homopterans, introducing eggs under the integument of the host. Subsequently, the larval development of pipunculides occurs in the host. Pipunculid larvae are endoparasites of Homoptera – *Auchenorrhyncha* (Figures 6 and 7) [5,6,7,8].



Source: <https://bdj.pensoft.net/article/53609/>

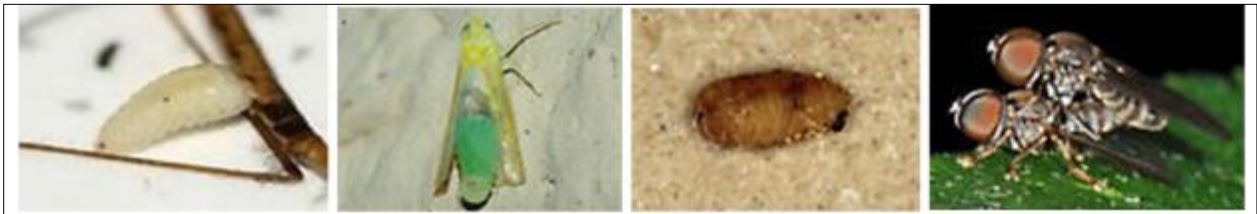
Figure 6 Female of *Eudorylas corniculans* Motamedinia & Skevington sp. n. (JSS52206) (A) habitus in lateral view; (B) ovipositor in lateral view. Scale bar = 0.25 mm



<https://www.biodiversity4all.org/taxa/144038-Pipunculidae>

Figure 7 Copulation of specimens of the Family Pipunculidae

Female flies usually look for suitable prey and introduce eggs into the host's hemocoel via a penetrating ovipositor. A host attacked by pipunculids is usually in the late nymphal stages; flies of the genus *Verralia* affect only the imaginal stage of the host (Cercopidae, whose nymphs live in foam masses and are therefore protected from pipunculids) (Figure 8) [9,10,11,12].



Source: <https://bugguide.net/node/view/67160>

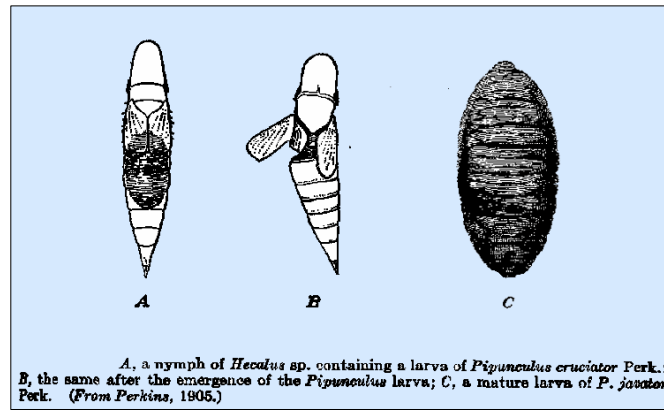
Figure 8 1 and 2: Larvae. 3: Puparium. 4: Adult male and female

Only one egg is laid inside the host. The same host can later be used by another female fly, however, only one parasitic larva completes development in the host. Pipunculid larvae, which began development in the host nymph, do not reach maturity until the host becomes an adult (Figures 9 and 10) [13,14,15,16,17].



Source: <https://bugguide.net/node/view/67160>

Figure 9 Food: Adults feed on honeydew secretions; larvae mostly parasitize leafhoppers and planthoppers; *Nephrocera* spp. parasitize crane flies Infected female



Source: From Perkins, 1905

Figure 10 A, a nymph of *Hecalus* sp. containing a larva of *Pipunculus cruciator* Perkins, 1905: B, the same after the emergence of the *Pipunculus* larva; C, a mature larva of *Pipunculus* sp.

1.3. Habitat

Adults are usually seen hovering among vegetation in forest clearings and edges (Figures 11, 12, 13 and 14).



