Open Access Research Journal of
Science and Technology
Journals home page: https://oarjst.com/
ISSN: 2782-9960 (Online)

OARJ OPEN ACCESS RESEARCH JOURNALS

(REVIEW ARTICLE)

Check for updates

Family Sepsidae associated with the decomposition of organic matter (Insecta: Diptera)

Carlos Henrique Marchiori *

Instituto Federal Goiano, Biological Sciences, Parasitology, Goiânia, Goiás, Brazil.

Open Access Research Journal of Science and Technology, 2022, 05(02), 016–038

Publication history: Received on 02 June 2022; revised on 06 August 2022; accepted on 08 August 2022

Article DOI: https://doi.org/10.53022/oarjst.2022.5.2.0059

Abstract

Sepsidae larvae are coprophagous or, more rarely, scavengers. Most species are associated with mammalian droppings, on which eggs are laid and within which larvae develop. The entire post-embryonic development lasts from 14 to 32 days. Many sepsis apparently plays an important biological role as decomposers of excrements of mammals and other animals. Some species may be of limited hygienic importance due to their association with human faeces. Others are useful tools in Forensic Entomology. The objective of this work is to inventory the biology, ecology, habitat, geographic distribution, taxonomy, life cycle, phenology, biological control, and work carried out on the Sepsidae 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 1926 to 2022. The mini review was prepared in Goiânia, Goiás, from September to October 2021, through the Biological Abstract, Periodicals CAPES and Scielo.

Keywords: Coprophagous; *Palaeosepsis*; *Archisepsis*; Scavengers; Forensic Entomology

1. Introduction

Sepsidae is a family of flies, commonly called black scavenger flies or ensign flies. The family name derives from the genus *Sepsis*, which in turn comes from the Greek = putrefaction (Figures 1, 2 and 3) [1].

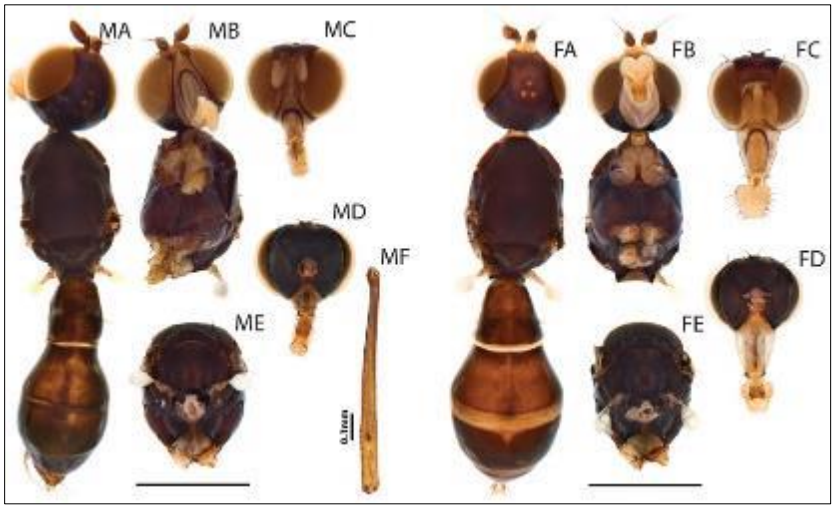
Source: https://www.youtube.com/watch?v=j-3qawFM1eg

Figure 1 Specimen of Sepsidae Family

* Corresponding author: Carlos Henrique Marchiori
Instituto Federal Goiano, Biology, Parasitology, Goiânia, Goiás, Brazil.

Source: http://www.maltawildplants.com/!faunafungi/maltawildlife.php?species=Sepsis%20lateralis

Figure 2 Specimen of Sepsidae Family

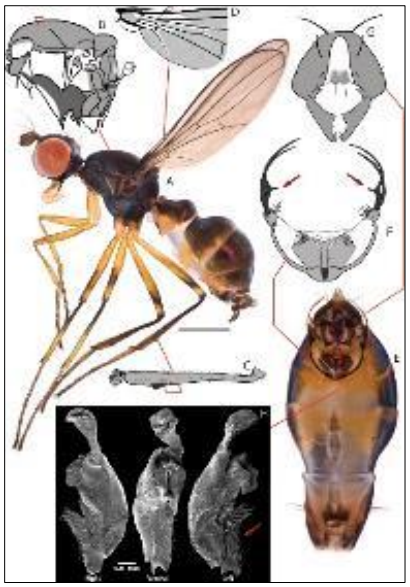


Source: https://zookeys.pensoft.net/articles.php?id=3578

Figure 3 Female (FA-FE). M and F prefixes refer to male and female specimen respectively. A Habitus, dorsal view (sans wings) B head and thorax, ventral view C Head capsule, anterior view D Head capsule, posterior view E Thorax, posterior view F (male only)–Rear tibia, dorsal view showing osmeterium

1.1. Description

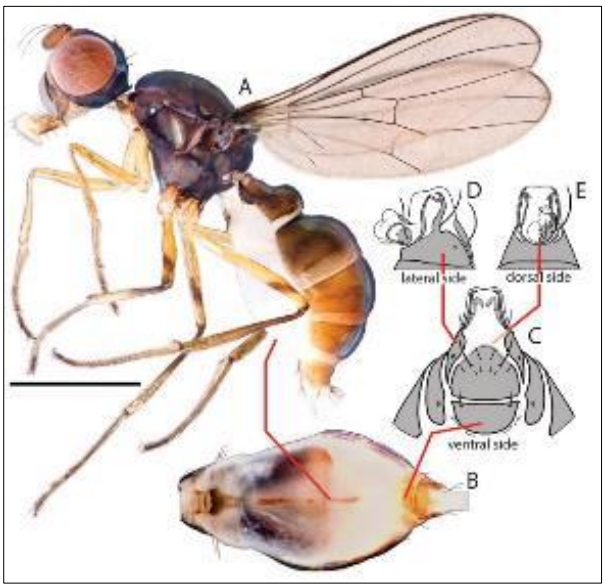
Sepsidae Family are slender flies that resemble tiny winged ants. They are usually black, sometimes shiny and other times with silvery hairs on the thorax. The head is rounded. Sepsids have one or more bristles on the posteroventral margin of the posterior spiracle of the thorax, a character that distinguishes the family from other acaliptrates (Figure 4) [2,3].



Source: https://zookeys.pensoft.net/articles.php?id=3578

Figure 4 Male. A Habitus, lateral view B Pleural microtomensity pattern; (white = smooth, light grey = lightly microtomentose, dark grey = heavily microtomentose) C Rear tibia, with focus on osomterium D Basal section of wing showing microtrichosity pattern (white=smooth, light grey=with microtrichia) E Whole abdomen, ventral view F Sternite appendage G Hypopygium, dorsal view H Phallus, right, ventral and left views; red arrow indicates basal spiny flap

Postvertical bristles are divergent or sometimes absent. Up to three pairs of frontal bristles are visible. They have ocelli with ocellular bristles. The whiskers and palps are poorly developed. The male's forelegs often have extrusions, spurs, teeth, or other ornamentation. The tibia has a dorsal prorsal bristle in most genera. The abdomen is usually constricted at the base (Figures 5, 6 and 7) [4,5,6].

