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Contribution to the knowledge of the Family Bibionidae (Insecta: Diptera)

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Abstract

Bibionidae, like other Bibionomorpha, are found primarily on decaying wood, humus-rich soil, and roots. In some cases, they can cause damage to cultivated plants. Some species emerge and fly in large groups. They can be collected using Malaise traps or by netting after emerging. Larvae can be serious agricultural pests, adults are important pollinators and sometimes the only ones, especially of orchids. The objective of this paper is to contribute to the knowledge of the Family Bibionidae. For this, a bibliographic survey of Bibionidae was carried out in the years 1949 to 2021. Only complete articles published in scientific journals and expanded abstracts presented in national and international scientific events 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: Damage; Larvae; Wing; Phylogeny; *Biblio*

1. Introduction

1.1. Description

Adults have a medium-small body, 5 to 12 mm long, generally hairy and characterized by an evident sexual dimorphism. The males have a blackish integument, a reduced head, holoptic eyes, a hunchbacked thorax, a shiny black body, small ridged antennae compared to the head, the females have a reddish body, are flatter and have less large and spaced eyes (Figures 1 and 2) [1].

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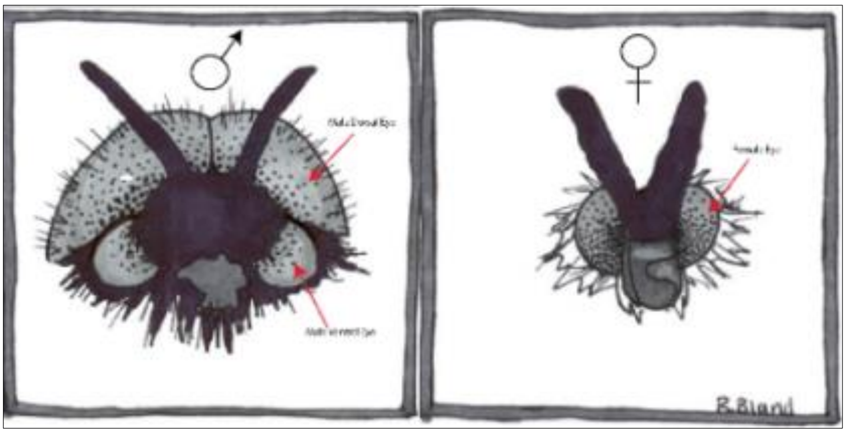
Source: https://www.biodiversidadvirtual.org/taxofoto/taxofoto/2283

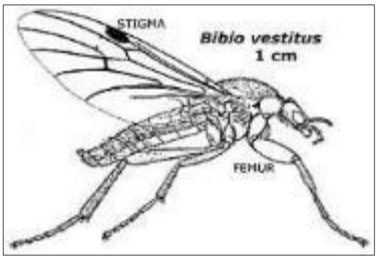
Figure 1 Specimens of Bibionidae



Source={{own}} |Author=Rachel Bland |Date=1/12/2009

Figure 2 Comparison of male and female eyes of flies in the family, Bibionidae

The head is free, relatively small compared to the rest of the body, provided with three ocelli. The male's eyes are considerably developed and extend towards the fronto-dorsal area until they touch (holoptic head). Each eye is divided, by a dividing line, into two areas: the anterior and dorsal are more developed and are composed of large ommatidia, the lateral and posterior are smaller and are composed of small ommatidia. Females have eyes smaller and more widely spaced. The antennae are poorly developed, consisting of 5-10 very short segments; in males they are inserted ventrally, below the connected eyes, near the mouthparts. The oral apparatus is suction, not piercing (Figures 3A and 3B, 4, 5 and 6) [1,2,3].

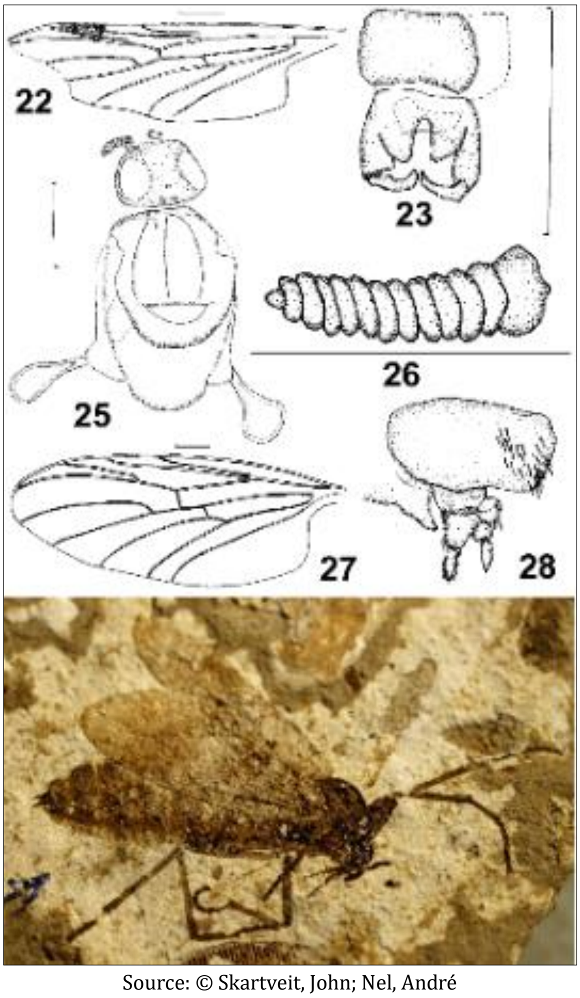


Source: Louise Kulzer

Figure 3A Some species have brilliantly marked legs, as in *Bibio femoratus* Wiedemann, 1820 where each leg femur is a contrasting. Wing Stigma

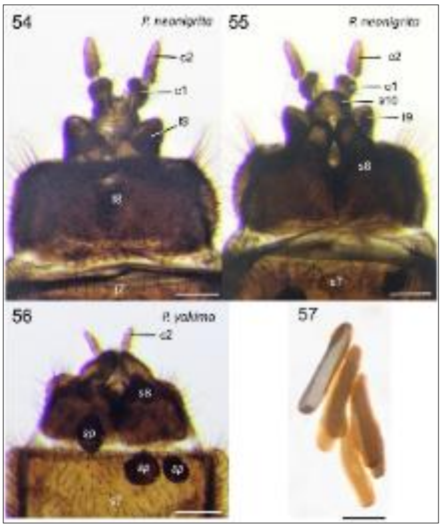
Source: © Fitzgerald, Scott J.

Figure 3B Habitus, male (above) and female (below), 28 October, North Carolina, USA, Matt Bertone. Images courtesy of Matt Bertone (© Matt Bertone 2013)



Source: © Skartveit, John; Nel, André

Figure 4 22. Male, wing (MNHN B 47593). 23. Male, terminalia, dorsal view (MNHN BK 223 8 C). 24. Female, habitus (MNHN B 47793). 25. Female, head and thorax (MNHN B 47981). 26. Female, antenna (MNHN BK 614). 27. Female, wing (MNHN BK 614). 28. Female, terminalia (MNHN BK 614). Scale = 1 mm



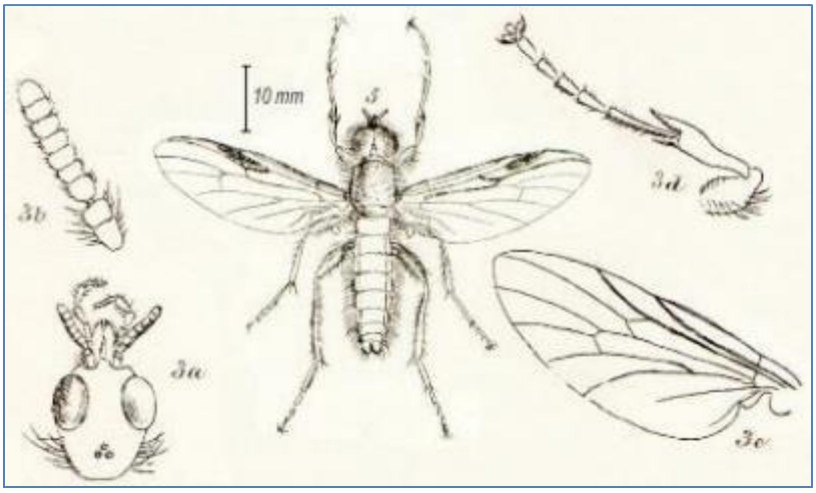
Source: © Fitzgerald, Scott J

Figure 5 Female terminalia and eggs. 54–56. Female terminalia. 54. dorsal. 55, ventral. 56. ventral. 57. heteroptera, eggs (dissected from abdomen). Scale bars = ca. 0.25 mm. Abbreviations: c1, cercus 1; c2, cercus 2; s7, sternite seven; s8, sternite eight; s10, sternite ten; sp, spermatheca; t7, tergite seven; t8, tergite eight; t9, tergite nine

Source: © Fitzgerald, Scott J.