Source: https://www.researchgate.net/figure/Tomosvaryella-argyrata-Pipunculidae-a-parasitoid-of-Scenergates-viridis-a-A_fig10_258388847

Figure 11 *Tomosvaryella argyrata* De Meyer, 1995 (Pipunculidae), a parasitoid of *Scenergates viridis* (Vilbaste, 1961) (Homoptera, Cicadellidae). (a) A puparium glued to the inner surface of a gall; note that the gall has fully opened. (b) A puparium next to sucked-out remains of a last-instar immature *S. viridis*. (c) A last-instar female nymph of *S. viridis* with a pipunculid larva inside its swollen abdomen (compare with an unparasitized nymph in Figure 16(e)). (d) An adult *T. argyrata* reared from *S. viridis*



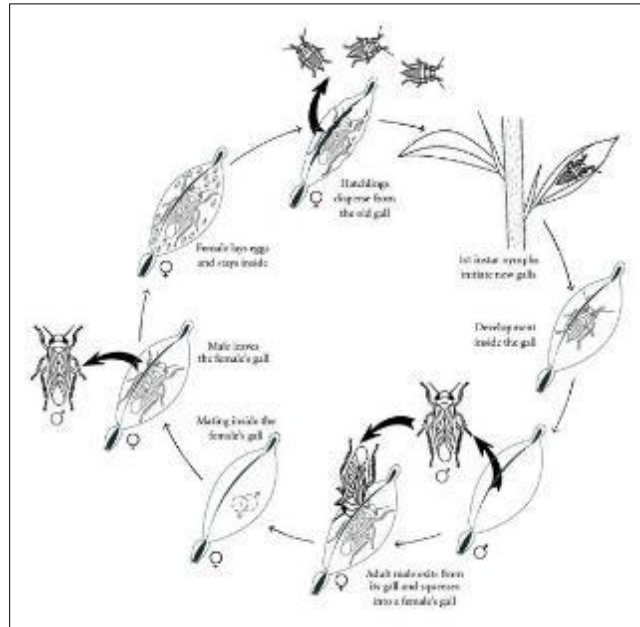
Source: https://www.researchgate.net/figure/Filatima-sp-moth-Gelechiidae-a-predator-of-the-galls-of-Scenergates-viridis-a-A_fig13_258388847

Figure 12 A dry overwintering gall of *Scenergates viridis* (Vilbaste, 1961) (Homoptera, Cicadellidae), collected in December. (a) Intact. (b) Split open. Note the dead female (white arrows) and live eggs (black arrows). ((a)-(b)). (a) A gall of *S. viridis* split open to expose the female next to its offspring, first-instar nymphs (summer generation). (b) A postoviposition female with damaged apical parts of the hindlegs (insets) ((a)-(b) (a) A gall of *S. viridis* split open to expose the female next to its offspring, first-instar nymphs (summer generation). *Filatima* sp. moth (Gelechiidae), a predator of the galls of *S. viridis*



Source: <https://www.hindawi.com/journals/psyche/2012/930975/>

Figure 13 a) *Alhagi maurorum* Medik (Fabaceae)) on the territory of the EcoCenter “Dzheiran” in Uzbekistan; note fresh green growth on the left and dead branches from the previous year on the right side of the shrub. (b) A camelthorn branch with thorns, ungalloped leaves, and galls of *Scenergates viridis* (Vilbaste, 1961) (Homoptera, Cicadellidae). (c) An intact gall of *S. viridis*. (d) An artificially opened gall with a female of *S. viridis* inside. Scale bar: 1 mm (d)



Source:

https://www.researchgate.net/publication/258388847_Life_History_of_the_Camelthorn_Gall_Leafhopper_Scenergates_viridis_Vilbaste_Hemiptera_Cicadellidae

Figure 14 The life cycle of *Scenergates viridis* (Vilbaste, 1961) (Homoptera, Cicadellidae)

1.4. Taxonomy, Phylogeny and Systematic

Unlike all Aschiza, Cyclorrhapha, pipunculids are only two larval ages. Many species have been studied for being parasitoids of pest insects in the suborder *Auchenorrhyncha* (Hem.): Cercopidae, Cicadellidae, Cixiidae, Delphacidae, Flatidae, Fulgoridae and Membracidae. The only exception is the genus *Nephrocerus*, which preys on adult Tipulidae mosquitoes. Despite its importance, little is known about its relationships with hosts.

The family has about 600 species of Diptera, belonging to 10 to 11 genera, common in all regions of the planet. In Russia, about 200 species.