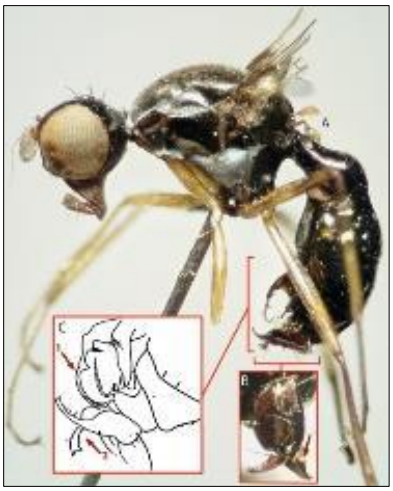


Source: https://zookeys.pensoft.net/articles.php?id=3578

Figure 5 Female. A Habitus, lateral view B Whole abdomen, ventral view C Abdominal posterior, ventral view D Same, lateral view E Same, dorsal view

Source: Salvador Vicenza Ph.D

Figure 6 Diptera-Sepsidae-*Sepsis*-black scavenger flies female wing



Source: Duda (1926)

Figure 7 Images of holotype (A, B) and drawing (C) from description for *Perochaeta orientalis* (Meijere, 1913) male. A image of habitus, lateral view B Image of hypopygium, dorsal view; red arrow pointing to the median protrusion on the surstylus C Drawing of abdominal posterior (lateral view); red arrow 1 shows how illustration has fused the two setae into one, red arrow 2 shows how the drawing fails to display the median protrusion

The larva is slender, tapering at the front end, and smooth except for ventral swellings. The larva is amphipneustic: It has two pairs of spiracles, one towards the head and one towards the tail. The bulbous posterior end with its pair of spiracles distinguishes it from the larvae of other acaliptrates. The pupa is enclosed within a puparium [7,8].

1.2. Biology, Ecology, Importance and geographic distribution

They are usually found around dung or decaying plant and animal material. Many species resemble ants, having a "waist" and a shiny black body. Many Sepsidae have a curious wing-flapping habit made more apparent by the dark spots on the wingtip (Figure 8) [9,10].

Source: by Steve & Alison: https://www.flickriver.com/photos/tags/sepsidae/interesting/

Figure 8 Top dog ensign fly *Themira* sp. (Diptera: Sepsidae) guarding its mould growing on the tubifera mould on rotting alstonia log on rainforest floor Mandalay Airlie Beach P1120386

Many species have a very wide distribution, reflecting the coprophagous habit of most Sepsidae. Some species have spread over large territories in association with livestock. Adult flies are found primarily in excreta of mammals, including humans (less frequently in other decaying organic matter), where they lay eggs and develop larvae, and in nearby vegetation, carrion, fermenting tree sap, and shrubs and herbs [11,12].

They are particularly active insects during the hottest hours of the day. Often, they are resting on the vegetation, pening and closing their wings rhythmically. Adult insects feed on nectar, but are often found on excrements from which they obtain proteins, water and minerals (Figure 9) [13,14].

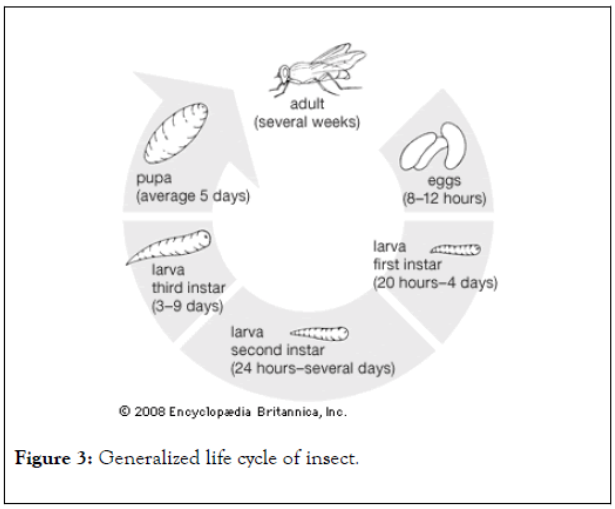


Figure 3: Generalized life cycle of insect.

Source: https://www.longdom.org/open-access/forensic-entomology-a-review-on-use-of-insects-for-investigation-55852.html

Figure 9 Generalized life cycle of insect

Sepsidae larvae are coprophagous or, more rarely, scavengers. Most species are associated with mammalian droppings, on which eggs are laid and within which larvae develop. The entire post-embryonic development lasts from 14 to 32 days [15,16,17].

Many sepsis apparently plays an important biological role as decomposers of excrements of mammals and other animals. Some species may be of limited hygienic importance due to their association with human faeces. Others are useful tools in Forensic Entomology [18,19,20].

1.3. Geographic distribution

Neotropical: Argentina (Salta), Belize, Bolivia, Brazil (Bahia, Espírito Santo, Goiás, Mato Grosso, Minas Gerais, Pará, Paraná, Pernambuco, Rio de Janeiro, Santa Catarina, São Paulo), Colombia, Costa Rica, Cuba, Dominican Republic,

Ecuador, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico (Hidalgo, Michoacán, Querétaro), Nicaragua, Panama, Paraguay, Peru, Uruguay, USA (Puerto Rico) and Venezuela [19,20].

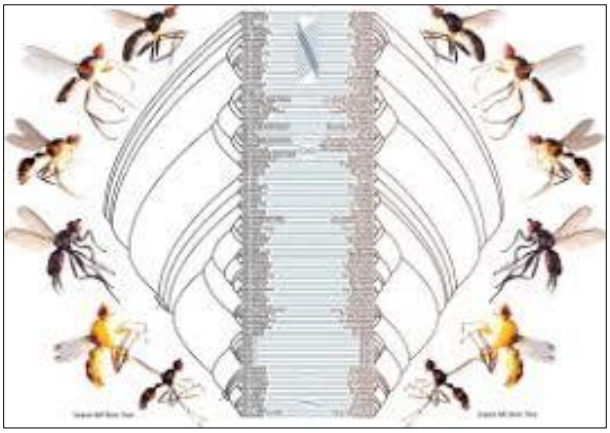
1.4. Taxonomy

The family Sepsidae is allocated in the Superfamily Sciomyzoidea, together with Coelopidae, Dryomyzidae, Helcomyzidae, Helosciomyzidae, Phaeomyiidae, Ropalomeridae and Sciomyzidae, and of these Helcomyzidae, Helosciomyzidae and Phaeomyiidae are not occur in Brazil. More than 300 species are described worldwide [21].

In Brazil, 21 species have been recorded valid distributed in six genera. In the Brazilian Amazon region, 13 species distributed in four genera [22,23,24,25].