Figure 6 Male terminalia. 4. Dorsal. 5. Posterodorsal. 6. Ventral. Scale bar = ca. 0.5 mm. Abbreviations: gc, gonocoxite; gs, gonostylus; p, paramere; sls, spine-like setae; t9, tergite nine

The thorax is short and convex. The legs are relatively long and robust, but shorter than those of many nematocera; the tarsus is made up of 5 segments and they have a nail. The tibiae anterior are shorter than the first tarsal segment and have a crown of spines or a long spur at the apex; Other spinal processes are present on the ventral side of the tibiae (Figures 7, 8, 9, 10, 11A and 11B) [3,4].

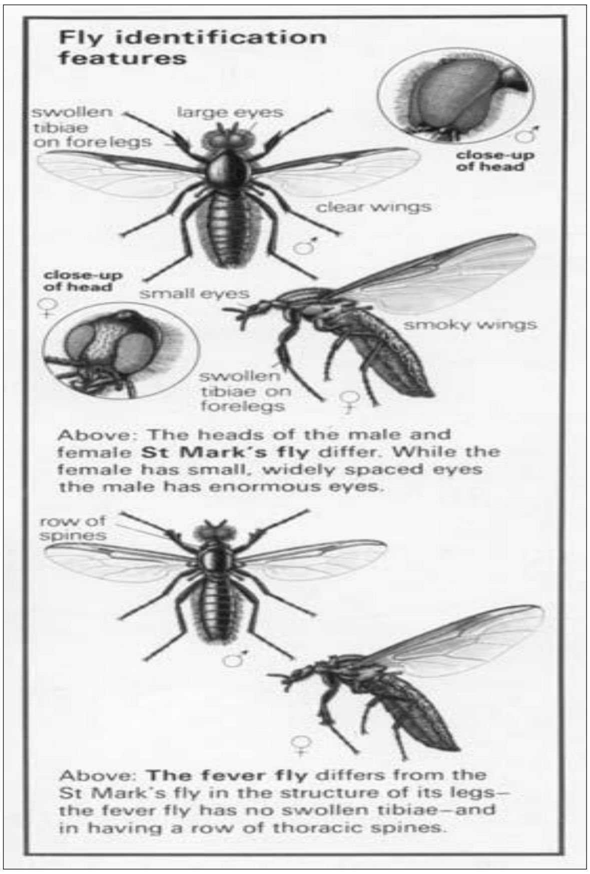


Source: https://www.delta-intkey.com/britin/dip/www/bibionid.htm

Figure 7 4, female; 4a, head of male; 4b, palp of male; 4c, antenna of male; 4d, anterior tibia and tarsus; 4e, apex of anterior tarsus, with claws and pulvilli. From Walker (1856, Plate XXIV), with 2mm scale added. *Bibio marci* (L., 1758) (from Walker). 3a-3c, *B. marci*, female: details of head (3a), antenna (3b), wing (3c), and fore-leg (3d). 5, *B. marci*, male. From Walker (1856, Plates XXIV and XXIX), with approximate length of the male insect (front of head to tip of abdomen) added

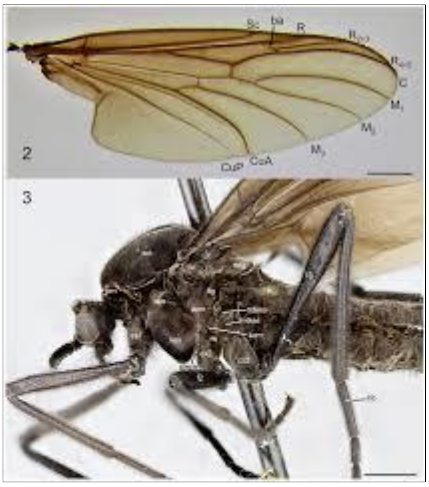
Source: Italy, Aosta province, St. Vincent. Photos by G. Haldimann

Figure 8 *Bibio* spp. 1-3. *Bibio sardocyrneus* sp. nov. 1. Male habitus (paratype, Villacidro), scale bar: 5 mm. 2. Female wing (paratype, Montimannu), scale bar: 5 mm. 3. Male hind leg (paratype, Villacidro), scale bar: 2 mm. 4. Male hind leg of *Bibio marci* (Linnaeus, 1758)



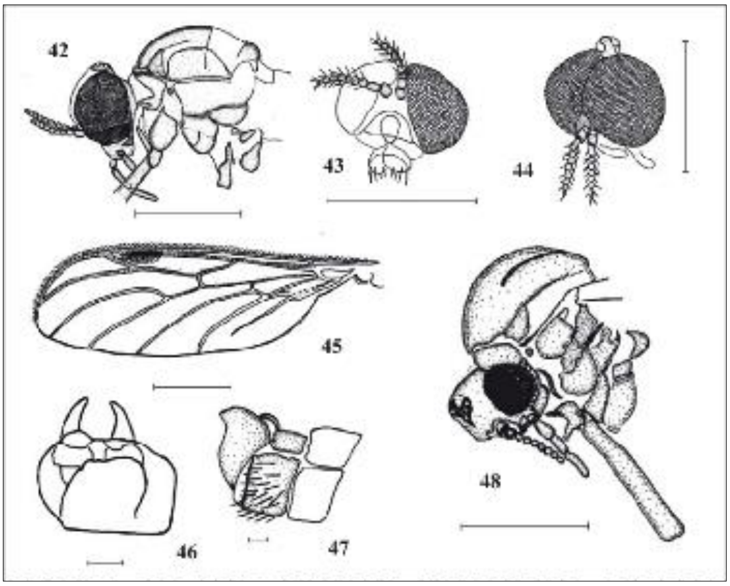
Source: Italy, Aosta province, St. Vincent). Photos by G. Haldimann

Figure 9 1-3. *Bibio sardocyrneus* Haenni 2009 (Diptera: Bibionidae) 1. Male habitus (paratype, Villacidro), scale bar: 5 mm. 2. Female wing (paratype, Montimannu), scale bar: 5 mm. 3. Male hind leg (paratype, Villacidro), scale bar: 2 mm. 4. Male