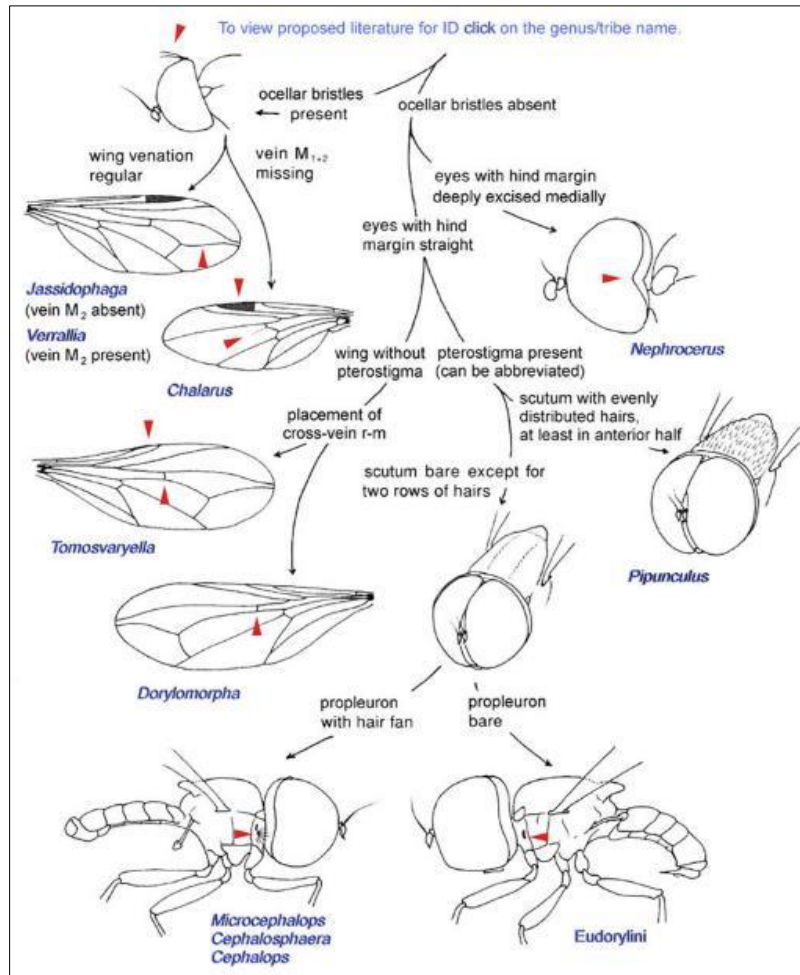
Subfamilies: Chalarinae, Nephrocerinae, Pipunculinae and †Protonephrocerinae (Figure 15).

Synonymy: Dorilaidae and Dorylaidae.

Genus: *Basileunculus*, *Cephalops*, *Cephalosphaera*, *Chalarus*, *Elmohardyia*, *Eudorylas*, *Metadorylas*, *Microcephalops*, *Parapipunculus* and *Tomosvaryella* [18,19,20,21,22,23].

Objective

The aim of this study is to report the characteristics of the Family Pipunculidae endoparasitoids of cicada (Order Homoptera (Insecta: Homoptera)).



Source: <http://www.kehlmaier.de/pipunculidae1.html>

Figure 15 Identification key to European genera/tribes of Pipunculidae

2. Methods

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

3. Studies conducted and selected

3.1. Study 1

The Pipunculidae represented worldwide by 1,405 species grouped into 28 genera or subgenera. Most of the described species are endoparasitoids exclusive to *Auchenorrhyncha* (Homoptera), including Cicadellidae, Delphacidae, Cercopidae, Cixiidae, Flatidae, Fulgoridae and Membracidae. Many of these families have species that are pests of different crops due to their eating habits, oviposition or the ability to act as vectors. Pipunculids are distributed throughout Latin America, Mexico and Chile (Figure 16) [24,25,26].

The taxonomy of the family is well known, but the biology of the group remains little known because studies on the life cycle and the relationship with the hosts are scarce. Only 6 species have known hosts in the region. With respect to distribution, for Latin America and the Caribbean, 279 species were recorded in 18 genera or subgenera.

As for biology, of the 15 pupae that were collected, 10 adults emerged and identified as: *Eudorylas schreiteri* (Shannon, 1927), *Eudorylas subopacus* (Loew, 1866), *Tomosvaryella longiseta* Ale-Rocha, 1996, *Tomosvaryella ongiseta* nov. sp. and *Tomosvaryella* sp. (Figure 17) [24,25,26].