1.5. Genus

Adriapontia Ozerov, 1996; *Afromeroplius* Ozerov, 1996; *Afronemopoda* Ozerov, 2004; *Afrosepsis* Ozerov, 2006; *Archisepsis* Silva, 1993; *Australosepsis* Malloch, 1925; *Brachythoracosepsis* Ozerov, 1996; *Decachaetophora* Duda, 1926; *Diploosmeteriosepsis* Ozerov, 1996; *Dicranosepsis* Duda, 1926; *Dudamira* Ozerov, 1996; *Idiosepsis* Ozerov, 1990; *Lasionemopoda* Duda, 1926; *Lasiosepsis* Duda, 1926; *Lateosepsis* Ozerov, 2004; *Leptomerosepsis* Duda, 1926; *Meroliosepsis* Duda, 1926; *Meroplius* Rondani, 1874; *Microsepsis* Silva, 1993; *Mucha* Ozerov, 1992; *Nemopoda* Robineau-Desvoidy, 1830; *Ortalischema* Frey, 1925; *Orygma* Meigen, 1830; *Palaeosepsioides* Ozerov, 1992; *Palaeosepsis* Duda, 1926; *Parapalaeosepsis* Duda, 1926; *Paratoxopoda* Duda, 1926; *Perochaeta* Duda, 1926; *Pseudonemopoda* Duda, 1926; *Pseudopalaeosepsis* Ozerov, 1992; *Saltella* Robineau-Desvoidy, 1830; *Sepsis* Fallén, 1810; *Susanomira* Pont, 1987; *Themira* Robineau-Desvoidy, 1830; *Toxopoda* Macquart, 1851; *Xenosepsis* Malloch, 1925 and *Zuskamira* Pont, 1987 (Figure 10) [26,27,28].



Source: https://www.sciencedirect.com/science/article/abs/pii/S105579031300211X

Figure 10 We here present a phylogenetic hypothesis for Sepsidae (Diptera: Cyclorrhapha), a group of schizophoran flies with ca. 320 described species that is widely used in sexual selection research. The hypothesis is based on five nuclear and five mitochondrial markers totaling 8813 bp for ca. 30% of the diversity (105 sepsid taxa) and – depending on analysis – six or nine outgroup species. Maximum parsimony (MP), maximum likelihood (ML), and Bayesian inferences (BI) yield overall congruent, well-resolved, and supported trees that are largely unaffected by three different ways to partition the data in BI and ML analyses

Objective

The objective of this work is to inventory the biology, ecology, habitat, geographic distribution, taxonomy, life cycle, phenology, biological control, and work carried out on the Sepsidae Family (Insecta: Diptera).

2. Methods

The method used to prepare this mini review was Marchiori 2021 methodology [29].

3. Studies conducted and selected

3.1. Study 1

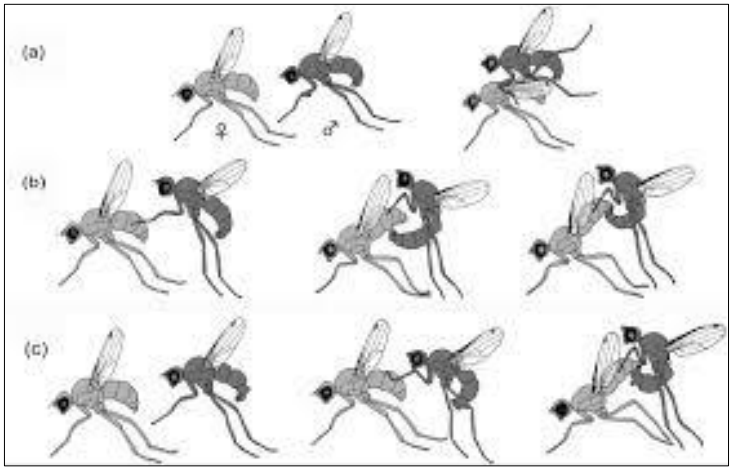
A very curious behavior of sepsids is the pre-copulatory guard that the male does to the female. It all starts when the male mounts the female on the substrate. The female will then proceed to oviposition before the couple leaves the substrate to mate in the surrounding vegetation. This behavior is extremely rare in insects, but very common in sepsids. There are examples of species in which populations of the same species show this behavior and others do not (an example is the species *Sepsis punctum* (Fabricius, 1794) (Figure 11).

Source: https://www.insetologia.com.br/2018/02/moscas-sepsideas-em-sao-paulo.html

Figure 11 Copulation between individuals of the Sepsidae Family

The reasons given for this behavior are the following: the females would benefit as this behavior would allow them to separate the wheat from the chaff, that is, to find the best partners. Another advantage would be the possibility of laying eggs in peace without being constantly harassed by other males. From the point of view of males, this behavior would be a response to the intense competition between males resulting from the greater number of individuals of this sex in the breeding sites.

A very curious feature of male sepsids is the presence of “thorns” on the femurs and tibias of the forelegs. These “thorns” allow males to firmly cling to females' wings before initiating copulation and, in some species, during copulation (Figure 12A).



Source: https://www.researchgate.net/figure/Mounting-techniques-in-Sepsidae-a-Typical-sepsid-mount-male-uses-modified-forelegs_fig3_5358727

Figure 12A Mounting techniques in Sepsidae. (a) "Typical" sepsid mount: male uses modified forelegs to clasp female wingbase; (b) Novel mounting technique in *Perochaeta dikowi* Puniamoorthy & Meier, 2008: male bends abdomen ventro-anteriad and makes contact with the ventral side of the female abdomen with his surstylus before sliding

posterior to establish genital contact; (c) Novel mounting technique in *Sepsis secunda* (Melander & Spuler, 1917): male bends abdomen ventro-anteriad to establish direct genital

Anyone who has observed sepsids will certainly have noticed the waving of the wings characteristic of this family. The function of this behavior is unknown, but it is not thought to be related to mating. It is also interesting to note that the dumbbells (hind wings that in Diptera are modified and whose function is to balance the flight) also move, but they are not synchronized with the wings (Figure 12B).

Source: https://bugguide.net/node/view/917704/bgimage

Figure 12B Copulation between individuals of the Sepsidae Family

The Sepsidae are the only dipteran family that has a gland (Dufour's gland) that presumably serves for chemical defence [30].

3.2. Study 2

The objective of this study was to describe the first occurrence of *Triplasta coxalis* (Ashmead, 1865) (Hymenoptera: Figitidae: Eucoilinae) as a parasitoid of *Archisepsis scabra* (Loew, 1861) (Diptera: Sepsidae) in Brazil. The experiment was carried out at the Igarapé Farm in Monte Alegre, Minas Gerais (Figure 12C) [31].

Source: https://www.alamy.com/stock-photo-black-scavenger-flies-sepsidae-cut-out-76010513.html

Figure 12C *Archisepsis scabra* (Loew, 1861) (Diptera: Sepsidae)

Fourty seven pupae of *A. scabra* were obtained, two of which yielded the parasitoid *T. coxalis.* The percentage of parasitism was 4.3% (Figure 13).