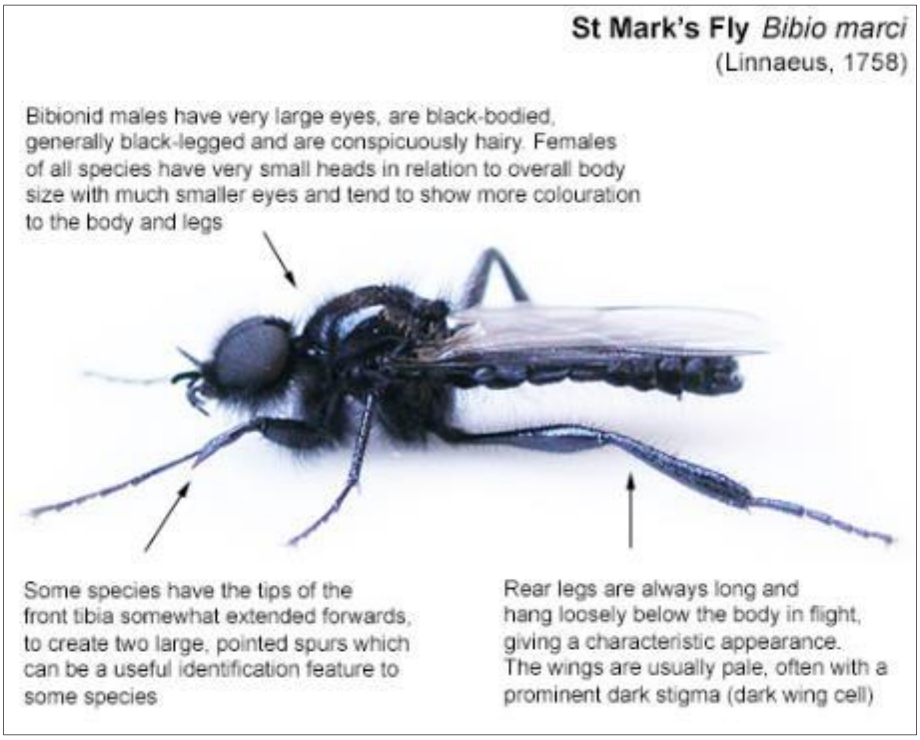
Source: © Fitzgerald, Scott J

Figure 10 Wing. 3. Female habitus, side view. Scale bars = ca. 1.0 mm. Abbreviations: ba, basal appendix of R2+3; aem, anepimeron; aes, anepisternum; c, thigh; f, femur; h, dumbbell; hb, hind basitarsus; kem, katepimeron; kes, kateepisternum; m, meron; mtaes, metanepisternum; mtg, mediotergite; mtkes, metakateepisternum; ltg, laterotergite; pltrch, pleurotrochantin; prn, pronotum; sct, scutum; t, trochanter



Source: https://www.researchgate.net/figure/48-Plecia-tenuicornis-spec-nov-male-42-47-female-48-42-Head-and-thorax_fig10_265020027

Figure 11A Male (42–47); female (48). – 42: Head and thorax, lateral view; – 43: Head, ventral view; – 44: Head, frontal view; – 45: Wing; – 46: Hypopygium, dorsal view; – 47: Terminalia, lateral view; – 48: Head and thorax, frontolateral view. Scale bars for figs 42–45 and 48 = 1 mm; for figs 46–47 = 0.1 mm

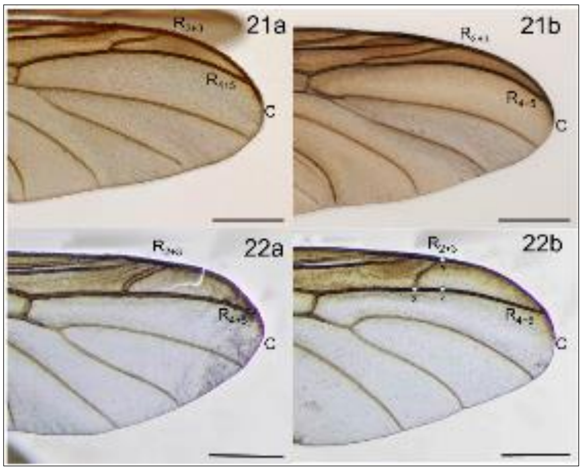


Source: http://www.eakringbirds.com/eakringbirds4/insectsbibionidae.htm

Figure 11B *Bibio marci* (L., 1758)

1.2. Bibionidae wing venation

The wings are well developed; the costal region is characterized by a strong vein, due to the approach of the radius and the subcosta to the costa. The most obvious character is the darkening of the coastal region, which tends to make it opaque. In some species, the browning develops into a true pterostigma. The grain is simplified and does not present homogeneous characters within the family (Figure 12). The main features are as follows:



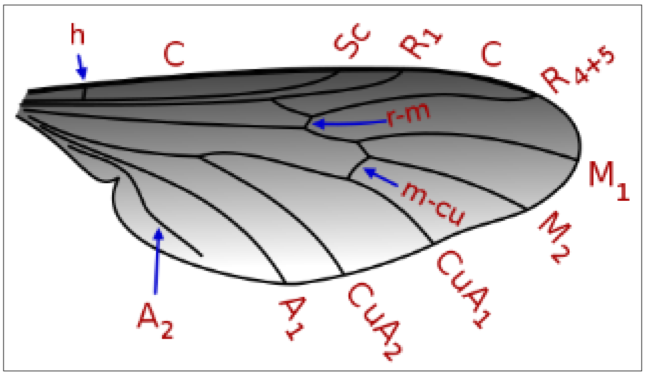
Source: © Fitzgerald, Scott J

Figure 12 Wings, illustrating variation in length and slope of vein R 2+3. 21a–ales (both from Maryland, USA). 22a. male. 22b. male (points, x, y, z described in "Discussion supporting generic diagnosis"). Scale bars = ca. 1.0 mm

- The costa extends along the entire anterior margin to the apex of the wing at the end of the first branch of the radial sector (R4 or R4 + 5);
- The subcosta (Sc) and the anterior branch of the radius (R1) are closely approximated by the rib and join along the anterior border; sometimes the subcosta merges with the costa;
- The radius can have two terminal branches (R1 and R4 + 5) or three (R1, R4 and R5), while the R2 + 3 branch of the radial sector is always missing;

1.2.1. *Bibio hortulanus* (L., 1758) female

- The average always has only two branches, M1 and M2;
- The elbow always presents, as in the generalities of Diptera, the only anterior branch divided into CuA1 and CuA2, interpreted by some authors as CuA and M4;
- There are two anal ribs, of which A1 is the most developed;
- The transverse ribs are reduced to the humeral (h), to a medial radius (r-m) and a median ulnar (m-cu);
- The medial radius connects the media and the radial sector before the respective bifurcations and forms an acute angle with the radial sector towards the posterior side;
- The central ulnar can have two different positions: in some species it connects the base of CuA with M1 + 2 before the bifurcation of the latter, In other species it has a more distal position and connects the intermediate section of CuA1 with the base of M2;
- In general, the Bibionidae veins delimit two relatively long basal cells in the region. There is strong sexual dimorphism (Figure 13) [5,6].



Source: https://www.wikiwand.com/en/Bibionidae

Figure 13 Bibionidae wing veins

1.3. Habitats and Damage

Bibionids, like other Bibionomorpha, are found primarily on decaying wood, humus-rich soil, and roots. In some cases, they can cause damage to cultivated plants. Some species emerge and fly in large groups. They can be collected using Malaise traps or by netting after emerging. Larvae can be serious agricultural pests, adults are important pollinators and sometimes the only ones, especially of orchids (Figures 14 and 15) [7,8].

Source: © Fitzgerald, Scott J

Figure 13 Larva, lateral view (head, at left, not visible; telescoped within thorax). 59. Pupa, dorsal. 60. Pupa, ventral. Scale bars = ca. 1.0 mm. Larvae can be serious agricultural pests

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Source: https://pt.dreamstime.com/bibio-marci-da-fam%C3%ADlia-bibionidae-chamada-march-flies-lovebugs-larvas-desses-insetos-vivem-no-solo-e-danificadas-p-%C3%A9-uma-image215149667

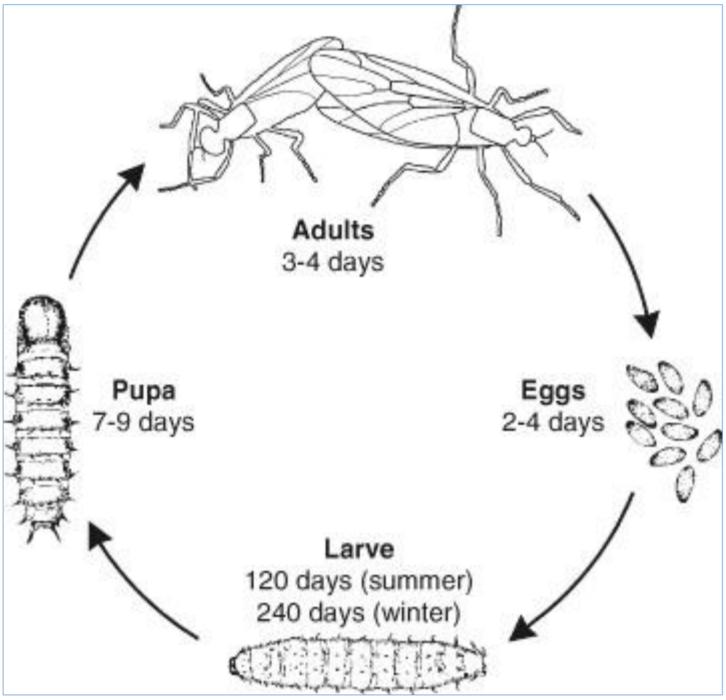
Figure 14 *Bibio marci* (L., 1758) is a fly in the Bibionidae family called march flies and lovebugs. Larvae of these insects live in the soil and damage plant roots