Source: https://repositorio.unesp.br/bitstream/handle/11449/152488/anhos_ak_dr_rcla.pdf?sequence=5

Figure 16 Diversity of species included in the infraorder Cicadomorpha. (a-c) Cicadoidea; (d-h) Cercopoid; (i-l) Membracoid; (m) Myerslopioidea



Source: <https://bugguide.net/node/view/1106071/bgpage>

Figure 17 *Eudorylas* spp.

This represents 6 new host associations for the Neotropical region. Among the dipterans that attack the pest species of *Auchenorrhyncha*, the pipunculids are the most important parasitoids, reaching in some species a percentage of parasitism of 60%. This highlights the importance of the family as a potential biological control agent in the Neotropics (Figure 18) [24,25,26].



Source: <https://www.padil.gov.au/barrow-island/pest/main/137329/10882>

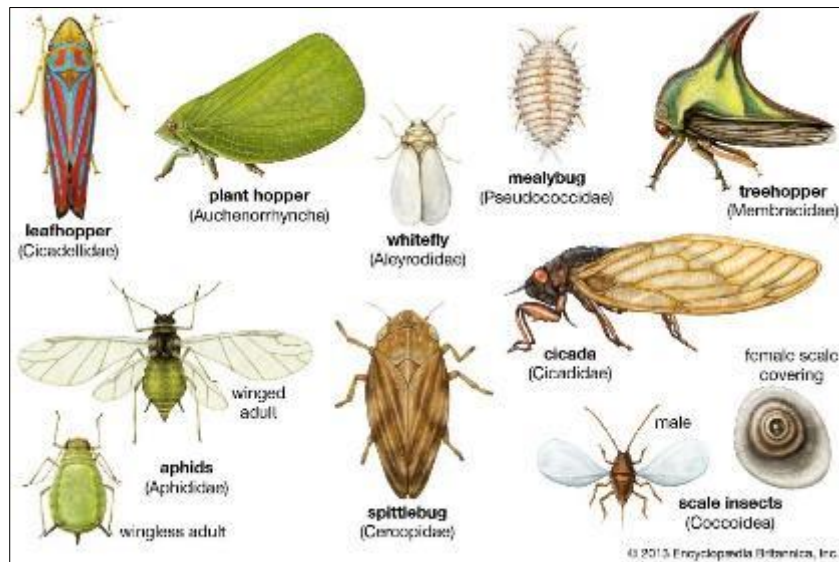
Figure 18 *Tomosvaryella* sp.

3.2. Study 2

3.2.1. Pipunculidae fauna of Argentina

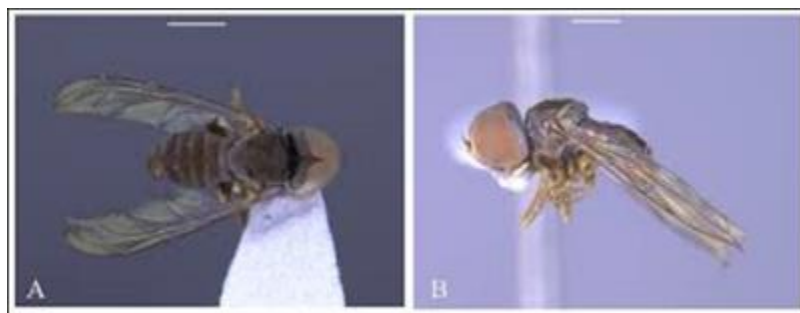
Agroeconomic importance

Due to their biology as parasitoids, they have great potential as biocontrollers of (Homoptera: Cicadellidae) pests in corn and rice crops and in walnut plantations, oak and alder. However, the aspects of its biology are little known in the Neotropical region, where so far only Records of six host species are known, the *Metadelphax propinquus* (Fieber, 1866) (Homoptera: Cicadellidae) cicadas, *Dicranotropis fuscoterminata* (Berg 1879) (Homoptera: Cicadellidae), *Dalbulus maidis* (DeLong & Wolcott, 1923) (Homoptera: Cicadellidae), *Cicadulina pastusae* Ruppel & DeLong, 1956 (Homoptera: Cicadellidae), *Scaphytopius acutus* (Say, 1830) Leafhoppers (Homoptera: Cicadellidae), *Dalbulus elimatus* (Ball, 1900) (Homoptera: Cicadellidae), *Scaphytopius nitridus* (DeLong, 1896) (Homoptera: Cicadellidae) and *Circulifer tenellus* (Baker, 1896) (Homoptera: Cicadellidae) (Figures 19 and 20).