Source: http://www.waspweb.org/Cynipoidea/Figitidae/Classification/Classification_World_Figitidae.htm

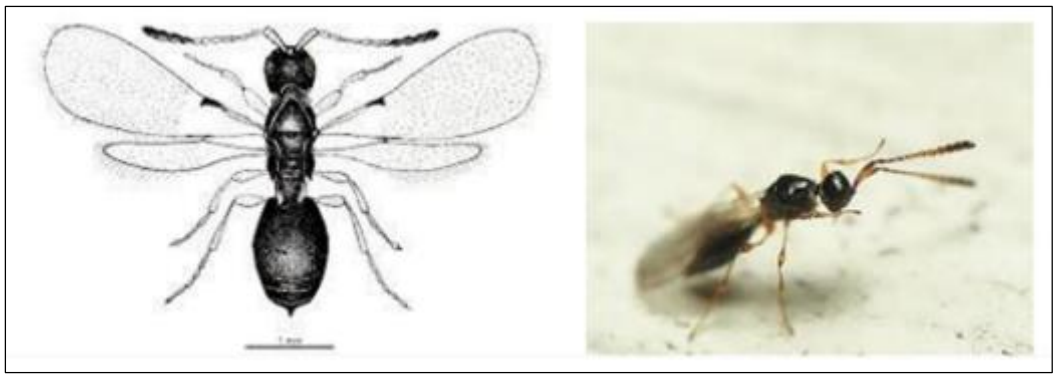
Figure 13 *Triplasta coxalis* (Ashmead, 1865) (Hymenoptera: Figitidae: Eucoilinae)

In Itumbiara, Goiás, *Spalangia drosophilae* Ashmead, 1885 (Hymenoptera: Pteromalidae), *Spalangia nigroaenea* Curtis, 1839 (Hymenoptera: Pteromalidae), *Trichopria* sp. (Hymenoptera: Diapriidae), *Paraganaspis egeria* Díaz, Gallardo & Walsh, 1996 (Hymenoptera: Figitidae) and *Triplasta atrocoxalis* (Ashmead, 1895) (Hymenoptera: Figitidae) were found as naturais enemy of *A. scabra*. In the same locality, as well as in Cachoeira Dourada, Goiás, *T. coxalis* was found parasitizing *Palaeosepsis* spp. (Diptera: Sepsidae) in cattle feces on pastureland (Figure 14).

Source: https://www.alamy.com/stock-photo/spalangia.html

Figure 14 *Spalangia drosophilae* Ashmead, 1885 (Hymenoptera: Pteromalidae)

Since the use of chemical substances for fly control may cause damage to the environment and also to human and animal health, the search for efficacious natural enemies may be a viable alternative for biological control programs over a long term (Figure 15) [31].



Source: https://www.researchgate.net/figure/Figura-8-Trichopria-sp-Hembra-habito-en-vista-dorsal-Loiacono-ined_fig1_321714533

Figure 15 *Trichopria* sp. (Hymenoptera: Diapriidae)

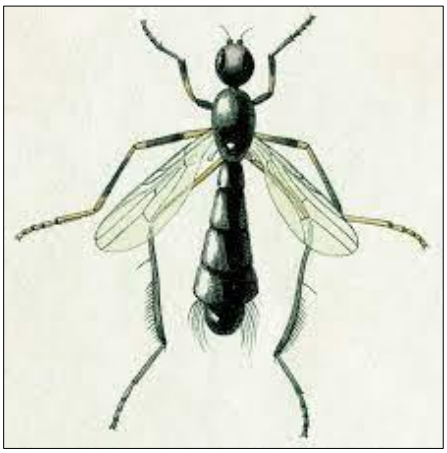
3.3. Study 3

The biology of the Sepsidae family is practically unknown for the Neotropics. They are usually found near or on animal feces or on various other materials such as garbage, animal carcass, bush and low foliage. This work reports the occurrence of *Archisepsis scabra* (Loew, 1861) (Diptera: Sepsidae) parasitoids collected in bovine and buffalo feces, in Itumbiara, GO (Figure 16).

Source: https://v3.boldsystems.org/index.php/Taxbrowser_Taxonpage?taxid=484351

Figure 16 *Spalangia nigroaenea* Curtis, 1839 Curtis (Hymenoptera: Pteromalidae)

One hundred and sixty-nine (169) pupae of *A. scabra* were obtained in feces cattle, from which ten specimens of the parasitoid emerged *Spalangia drosophilae* Ashmead, 1885 (Hymenoptera: Pteromalidae), a specimen of *Spalangia nigroaenea* Curtis, 1839 Curtis (Hymenoptera: Pteromalidae) and eight specimens of *Triplasta atrocoxalis* (Ashmead, 1839) (Hymenoptera: Pteromalidae). The percentage of parasitism was 11.2%. The percentages of parasitism presented by the parasitoids *S. drosophilae*, *S. nigroaenea* and *T. atrocoxalis* was 5.9%, 0.6% and 4.7%, respectively (Figure 17).



Source: https://diptera-info.nl/infusions/checklist/view_family.php?fam_id=139

Figure 17 *Archisepsis scabra* (Loew, 1861) (Diptera: Sepsidae)

In buffalo feces, 310 *A. scabra*, from which four individuals of *Paraganaspis egeria* Díaz, Gallardo and Walsh, 1996 (Hymenoptera: Figitidae), a specimen of *S. drosophilae* and a specimen of *Trichopria* sp. (Hymenoptera: Pteromalidae) the percentage of parasitism was 1.9%.

The percentages of parasitism presented by the parasitoids *P. egeria*, *S. drosophilae* and *Trichopria* sp. were 1.3%, 0.3% and 0.3%, respectively [32].

3.4. Study 4

Study of Diptera species of medical, sanitary, veterinary, and economic importance in Brazil.

The aim of this study was to verify the species of flies collected in buffalo feces in Itumbiara, southern Goiás, Brazil. Three thousand four hundred and seventy-three (3473) pupae of flies were collected in buffalo feces, belonging to three

families and six different species. 628 pupae of flies were collected in bovine feces, belonging to four families and 10 species table (1) and table (2).

Table 1 Species of flies collected in buffalo feces in southern Goiás, from May 2003 to June 2004

Diptera species	Number of pupae collected	Percentage
Archisepsis scabra	310	9.0
Brontaea quadristigma	138	4.0
Brontaea debilis	127	3.7
Cyrtoneurina pararescita	19	0.5
Palaeosepsis sp.	1948	56.0
Sarcophagula occidua	931	26.8
Total pupae: 3473	3473	100.0

Table 2 Species of flies collected from bovine feces in southern Goiás, from May 2003 to June 2004

Diptera species	Number of pupae collected	Percentage
Archisepsis scabra	40	6.5
Brontaea debilis	56	8.9
Brontaea quadristigma	49	7.8
Cyrtoneurina pararescita	151	24.0
Chrysomya megacephala	51	8.1
Musca domestica	10	1.6
Oxysarcodexia thornax	70	11.2
Palaeosepsis spp.	107	17.0
Ravinia belforti	63	10.0
Sarcophagula occidua	31	4.9
Total pupae	628	100.0

Probably, this difference in the number of flies collected in the two substrates is due to a greater supply of bovine faeces in the pastures, due to the greater number of animals (100 heads), reducing the number of insects per faecal plate than that of faeces of buffaloes (10 heads). Buffalo feces showed greater diversity of fly species (Figure 18).

Source: https://www.dreamstime.com/stock-image-isolated-fly-sepsidae-image23247911

Figure 18 *Palaeosepsis* sp. Sepsidae Family

The most collected species in buffalo feces and bovine feces were: *Palaeosepsis* sp. (Sepsidae) and *Cyrtoneurina pararescita* (Diptera: Muscidae) (Couri, 1995) (Muscidae)., respectively. The biology of the Sepsidae family is practically unknown for the Neotropics. They are usually found near or on animal feces or on various other materials such as garbage, animal carcass, bush and low foliage.