Source: https://myloview.com.br/fotomural-larvae-of-fly-from-the-family-bibionidae-called-march-flies-and-no-F090F55

Figure 15 Larvae of fly from the family Bibionidae called march flies and lovebugs on soil. This insects live in soil and damaged plant roots

1.4. Biology

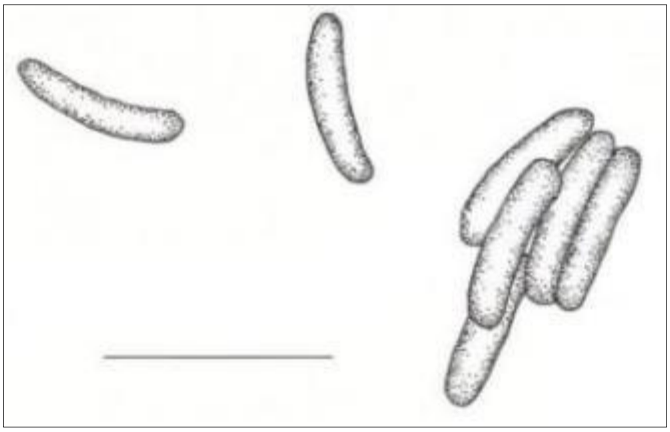
Postembryonic development takes place in four stages, three larval and one pupal. The larva, vermiform in appearance, is legless and eucephalic, with a dark head and greyish body, and when mature it can reach a length of 20-25 mm. The integument has spiny ornaments on the back (Figure 16).



Source: https://link.springer.com/referenceworkentry/10.1007/978-1-4020-6359-6_2099

Figure 16 Life cycle of the Family Bibionidae

The larvae are generally gregarious and live in the soil, generally in moist substrates rich in organic matter. They are often found in manure or other organic substrates used as fertilizers. In the early larval stages, they are saprophagous, feeding primarily on fungi and organic matter ingested with the soil, while later eroding organic materials, including plant roots. For this reason, they can occasionally be harmful when they reach high concentrations. Pupation takes place on the ground, emerging through a dorsal longitudinal fracture of the cuticle (Figure 17).

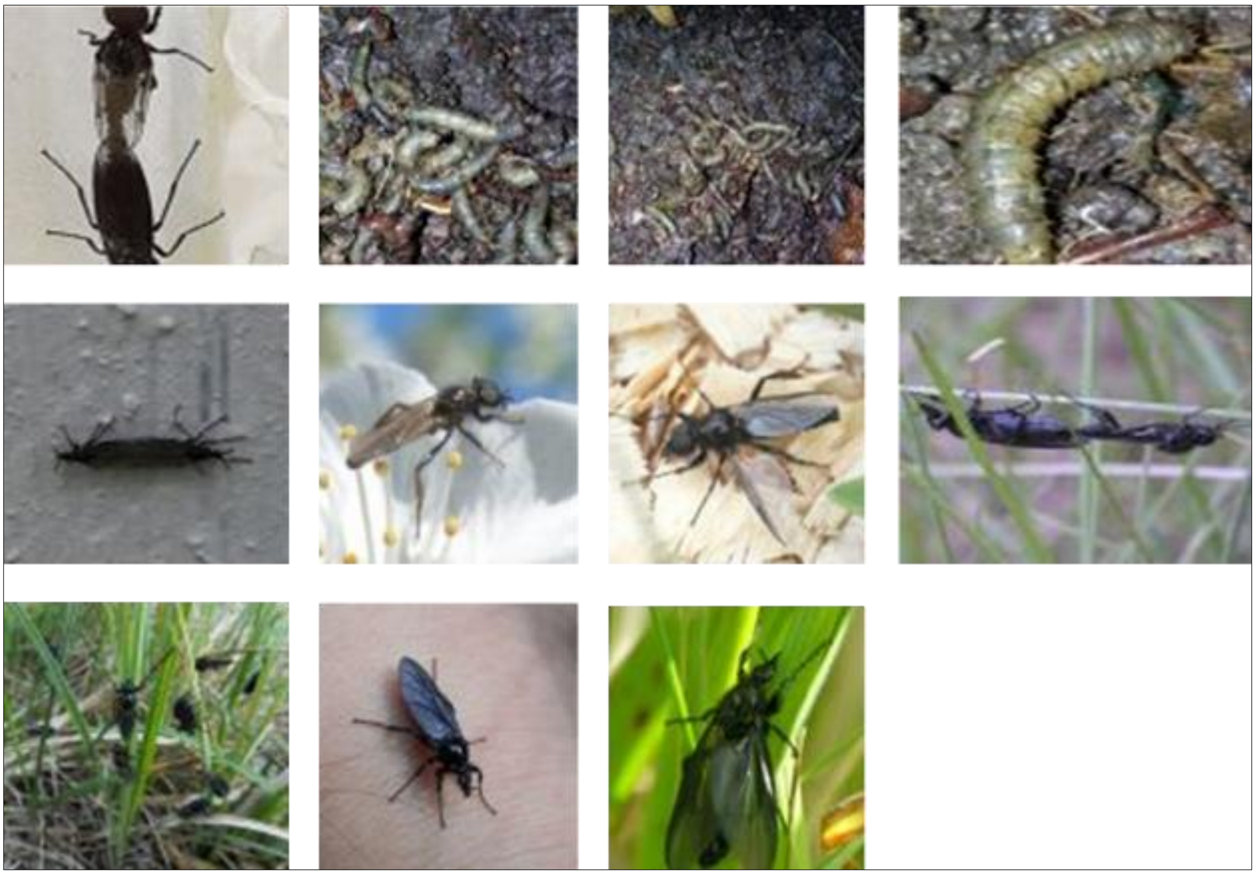


Source: https://bioone.org/journals/entomological-news/volume-124/issue-5/021.124.0503/Immature-Stages-Description-of-March-Fly-Penthetria-japonica-Wiedemann-Diptera/10.3157/021.124.0503.short?tab=ArticleLink

Figure 17 Egg of the Family Bibionidae

The pupa is oblong, obtect, protected by the exuvia of the last larval stage (puparium).

Adults have diurnal habits, are very short-lived, some do not feed, spend most of their time mating. They remain attached during flight. They sometimes form large swarms. In general, their adult life is very short, some species do not even feed themselves: males copulate and die, females last a little longer, lay eggs and find their children's parents again. The genus *Plecia* is almost always seen at the time of copulation, they even fly like that, which gives them the name love flies (Figure 18) [7,8].



Source: https://ukrbin.com/show_image.php?imageid=83748

Figure 18 Biology of Bibionidae Family

In my yard they are attracted to my house and to me. Like I say, they're a bit dull for a fly. But what they lack in wits they make up for in evolutionary strategy. March fly adults emerge very early in spring, before there are many predators about. And they emerge en masse, making it really easy to find each other. They mate, lay eggs, and die before the competition really gets going. And each March they once again prove how successful this strategy can be (Figures 19 and 20).