Source: Encyclopædia Britannica, Inc.

Figure 19 Representative homopterans



<https://bdj.pensoft.net/article/53609/>

Figure 20 *Eudorylas* Aczél, 1940 (Diptera, Pipunculidae)

3.3. Biology

Most are obligate endoparasitoids of *Auchenorrhyncha* Homoptera, notably Cicadellidae, Cercopidae, Delphacidae, Membracidae, Issidae, Cixiidae and Flatidae. They mainly attack their nymphs in different stages of development. It has been also recorded the development of some species of *Neph rocerus* Ikon, 1873 in Tipulids (Diptera: Tipulidae).

The female actively seeks out her host, which she secures with her legs and pierces her intersegmental region. to lay one or more eggs. The oviposition can occur directly on the spot or in flight, when she transports the host to her host

plant. The larva consumes the tissue of the host and can reach to occupy the entire abdomen and part of the chest. When it reaches maturity, it causes its death and emerges to seek substrate where to pupate, regularly in soil, leaf litter, or plant material decomposing (Figure 21).

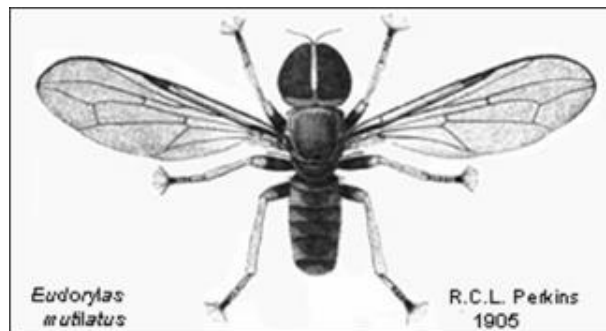


Source: [https://www.google.com/url?sa=i&url=http%3A%2F%2Fwww.canacoll.org%2FDiptera%2FStaff%](https://www.google.com/url?sa=i&url=http%3A%2F%2Fwww.canacoll.org%2FDiptera%2FStaff%2F)

Figure 21 Specimens of Pipunculidae

Adults are commonly found flying on the vegetation and although they are present in all terrestrial habitats, prefer open places and sunny as clearings or forest edges. In regions semi-arid can be found associated with small bodies of water such as creeks or streams. Pipunculids usually feed of sugary substances of all kinds, however, it is common to find numerous groups, sucking on Homoptera that secrete this type of substance rich in amino acids and sugars.

Because several species of pipunculids exhibit behavior "hilltopping" or flight towards the tops of mountains or hills in order to increase the frequency of encounters and mating in a relatively smaller area the collection, following this pattern is a great way to obtain data on its local diversity, in addition to obtain a large number of specimens. Among the most traditional methods Malaise-type traps are also effective, emergency traps and manual collection with net entomology, among others (Figure 22).



Source: <https://bdj.pensoft.net/article/53609/>

Figure 22 Specimens of Pipunculidae

The simplest breeding technique consists of capturing Homoptera, nymphs or adults with signs of parasitoidism. (Dilated abdomen), these are placed individually with a portion of its host plant, in jars with a layer of sand. The sand is kept moist and the jar covered with fine mesh cloth to allow air circulation. When the larvae emerge followed by pupation, which occurs on the surface or inside the soil substrate. The duration of the pupal stage varies from according to temperature. At an average temperature of 20° C the time in the pupal stage varies from 13 to 17 days, in all cases females have a longer pupal period.

3.3.1. Main groups of Pipunculidae

Chalarus, *Pipunculus*, *Cephalosphaera*, *Cephalosphaera* (*Neocephalopsphaera*), *Cephalosphaera* (*Cephalopsphaera*), *Microcephalops*, *Cephalops*, *Cephalops* (*Cephalops*), *Cephalops*, (*Semicephalops*), *Eudorylini*, *Tomosvaryella*, *Eudorylas* and *Elmohardyia*.