Preliminary survey of Sepsidae in Roraima, Maracá Project, species of *Archisepsis scabra* (Loew, 1861) (Diptera: Sepsidae), *Palaeosepsis insulares* Williston, 1896 (Sepsidae) and *Palaeosepsis pusio (*Schiner, 1868) (Sepsidae) (9) were collected (Figure 19).

Source: https://www.cirrusimage.com/fly_black_scavenger_sepsidae/

Figure 19 Sepsid fly on faeces

The species that showed preference for bovine feces were: *Brontaea debilis* (Williston, 1896) (Muscidae), *Brontaea debilis* (Williston, 1896) (Muscidae), *C. pararescita*, *Chrysomya megacephala* (Fabricius, 1794) (Calliphoridae), *Musca domestica* L., 1758, *Oxysarcodexia thornax* (Walker 1849 (Sarcophagidae) *Ravinia belforti* (Prado & Fonseca, 1932) (Sarcophagidae). Regarding the buffalo feces were: *A. scabra*, *Palaeosepsis* sp. and *Sarcophagula occidua* (Fabricius, 1794) (Sarcophagidae) (X^2=2105.69; GL: 10; P=0.05) [33,34].

3.5. Study 5

I happened upon a pile of fresh excrement out in the woods and it was indeed a busy place, with all sorts of flying insects competeing for space at the trough. The tiniest (<4mm) of the visible participants was this curious-looking fly in the Sepsidae family. They are fairly common here in the American Midwest if you know where to look. (of course, I can't blame anyone not relishing the sight of shit, but we fly enthusiasts go where the action is. Ye of faint heart may see these little gals hanging out in low foliage too, sans poo) (Figure 20) [35].

Source: photographed at West Chicago Prairie, DuPage County, Illinois. Size: 5mm

Figure 20 *Nemopoda nitidula* (Fallén, 1820) on faeces (Sepsidae)

Turns out she was laying eggs (below) but I didn't notice what she was doing until later. Otherwise, I'd have taken more shots. The Black Scavenger Flies (34 North American species) are small, shiny black, with round heads and the most common genus, *Sepsis,* has a pigment spot on the tip of the wing. Larvae live in excrement and decaying material (Figure 21) [35].

Source: https://en.wikipedia.org/wiki/Nemopoda_nitidula

Figure 21 *Nemopoda nitidula* (Fallén, 1820)

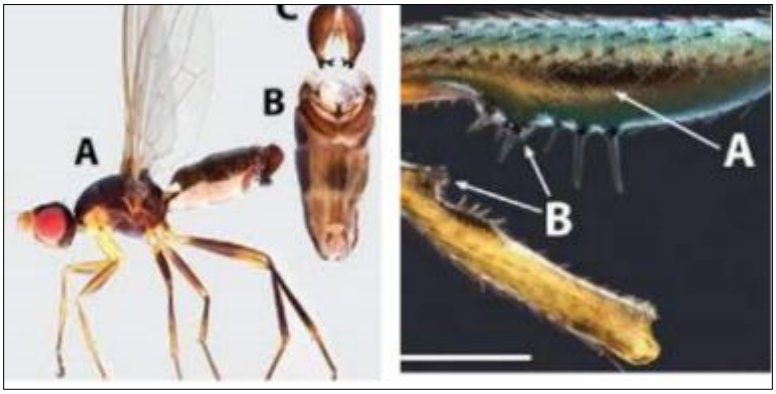
3.6. Study 6

Archisepsis armata (Schiner, 1868), the species chosen for this work, is a very abundant and widely distributed sepsis species in the Neotropical region, this was not only recorded for El Salvador, Suriname, French Guiana and Chile (Figure 22).

Source: https://sepsidnet.biodiversity.online/species/Sepsidae-000022-armata

Figure 22 *Archisepsis armata* (Schiner, 1868). Male alcohol-vouchered specimen

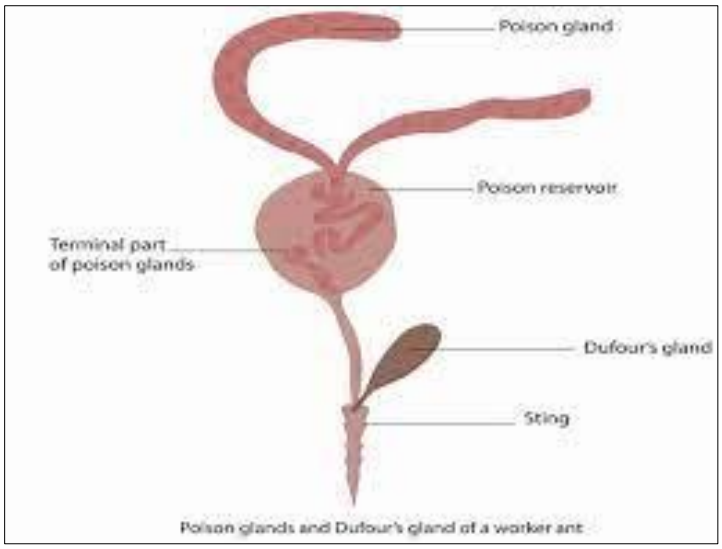
For Brazil, this has already been recorded in 11 states, including Pará, and individuals of this species are easily found near animal feces in quite numerous groups. Sporadic observations of individuals of a Palearctic sepsis species *Sepsis cynipsea* (Linnaeus, 1758) verified wasps of the genus *Vespula* Thomson, 1869 and a predatory fly of the genus *Scathophaga* Linnaeus, 1758 attacking and soon afterwards rejecting the individuals of that species (Figures 23A and 23B).



Source: https://www.researchgate.net/figure/Focus-stacked-image-of-male-Sepsis-cynipsea-Linneaus-1758-fore-femur-and-tibia_fig1_259891303

Figure 23A *Sepsis cynipsea* (Linnaeus, 1758) (A) habitus, lateral view; (B) abdomen, ventral view; (C) dissected claspers, dorsal view. Figure 23B Image of male *Sepsis cynipsea* (Linneaus, 1758) fore femur and tibia, anterior view. The resolution of the image is high enough to show: (A) cuticular sculpturation detail on the femur; (B) sexually dimorphic ornamentation in detail on both femur and tibia

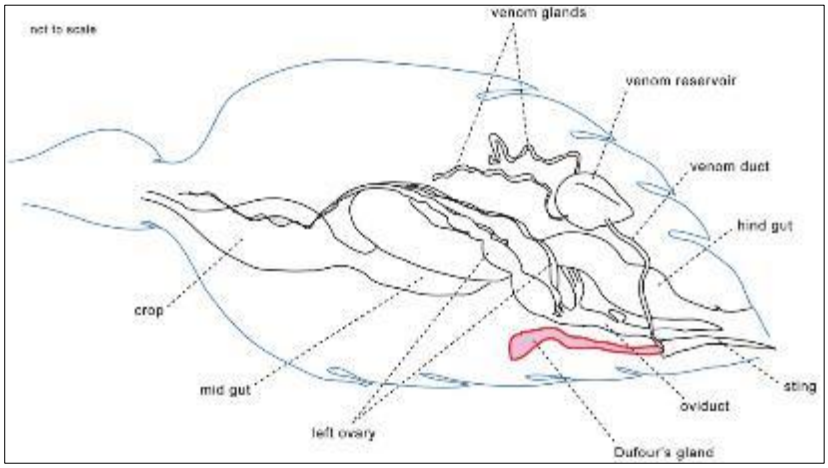
Observations on the formation of sepsis swarms highlighted in his work that the substances released by the Dufour gland would be responsible for the formation of sepsis aggregations on Old World vegetation, also for its palatability. He also observed some species of birds from Europe preying on sepsids in these clusters (Figure 24).