Source: https://bugguide.net/node/view/84106/bgimage

Figure 19 Pupae of Bibionidae Family. An adult emerging from a pupa (upper part)

Source: https://naturdata.com/especies-portugal/taxon/0@1-animalia:arthropoda:insecta:diptera:bibionidae/

Figure 20 Copulation in individuals of the Family Bibionidae

1.5. Taxonomy

Only 8 genera are recognized for the Bibionidae. More than 700 species have been described for the world. Less than 200 are known for the Neotropical region. Of all the genera of the family, only *Hesperinus* has not been found in the region. *Enicoscolus* and *Bibiodes* species are typically Nearctic with some extensions to northwestern Mexico. Six species belonging to the remaining genera, *Penthetria, Plecia, Dilophus, Bibio* and *Bibionellus*, have been assigned to Costa Rica and another 19 to surrounding areas. However, it is expected that at least 30 species represent the diversity of Bibionidae in the country (Figures 21, 22, 23, 24, 25, 26 and 27) [9,10].

Source: https://bugguide.net/node/view/1348638

Figure 21 Genus *Bibio*

Source: https://www.gbif.org/pt/species/1590424/treatments

Figure 22 Genus *Penthetria*

Source: https://www.biotaxa.org/Zootaxa/article/view/zootaxa.5005.1.2

Figure 23 Genus *Plecia*

Source: https://www.biodiversity4all.org/photos/1218213

Figure 24 Genus *Dilophus*

Source: https://inaturalist.nz/taxa/1225899-Bibionellus

Figure 25 Genus *Bibionellus*

Source: https://www.mindat.org/taxon-1586248.html

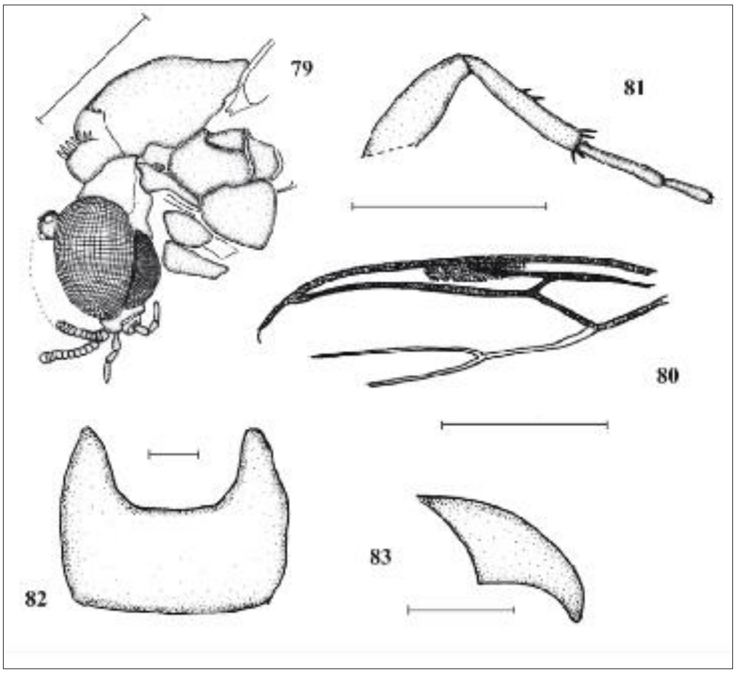
Figure 26 Genus *Hesperinus*

Source: https://bugguide.net/node/view/1945208/bgpage

Figure 27 Genus *Bibiodes*

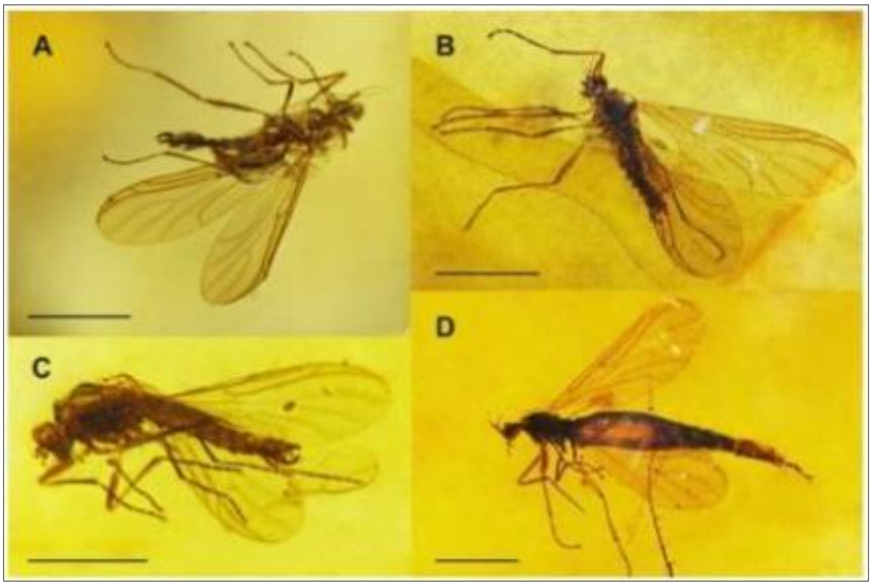
1.6. Fossils

The bibionids are more represented by fossils than all the other families of Diptera. There are some dubious fossils from the Jurassic, those from the Late Cretaceous seem very similar to living species. There are abundant fossils in the Tertiary period, although many species have been described based on very fragmentary material (Figures 28 and 29).



Source: https://www.researchgate.net/figure/83-Dilophus-palaeofebrilis-spec-nov-male-79-Head-and-thorax-lateral-view-80_fig15_265020027

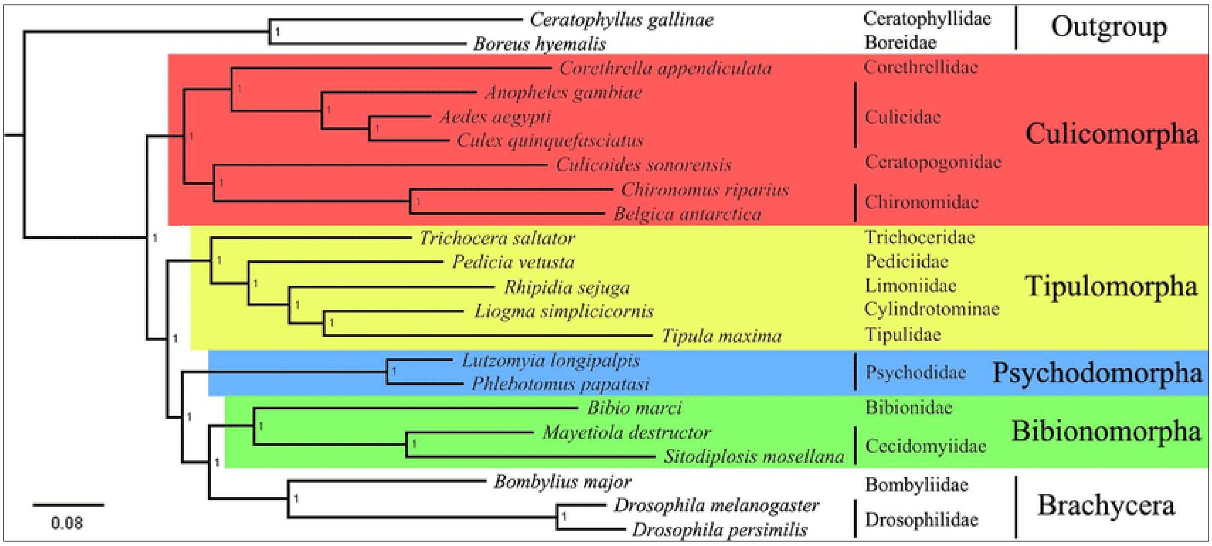
Figure 28 *Dilophus palaeofebrilis* spec. nov., male. – 79: Head and thorax, lateral view; – 80: Wing; – 81: Front leg, lateral view; – 82: Hypopygium, ventral view; – 83: Gonostylus. Scale bars for figs 79–81 = 1 mm; for figs 81, 82 = 0.1 mm



Source: https://www.mdpi.com/2075-4450/12/4/364/htm

Figure 29 Habitus photographs of *Burmahesperinus antennatus* gen. et sp. nov. ((A), holotype), *B. conicus* gen. et sp. nov. ((B), holotype), *B. pedicellatus* gen. et sp. nov. ((C), holotype), and *Burmahesperinus* sp. ((D), female specimen No. MP/4081). Scale bars = 1 m

Most species can be identified within present-day genera. In particular the genera *Plecia* and *Bibio* that are abundant in the Tertiary. Fossils from Europe include many species of the tropical genus *Plecia* that do not exist in Europe today, showing that the climate was more temperate during this period (Figure 30) [9,10].