3.4. Pipunculidae fauna of Argentina

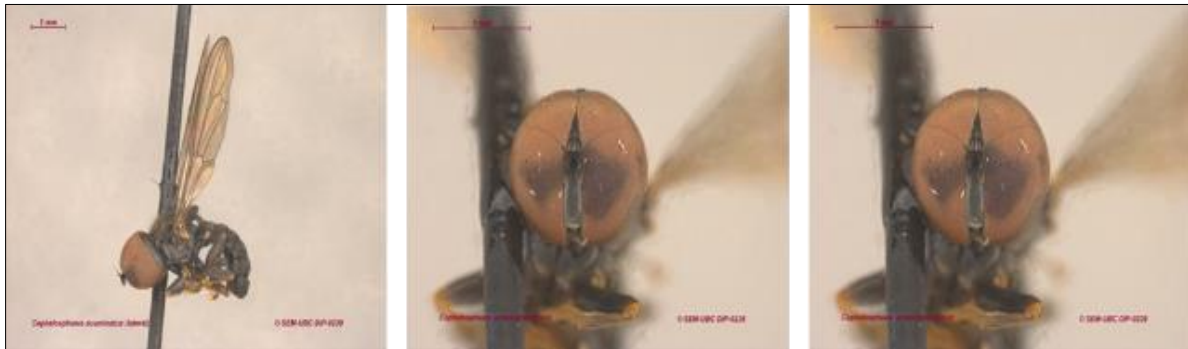
In Argentina, 44 species were recorded, which represent approximately 20% of the neotropical species and 3% of the world's fauna. The best represented geographical region and where more collections were made is the Argentine Northwest. The central and southern regions remain practically unstudied, nor do they have geographic records, except for some Patagonians and one in the extreme south. We believe that the number of species in the country should be at least four times greater, which makes it necessary to collect specimens in all geographic regions as well as to form qualified people for your study [27,28,29,30,31].

3.5. Diptera

3.6. Pipunculidae

3.7. Spencer Entomological Collection.

Small-sized (body length: 2.0–11.5 mm), usually uniformly dark brown to black coloured flies easily recognised by the semi-globose to globose head, that is largely occupied by the compound eyes, the long and rather narrow wings and in the female, the piercing ovipositor, adapted for injecting eggs into the host (Figures 23, 24, 25, 26, 27, 28, 29, 30 and 31) [32].



Source: <https://www.zoology.ubc.ca/entomology/main/Diptera/Pipunculidae/>

Figure 23 *Cephalosphaera acuminatus* (Cresson, 1911)



Source: <https://www.zoology.ubc.ca/entomology/main/Diptera/Pipunculidae/>

Figure 24 *Chalarus spurius* (Fallen 1816)



Source: <https://www.zoology.ubc.ca/entomology/main/Diptera/Pipunculidae>

Figure 25 *Pipunculus ater* (Meigen, 1824)



Source: <https://www.zoology.ubc.ca/entomology/main/Diptera/Pipunculidae>

Figure 26 *Pipunculus cinctus* Banks, 1915



Source: <https://www.zoology.ubc.ca/entomology/main/Diptera/Pipunculidae>

Figure 27 *Pipunculus fuscus*, Loew 1866



Source: <https://www.zoology.ubc.ca/entomology/main/Diptera/Pipunculidae>

Figure 28 *Pipunculus loewii* Kertész, 1900



Source: <https://www.zoology.ubc.ca/entomology/main/Diptera/Pipunculidae>

Figure 29 *Pipunculus oahuensis* Perkins, 1905



Source: <https://www.zoology.ubc.ca/entomology/main/Diptera/Pipunculidae>

Figure 30 *Pipunculus swezeyi* Perkins, 1905



Source: <https://www.zoology.ubc.ca/entomology/main/Diptera/Pipunculidae>

Figure 31 *Verrallia csikii* Aczel 1940

4. Conclusion

The Pipunculidae Family are obligate endoparasitoids of Homoptera, notably Cicadellidae, Cercopidae, Delphacidae, Membracidae, Issidae, Cixiidae and Flatidae. They mainly attack their nymphs in different stages of development. It has been also recorded the development of some species of *Nepherocerus* Ikon, 1873 in Tipulids (Diptera: Tipulidae). The female of Pipunculidae actively seeks out her host, which she secures with her legs and pierces her intersegmental region. To lay one or more eggs. The oviposition can occur directly on the spot or in flight, when she transports the host to her host plant. The larva consumes the tissue of the host and can reach to occupy the entire abdomen and part of the chest. When it reaches maturity, it causes its death and emerges to seek substrate where to pupate, regularly in soil, leaf litter, or plant material decomposing.

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