Source: Adapted from Chapman (1998)

Figure 24 Dufour"s gland, poison gland and sting apparatus

Substance released by the Dufour gland, it has the defensive function of the Dufour gland in sepsids, through the secretion of repellent chemicals. Sepsidae species: *Sepsis punctum* (Fabricius, 1794), *Nemapoda nitidula* (Fallén, 1820) and *Themira putris* (Linnaeus, 1758) the gland has a defensive function and is linked to the final part of the intestine of sepsis (Figure 25).



Source: https://jhr.pensoft.net/article/1649/

Figure 25 Diagram showing position of the Dufour's gland among other abdominal organs in the polistine wasp *Ropalidia marginata* (Lepeletier, 1836) (Hymenoptera)

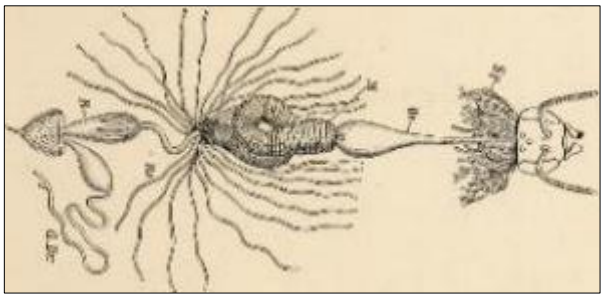
Not all genera of the Sepsidae family have the Dufour's gland, it is absent in the genera: *Orygma* Meigen, 1830, *Ortalischema* Frey 1925 and *Toxopoda* Macquart, 1851. The family Sepsidae is allocated in the Superfamily Sciomyzoidea, together with Coelopidae, Dryomyzidae, Helcomyzidae, Helosciomyzidae, Phaeomyiidae, Ropalomeridae and Sciomyzidae, and of these Helcomyzidae, Helosciomyzidae and Phaeomyiidae are not occur in Brazil. *Archisepsis armata* (Schiner, 1868) is unpalatable for two insectivorous predators easily found in the metropolitan region of Belém do Pará (Figure 26) [36,37,38,39,40, 41,42,43].

Source: https://sepsidnet.biodiversity.online/species/Sepsidae-000022-armata

Figure 26 *Themira putris* (Linnaeus, 1758)

3.7. Study 7

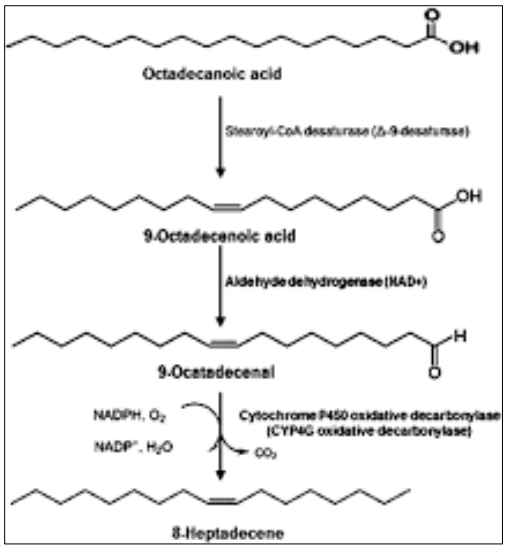
Predation is one of the main selection pressures that determines the shape and behavior of organisms. In this way, there are several defense mechanisms that contribute significantly to avoid or reduce the attack predators, such as coloration patterns, body shape, behavior, and chemical use. Some organisms may secrete chemical compounds or acquire secondary compounds through their diet, making them unpalatable. These compounds can cause the predator to simply release the prey or can in some cases even paralyze or kill the predator (Figure 27) [44,45].



Source: https://commons.wikimedia.org/wiki/File:Dufour%27s_gland_of_Apis_mellifera.jpg

Figure 27 Dufour's gland

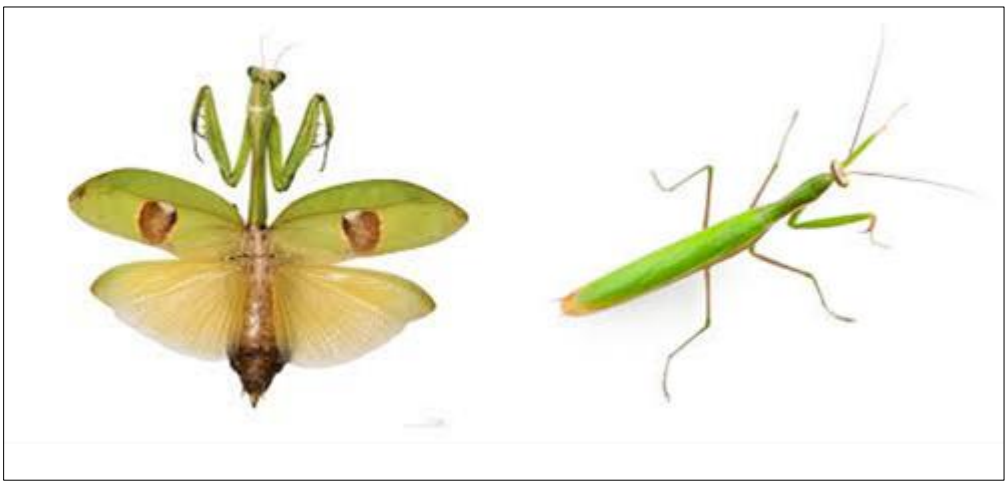
Some organisms can secrete chemical compounds or acquire secondary compounds through their diet, making them unpalatable. These compounds can cause the predator to simply release the prey or can in some cases even paralyze or kill the predator. The use of chemical defenses is a rare phenomenon among Diptera species. The family Sepsidae, characterized by relatively small individuals, coloration generally dark and ant-like, unlike all other flies, can be unpalatable, due to the production of chemical substances through a gland, known as Dufour's gland. However, this gland is not present in all genera (Figure 28) [46,47].



Source: https://repositorio.unesp.br/bitstream/handle/11449/172477/2-s2.0-84956610860.pdf?sequence=1

Figure 28 Schematic representation of the pathway of unsaturated alkene biosynthesis, with the respective proteins identified in the present study for Dufour's gland

In this study, the species of Sepsidae *Archisepsis armata* (Schiner, 1868) was used, because it is a common and abundant species in the region of Belém. The specimens were collected on bovine feces and animal carcasses and were captured with transparent plastic bags and an entomological net. After capture, the specimens were packed in plastic bags and transported to the laboratory Individuals of the *Drosophila melanogaster* Meigen, 1830. (Diptera, Drosophilidae) species were used as a control group. These were collected with the aid of transparent plastic bags, using rotten banana as bait. These were also packed in plastic bags and taken to the laboratory (Figure 29) [48,49].