Source: doi:10.1371/journal.pone.0173207.g007

Figure 30 Phylogenetic tree. The tree was inferred through a maximum-likelihood analysis of amino acid sequence data of 1,709 singlecope orthologs genes. Branch lengths correspond to the number of changes on that branch. Numbers adjacent to each node are BV

Objective

The objective of this paper is to contribute to the knowledge of the Family Bibionidae.

2. Methods

The method used to prepare this mini review was Marchiori 2021 methodology [14].

3. Studies conducted and selected

3.1. Study 1

3.1.1. Subfamily Pleciinae

Penthetria sp. (Figure 31) [12,13,14].

Source: https://www.biotaxa.org/Zootaxa/article/view/zootaxa.4926.4.1

Figure 31 *Penthetria* sp. Subfamily Pleciinae

Examined material: Nicaragua: Matagalpa: Fuente Pura, 21-VII-94, col. J.M. Maes, J. Tellez & J. Hernandez, det. S. Fitzgerald 1997 (2 ex. col. SEA). France: 68: Kembs, V-92 (1 ex. col. SEA).

Plecia plagiata Wiedemann, 1824 (Figure 32).

Plecia heteroptera Macquart, 1846.

Plecia vittata Wiedemann; Bellardi, 1862.

Plecia bellardii Townsend, 1912.

Source: https://www.inaturalist.org/taxa/293785-Plecia-plagiata

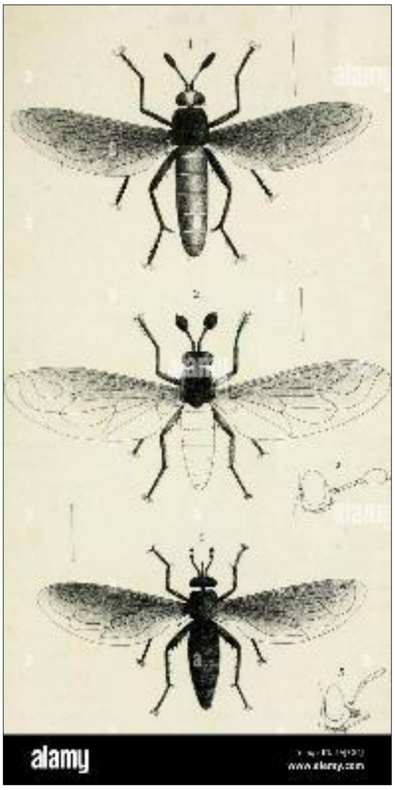
Figure 32 *Plecia plagiata* Wiedemann, 1824

Distribution: Guatemala, Nicaragua (Osten Sacken, 1886; Maes, 1990) (Managua, Masaya, Chontales), Panama, Colombia, Brazil.

Plecia rostellata Loew, 1858.

Plecia rostellata Loew, 1858.

Plecia rostrata Bellardi, 1859 (Figures 33A and 33B).



Source: https://www.alamy.com/diptres-exotiques-nouveaux-ou-peu-connus-146-rubripes-144-rufiventre-147

Figure 33A *Plecia rostrata* Bellardi, 1859

Distribution: Mexico, Nicaragua (Osten Sacken, 1886; Maes, 1990) (Chontales), Brazil*, Argentina.

Plecia sp.

Source: https://www.ecoregistros.org/site_en/imagen.php?id=234326

Figure 33B *Plecia* sp.

Distribution: Nicaragua (Maes, 1990) (Madrid) [12,13,14].

Examined material: Nicaragua: 3 km. N. Jinotega, VII-89, col. F. Reinboldt, det. S. Fitzgerald 1997 (29 ex. col. SEA). - Nicaragua: 5 km. Jinotega: Los Pinares, 29-V-92, col. J.M. Maes & C. Pineda, det. S. Fitzgerald 1997 (2 ex. col. SEA). - Nicaragua: Matagalpa: Fuente Pura, 22-I-94, col. J.M. Maes, J. Tellez & E. Van Den Berghe, det. S. Fitzgerald 1997 (4 ex. col. SEA). Nicaragua: Matagalpa: Fuente Pura, 20-III-94, col. J.M. Maes & A. De La Fuente, det. S. Fitzgerald 1997 (1 ex. col. SEA). Nicaragua: Matagalpa: Fuente Pura, 12-VI-94, col. J.M. Maes, J. Tellez & J. Hernandez, det. S. Fitzgerald 1997 (1 ex. col. SEA). Nicaragua: Matagalpa: Selva Negra, 17-I-93, col. V. Hellebuyck & M. Pogatshnik, det. S. Fitzgerald 1997 (1 ex. col. SEA). Paraguay: San Pedro Gral. Resquin: Naranjillo, 1-I-94, col. B. Garcete, det. S. Fitzgerald 1997 (1 ex. col. SEA).

3.1.2. Subfamily Bibioninae

Bibio superfluus Schiner, 1868.

Distribution: Nicaragua, Colombia.

Examined material: Nicaragua: Matagalpa: Fuente Pura, 20-III-94, col. J.M. Maes & A. De La Fuente, det. S. Fitzgerald 1997 (8 ex. col. SEA). Nicaragua: Matagalpa: Fuente Pura, 10-IV-94, col. J.M. Maes & A. De La Fuente, det. S. Fitzgerald 1997 (2 ex. col. SEA) (Figure 34A).

Source: http://insecta.pro/ru/taxonomy/389268

Figure 34A *Dilophus fumosus* Coquillet, 1904

Dilophus fumosus Coquillet, 1904.

Distribution: Nicaragua (Coquillet, 1904:91; Hardy, 1966:9; Maes, 1990) (Granada: Granada: typus). *Dilophus melanarius* Wulp, 1881.

Dilophus melanarius Wulp, 1881 [*Philia*] [melanaria] (Figure 33B).

Source: https://www.ecoregistros.org/site_en/imagen.php?id=234326

Figure 33B *Dilophus* sp.

Distribution: Mexico, Nicaragua (Maes, 1990) (Managua), Costa Rica.

Dilophus rhynchops Coquillet, 1904.

Dilophus rhynchops Coquillet, 1904.

Distribution: Nicaragua (Coquillet, 1904:91; Hardy, 1966:10; Maes, 1990) (Granada: Granada: typus).

Dilophus sp.

Distribution: Nicaragua (Osten Sacken, 1886; Maes, 1990) (Chontales) (Figure 34C).

Source: https://commons.wikimedia.org/wiki/File:Dilophus_sp._feeding_on_Hakea_prostrata.jpg

Figure 34C *Dilophus* sp.

Examined material: Nicaragua: Matagalpa: Fuente Pura, 22-I-94, col. J.M. Maes, J. Tellez & E. Van Den Berghe, det. S. Fitzgerald 1997 (2 ex. col. SEA). Nicaragua: Matagalpa: Fuente Pura, 20-III-94, col. J.M. Maes & A. De La Fuente, det. S. Fitzgerald 1997 (2 ex. col. SEA). Nicaragua: Matagalpa: Fuente Pura, 10-IV-94, col. J.M. Maes & A. De La Fuente, det. S. Fitzgerald 1997 (6 ex. col. SEA). Nicaragua: Matagalpa: Fuente Pura, 6-VII-94, Malaise trap, col. J.M. Maes, det. S. Fitzgerald 1997 (6 ex. col. SEA). - Nicaragua: 50 km NE Matagalpa: El Coyolar, 20-XI-91, 900 m., in spontaneous pottery, col. J.M. Maes, S. Hue & X. Palacios, det. S. Fitzgerald 1997 (1 ex. col. SEA). Nicaragua: Isla de Ometepe, VII-89, col. F. Reinboldt, det. S. Fitzgerald 1997 (1 ex. col. SEA). - Costa Rica: San Ramon de Tres Ros, IX-91, col. J.M. Maes, det. S. Fitzgerald 1997 (2 ex. col. SEA). G. sp. Examined material: - Belgium: Tournai: Bois des Houppes, 5-V-80, col. J.M. Maes (1 ex. col. SEA) [12, 13, 14].

3.2. Study 2

The classification of basal Diptera groups was recently revised (Amorim & Yeates, 2006). The taxon “Nematocera”, known to be paraphyletic in relation to Brachycera, was formally eliminated, its infraorders being recognized as suborders, among them, Bibionomorpha. The suborder Bibionomorpha is a group composed of Pachyneuridae, Bibionidae, Cecidomyiidae, Sciaridae, Rangomaramidae, Ditomyiidae, Bolitophilidae, Diadocidiidae, Keroplatidae, Lygistorrhinidae and Mycetophilidae. The inclusion of Anisopodidae in the group is the reason for some divergence in the literature. This family was treated as part of the Bibionomorpha (Figure 35).

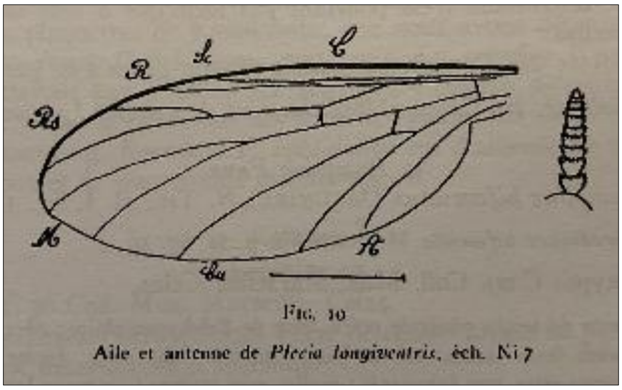
Source: https://inaturalist.nz/taxa/1227191-Pleciinae

Figure 35 Subfamily Pleciinae

Bibionidae. There are currently around 700 described species in the world for eight genera all genera have Neotropical representatives, with a total of 169 species. There are records of seven genera and 40 species for Brazil. Currently, the group is organized into four subfamilies, Hesperininae, Penthetriinae, Pleciinae and Bibioninae the first three being monotypic. In Mato Grosso do Sul, it is expected to find the genera *Dilophus* Meigen, *Bibio* Linnaeus, *Bibionellus* Edwards and *Enicocolus* Hardy [15, 16, 17].

3.3. Study 3

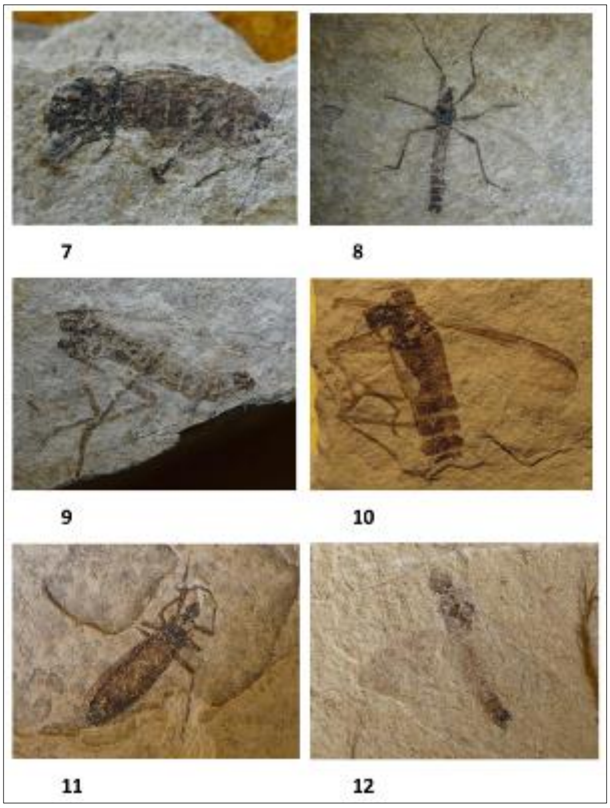
Penthetria longiventris (Théobald, 1937), is a species of flies or dipterans in the family of Bibionidae or "St. Mark's flies" (or black flies) and in the genus *Penthetria* (Figure 36) [18].



Source: https://pt.frwiki.wiki/wiki/Penthetria_longiventris

Figure 36 *Penthetria longiventris* (Théobald, 1937). Female holotype by Nicolas Théobald ech. Ni7 p.133 pl. II - Wing and antenna

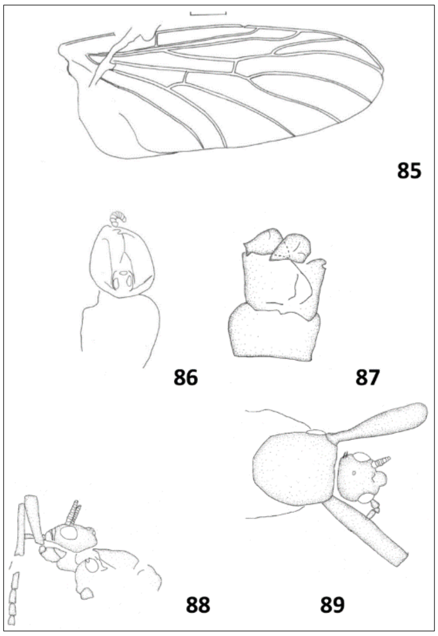
Black head and thorax. Brown abdomen, brown legs, pale yellow wings. Rounded head; 2 cylindrical antennae, tapering slightly towards the end; about ten short, finely furred articles, the last article a little longer than the previous ones. oval chest; notopleural suture very marked, longitudinal; the two sutures are parallel and meet at the back by a transverse suture, thus forming a V-shaped depression (Figure 37) [18].



Source: Published in: Skartveit, J. & Nel, A. 2017. Revision of fossil Bibionidae (Insecta: Diptera) from Fr

Figure 37 *Penthetria longiventris* (Théobald, 1937), female. Paratype of *Plecia superba* Théobald, FSL 391901. *Penthetria luberonica* Skartveit & Nel, 2017. male. Holotype of *P. luberonica* sp. N

Slender and finely haired legs, slightly swollen thigh, thin and long shins with a spur at the end, a spur on the leg anterior, two spurs for the others; tarsi with 5 articles, the first of which is the longest, the last one has two claws. elongated wings, extending beyond the abdomen; C marginal, extending to the top of the wing; Sc parallel to C, contiguous to R, ends in C towards the outer third of the wing; R is attached to C beyond the outer third, Rs is (Figure 38) [18].



Source: Published in: Skartveit, J. & Nel, A. 2017. Revision of fossil Bibionidae (Insecta: Diptera) from Fr

Figure 38 *Penthetria longiventris* (Théobald, 1937). Female, wing. MNHN Monteils 11

separated from the anterior towards the inner third, concave backwards, goes to the top of the wing, gives off an anterior branch bent and connecting to C; M divided into two branches, the anterior branch connects to Rs by a transverse rib, forming a closed RM cell; Cu leaves the base of the wing, connected to M by a transverse rib; one. brown abdomen; 8 distinct segments; fine hairs. Maximum width in the 3rd segment, gradually decreases towards the rear. The total length of the body is 11 mm; the length of the head 1 mm; the length of the thorax 2.5 mm; the length of the abdomen 7.5 mm; the wing length 9.5 [18].

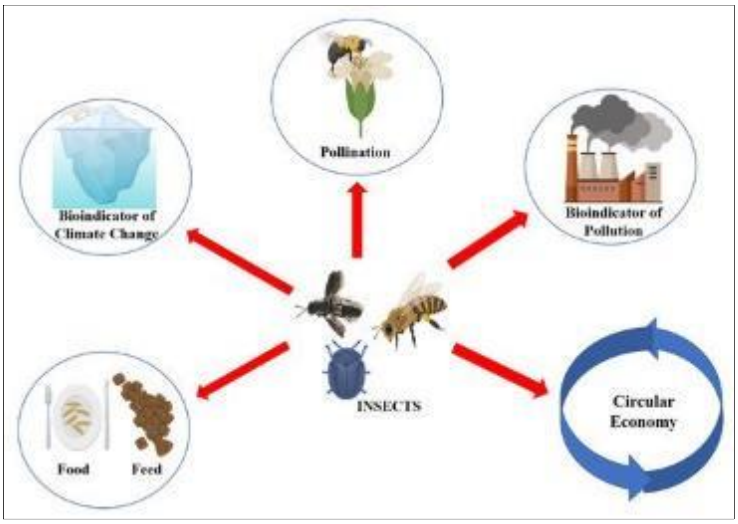
3.4. Study 4

The term bioindicator can be used in several contexts, such as: indication of habitat alteration, destruction, contamination, rehabilitation, vegetation succession, climate change and consequent degradation of soils and ecosystems (Figure 39).