Source: https://en.wikipedia.org/wiki/Stagmatoptera

Figure 29 *Stagmatoptera binotata* Scudder, 1869

The predator models used in this work were adult spiders of the species *Plexippus paykulli* (Audouin, 1826) (Araneae, Salticidae) and 1st instar mantis nymphs of the species *Stagmatoptera binotata* Scudder, 1869 (Insecta, Mantodea). Spiders were collected inside residences in the urban area of Belém. *Mantis* nymphs were obtained from oothecae. In this way, it reduces the chance that these predators have had previous contact with the sepsids [50,51,52].

During the palatability tests, the spiders and the praying mantis were divided into two groups of 15 individuals each. Thus, 15 spiders received only drosophilids and 15 received only *A. armata*. The same was done with the praying mantises, totaling 30 individuals of spiders and 30 of mantises, 15 of each fed on drosophilids and 15 on sepsis. Before the experiment the predators were without food for a period of 48 hours. After inserting the sepsids and drosophilids into the pots, observations were carried out for a period of up to 30 minutes and all predator reactions were recorded (Figure 30) [50,51,52].

Source: https://eol.org/pt-BR/pages/1213855

Figure 30 *Plexippus paykulli* (Audouin, 1826) (Araneae, Salticidae)

Two categories of behavior of *S. binotata* in relation to A. armata were observed, which are the following: "Attacked and ate" and "No reaction", the first being the most common (93.3%). In relation to *D. melanogaster*, three categories were observed: "Attacked and ate" (86.7%), "Attacked and ignored" (6.6%) and "No reaction" (6.7%) [50,51,52].

Three categories of behavior of *P. paykulli* in relation to *A. armata* were observed, which are the following: "Attacked and ate" (73.3%), "Attacked and ignored" (6.7%) and "No reaction" (20%). In relation *to D. melanogaster*, three categories were observed: "Attacked and ate" (86.7%), "Attacked and ignored" (6.6%) and "No reaction" (6.7%) None of the predators showed repulsive behavior when coming into contact with the sepsids. According to the results obtained, there was no significant difference between the consumed specimens of *D. melanogaster* and *A. armata* for both *S. binotata* (P=0.619) and *P. paykulli* (P=0.813) [50,51,52].

3.8. Study 8

Genus *Palaeosepsis* Duda, 1926

Palaeosepsis dentata (Becker, 1919)

dentatiformis (Duda, 1926)

Sepsis dentata Becker, 1919: 207.

Sepsis dentatiformis Duda, 1926a: 46.

Distribution of *Palaeosepsis dentata*. Argentina (Tucumán), Bolivia, Brazil (Minas Gerais, Rio de Janeiro, Santa Catarina, São Paulo), Colombia, Costa Rica, Ecuador, French Guiana, Honduras, Panama, Peru, Venezuela. Distribution of *Palaeosepsis dentatiformis*. Costa Rica, Ecuador anf Venezuela (Figures 31, 32, 33, 34, 35, 36, 37 and 38) [53].

Source: Diego Alfonso Rosa

Figure 31 *Palaeosepsis* sp. (Diptera: Sepsidae)

Source: Diego Alfonso Rosa

Figure 32 *Palaeosepsis* sp. (Diptera: Sepsidae)

Source: Diego Alfonso Rosa

Figure 33 *Palaeosepsis* sp. (Diptera: Sepsidae)

Source: Diego Alfonso Rosa

Figure 34 *Palaeosepsis* sp. (Diptera: Sepsidae)

Source: Diego Alfonso Rosa

Figure 35 *Palaeosepsis* sp. (Diptera: Sepsidae)

Source: Diego Alfonso Rosa

Figure 36 *Palaeosepsis* sp. (Diptera: Sepsidae)

Source: Alec Earnshaw

Figure 37 *Palaeosepsis* sp. (Diptera: Sepsidae)

Source: Alec Earnshaw

Figure 38 *Palaeosepsis* sp. (Diptera: Sepsidae)

4. Conclusion

Sepsidae larvae are coprophagous or, more rarely, scavengers. Most species are associated with mammalian droppings, on which eggs are laid and within which larvae develop. The entire post-embryonic development lasts from 14 to 32 days. Many sepsis apparently plays an important biological role as decomposers of excrements of mammals and other animals. Some species may be of limited hygienic importance due to their association with human faeces. Others are useful tools in Forensic Entomology.

References

[1] Greenberg B. Flies and Disease: II. Biology and Disease Transmission. 1th ed. New Jersey: Princeton Legacy Library. 2019.

[2] Clausen CP. Entomophagous insects. 1th ed. London: McGraw-Hill Book Co. Inc. 1940.

[3] Costa C, Ide S, Simonka CE. Insetos Imaturos: metamorfose e identificação. 1th. ed. Ribeirão Preto: Holos Editora. 2006.

[4] Zuska J. Zoogeographic aspects of the European fauna of the family Sepsidae (Diptera). Acta Entomologica Bohemoslovaca. 1970a; 40(3): 605-610.

[5] Zuska J. A revision of the genus *Parapalaeosepsis* (Diptera, Sepsidae). Acta Entomologica Bohemoslovaca.. 1970b: 67(1): 50-61.

[6] Iwasa M. Studies on the Sepsidae from Japan (Diptera): I. Revision of the Genus *Sepsis* Fallen, with a key to the Japanese Genera. Kontyu. 1980; 48(3): 402-412.

[7] Snowball GA. A consideration of the insect population associated with cow dung at Crawley. Journal of the Royal Society of Western Australia. 1944; 28: 219-245.

[8] Papp L. Ecological and production biological data on the significance of flies breeding in cattle droppings. Acta Zoologica Hungarica. 1971; 17(1-2): 91-105.

[9] Zuska J. Asian *Themira* (Diptera: Sepsidae): descriptions of two new species and distributional notes. Proceedings of the Entomological Society of Washington. 1974; 76(2): 190-197.

[10] Ozerov AL. New data on the Neotropical sepsids (Diptera Sepsidae). Russian Entomological Journal. 1992; 1(1): 81–86.

[11] Catts EP, Haskell NH. Entomology and death: A procedural guide. 1th ed. Clemson: Joyce's Print Shop Inc. 1990.

[12] Eisner T. Chemical defense against predation in arthropods. In: Sondheimer E, Simeone JB, eds. Chemical Ecology. 1th ed. New York: Academic Press. 1970; p. 157-215.

[13] Zuska J. Three new synonyms in the European Sepsidae (Diptera). Acta Entomologica Bohemoslovaca. 1971; 68 (1): 58-59.

[14] Zuska J, Colless DH. Australian Sepsidae (Diptera). Journal of the Australian Entomological Society. 1984; 23(1): 59-67.

[15] Malloch JR. Notes on Australian Diptera. Proceedings of the Linnean Society of New South Wales. 1925; 50(7): 311–340.

[16] Duda O. Monograph of the Sepsidae (Dipt.). Annals of the Natural History Museum in Vienna. 1926; 39: 1-153.