Source: Depositphotos bioindicators help in analyzing the quality of aquatic ecosystems

Figure 39 Bibionidae as bioindicators of environmental impacts

Bioindicators are species that may have a narrow range with respect to one or more ecological factors, and when present, may indicate a particular or established environmental condition. Bioindicators, must have their taxonomy, cycle and biology well known and have characteristics of occurrence in different environmental conditions or be restricted to certain areas. In addition, they must be sensitive to changes in the environment so that they can be used to monitor environmental disturbances. Each bioindicator belongs to different scales of disturbance incidence, revealing information about a disturbance (Figure 40).



Source: https://www.mdpi.com/2075-4450/13/1/41/htm

Figure 40 Insects play a key role in ecosystem functions maintenance. They are the key pollination agents of most crops and wild vegetation and find a role in the circular economy. Moreover, they are bioindicators of climate change and pollution and find applications in feed and food

Taxonomic groups that are not included in the current lists of threatened species, but that deserve to be evaluated as bioindicators, include Coleoptera (Carabidae, Staphylinidae and Cicindelidae); some groups of hemipterans, such as the Pentatomoidea; various families of Diptera, such as Drosophilidae, Tephritidae and Bibionidae; and some moths, such as Geometridae and especially the frugivorous Noctuidae (Catocalinae) [19,20,21].

3.5. Study 5

Bibionids are sporadic and infrequent pests. Although grass and cereals are most vulnerable, a wide range of crops is attacked. Damage is most severe after grass or when plants are under stress. The presence of organic matter during oviposition increases the likelihood of damaging populations (Figure 41) [22].

Source: https://www.dreamstime.com/larvae-fly-family-bibionidae-called-march-flies-lovebugs-soil-insects-live-damaged-plant-root-roots-image216182523

Figure 41 Larvae of fly from the family Bibionidae called March flies and lovebugs on soil. These insects live in soil and damaged plant roots

Many natural enemies exist but their impact on adult or larval populations has not been quantified. Given the pattern of attacks and lack of approved insecticides, cultural control methods are more appropriate than chemical. The role of adult bibionids in pollination and of larvae involved in soil processes could be of greater importance than any damage caused by the group (Figures 42 and 43) [22].

Source: http://shutterstock.puzzlepix.hu/kep/2089670929

Figure 42 Radish damaged by maggots of Bibionidae called March flies and lovebugs on soil

Source: http://shutterstock.puzzlepix.hu/kep/2089670929

Figure 43 Radish damaged by maggots of Bibionidae called March flies and lovebugs on soil

3.5.1. March Flies

Adult March flies generally live in wooded areas and are often found on flowers—adults of some species feed on nectar, pollen, and honeydew, but adults of other species don't feed at all, and in either case, they are very short- lived. They're considered important pollinators in orchards and for some species of irises and orchids. *Bibio slossonae* Cockerell, 1909 visits the fall-blooming shrub, witch hazel. Their larvae, drab and primitive-looking, feed en masse on rotting organic material like leaves, wood, compost, and rich soil, and sometimes they damage plant roots. The best way to clear them out of the soil is to turn chickens out on the land when it is being dug in spring; they devour the larvae greedily (Figures 44, 45, 46, 47, 48, 49, 50, 51 and 53) [23].

Source: https://www.zoology.ubc.ca/entomology/main/Diptera/Bibionidae/id-index-l.php

Figure 44 *Bibio albipennis* ♂ Say 1823, *B. albipennis* ♀

Source: https://www.zoology.ubc.ca/entomology/main/Diptera/Bibionidae/id-index-l.php

Figure 45 *Bibio inaequalis* ♀ (Foscolombe, 1854), *B. fumipennis* ♂

Source: https://www.zoology.ubc.ca/entomology/main/Diptera/Bibionidae/id-index-l.php

Figure 46 *Bibio nervosus* ♀ Loew, 1864 *B. nervosus* ♂

Source: https://www.zoology.ubc.ca/entomology/main/Diptera/Bibionidae/id-index-l.php

Figure 47 *Bibio palliatus* ♀ Loew, 1864, *B. palliatus* ♂

Source: https://www.zoology.ubc.ca/entomology/main/Diptera/Bibionidae/id-index-l.php

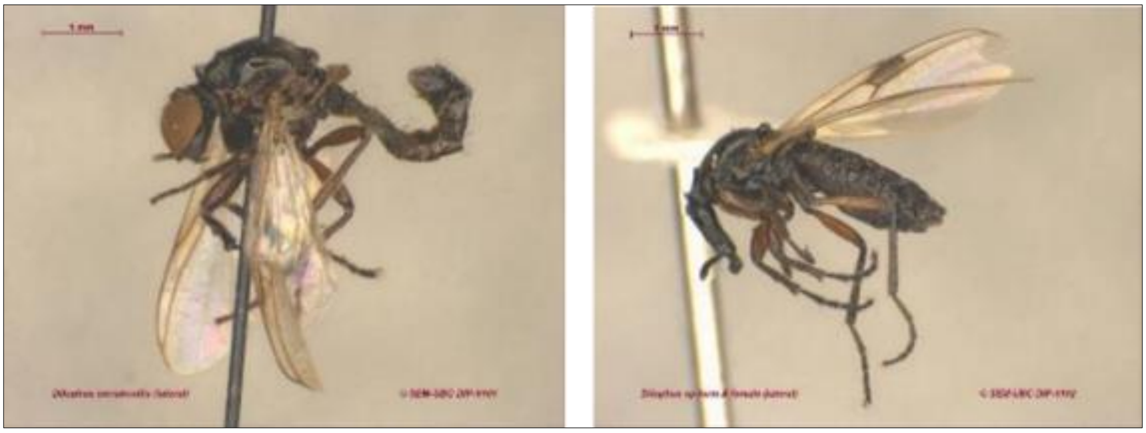
Figure 48 *Bibio slossonae* ♀ Cockerell 1909, *B. slossonae* ♂

Source: https://www.zoology.ubc.ca/entomology/main/Diptera/Bibionidae/id-index-l.php

Figure 49 *Bibio vestitus* ♂ Walker, 1848, *B. vestitus* ♀

Source: https://www.zoology.ubc.ca/entomology/main/Diptera/Bibionidae/id-index-l.php

Figure 50 *Bibio tristis* ♂ Williston 1893, *Dilophus breviceps* ♀ Loew, 1869



Source: https://www.zoology.ubc.ca/entomology/main/Diptera/Bibionidae/id-index-l.php

Figure 51 *Dilophus serraticollis* ♂ Walker, 1848, *Dilophus* sp. ♀

Source: https://www.zoology.ubc.ca/entomology/main/Diptera/Bibionidae/id-index-l.php

Figure 52 *Dilophus* sp. ♂ *Dilophus stigmatera* ♀ (Fabricius, 1965)

Source: https://www.zoology.ubc.ca/entomology/m

Figure 53 *Dilophus stigmatera* ♂ (Fabricius, 1965), *Dilophus tibialis* ♀ Loew, 1869

4. Conclusion

The Bibionidae, like other Bibionomorpha, are found primarily on decaying wood, humus-rich soil, and roots. In some cases, they can cause damage to cultivated plants. Some species emerge and fly in large groups. They can be collected using Malaise traps or by netting after emerging. Larvae can be serious agricultural pests, adults are important pollinators and sometimes the only ones, especially of orchids.

Compliance with ethical standards

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