[17] Robineau-Desvoidy A, Baptiste J. Essay on *Myodaria*. Sciences, Mathematics and Physics. 2018; 2(2): 1–813.

[18] Hennig W. Sepsidae. In: Lindner E, eds. The Flies of the Palaearctic Region. 1th. Stuttgart: The only comprehensive work on Palearctic genera and species. 1949; p. 1-90.

[19] Eberhard WG. Mating systems of sepsid flies and sexual behavior away from oviposition sites by *Sepsis neocynipsea* (Diptera: Sepsidae). Journal of the Kansas Entomological Society. 1999; 72(1): 129-130.

[20] Byrd SH, L. Castner JL. Forensic Entomology: the utility of arthropods in legal investigations. 1th ed. London: CRC Press LLC. 2000.

[21] Pont AC. Two new genera of West Palaearctic Sepsidae (Diptera). Entomologica Scandinavica. 1987; 18 (3): 265–272.

[22] Ang Y, Meier R. Five additions to the list of Sepsidae (Diptera) for Vietnam: *Perochaeta cuirassa* sp. n., *Perochaeta lobo* sp. n., *Sepsis spura* sp. n., *Sepsis sepsi* Ozerov, 2003 and *Sepsis monostigma* Thompson, 1869. ZooKeys. 2010; 70: 41-56.

[23] Zuska J. Redescription of the genus *Nemopoda* and a revision of the Ethiopian species (Diptera, Sepsidae). Acta Entomologica Bohemoslovaca. 1977; 74(1): 35-40.

[24] Silva VC. Review of the family Sepsidae in the Neotropical region. The genera *Palaeosepsis* Doubt, 1926, *Archisepsis* Gen. nov. and Gen. *Microsepsis*. nov. Key to the Neotropical Genera (Diptera, Schizophora). Iheringia. Zoology Series. 1992; 37: 117-170.

[25] Silva VC. Revision of the family Sepsidae of the Neotropical region. The genus *Meropliosepsis* Doubt, 1926 (Diptera, Schizophora). Revista Brasileira de Entomologia. 1992; 36(3): 549-552.

[26] Ozerov AL. To the fauna and taxonomy of African Sepsidae (Diptera). Russian Entomological Journal. 1996; 4: 127–144.

[27] Ozerov AL. New genera and species of Sepsidae (Diptera). Russian Entomological Journal. 2004; 12(4): 399–420.

[28] Ozerov AL. New genus and three new species of sepsid flies (Diptera, Sepsidae) from Vietnam. Zoological Journal. 1992; 71: 147–150.

[29] Marchiori CH. Biology and feeding behavior of ceratopogonid adult (Diptera: Ceratopogonidae). International Journal of Frontiers in Science and Technology Research. 2021; 1(2): 007–024.

[30] Hennig W. The Acalyptratae of Baltic amber and their importance for the study of the phylogenetic development of this Diptera group. Stuttgart Contributions to Natural History. 1965; 145: 1-215.

[31] Marchiori CH. *Archisepsis scabra* (Loew 1861) (Diptera: Sepsidae), new host for the parasitoid *Triplasta coxalis* (Ashmead, 1865) (Hymenoptera: Figitidae: Eucoilinae) in Brazil. Ciência e Agrotecnologia. 2008; 32: 1311-1312.

[32] Marchiori CH. Occurrence of microhimenopterous parasitoids of *Archisepsis scabra* (Loew) (Diptera: Sepsidae) on bovine dung and buffalo. Revista Biotemas. 2006; 19(2): 77-80.

[33] Marchiori CH. Arthropods associated with bovine fecal masses in the south of the State of Goias. Neotropical Entomology. 2001; 30(1): 19-24.

[34] Marchiori CH. Study of Diptera species of medical, sanitary, veterinary, and economic importance in Brazil: Bibliographic summary. Open Access Research Journal of Multidisciplinary Studies, 2021: 1(2): 066–078.

[35] Iancu L, Purcarea C. First record of *Themira nigricornis* (Meigen, 1826) (Sepsidae: Diptera) in Romania. Works of the National Museum of Natural History Grigore Antipa. 2012; 57(1): 27–33.

[36] Parker GA. Reproductive behaviour of *Sepsis cynipsea* (L.) (Diptera: Sepsidae). The significance of the precopulatory passive phase and emigration. Behaviour. 1972; 41: 242–250.

[37] Bristowe WS. The mysterious swarms of sepsid flies and their unpalatability to spiders. Proceedings and transactions of the British Entomological and Natural History Society. 1979; 12: 16–19.

[38] Silva VC. Family Sepsidae. Zootaxa. 2016; 4122(1): 648-652.

[39] Silva VC. Preliminary survey of Sepsidae (Diptera, Schizophora) in Roraima, Maracá Project, with description of a new species. Acta Amazonica. 1991; 21: 369-374.

[40] Zuska J, Colless DH. Australian Sepsidae (Diptera). Journal of the Australian Entomological Society. 1984; 23(1): 59-67.

[41] Hayes RA, Crossland MR, Hagman M, Capon RJ, Shine R. Ontogenetic variation in the chemical defenses of cane toads (*Bufo marinus*): toxin profiles and effects on predators. Journal of Chemical Ecology. 2009; 35: 391-399.

[42] Zuska J. Family Sepsidae. In: Crosskey RW. eds. Catalogue of the Diptera of the Afrotropical region. 1th ed. London: British Museum (Natural History); 1980. p. 591-595.

[43] Silva AZ. Palatability study of *Archisepsis armata* (Schiner, 1868) (Diptera, Sepsidae) [Ph.D. Dissertation]. Belem: Museu Paraense Emilio Goeldi; 2017.

[44] Bristowe WS. The mysterious swarms of sepsid flies and their unpalatability to spiders. Proceedings British Entomological and Natural History Society. 1979; 12: 16–19.

[45] Carrel JE, Eisner T. Spider sedation induced by defensive chemicals of milliped prey. Proceedings of the National Academy of Sciences. 1984; 81: 806-810.

[46] Hagman M, Phillips BL, Shine R. Fatal attraction: adaptations to prey on native frogs imperil snakes after invasion of toxic toads. Proceedings of the Royal Society B. 2009; 276: 2813-2818.

[47] Noge K, Prudic KL, Becerra JX. Defensive roles of (E)-2-alkenals and related compounds in Heteroptera. Journal of Chemical Ecology. 2012; 38: 1050-1056.

[48] Rafter J, Agrawal AA, Preisser E. Chinese mantids gut toxic monarch caterpillars: 22 avoidance of prey defence? Ecological Entomology. 2013; 38: 76–82.

[49] Wharton RA, Moon RD. Puparia of cyclorrhaphous Diptera from bovine dung in open pastureland rangeland in the transition zone of Western North Annals of the Entomological Society of America. 1979; 72: 80-89.

[50] Zuska J. Family Sepsidae. In: Delfinado MD, Hardy DEA, eds. Catalog of the Diptera of the Oriental region. Suborder Cyclorrhapha (excluding division Aschiza). 3th ed. Honolulu: University Press of Hawaii; 1977. p. 174-181.

[51] Lima SL. Stress and decision making under the risk of predation: recent developments from behavioral, reproductive, and ecological perspectives. Advances in the Study of Behavior. 1998; 27: 215– 290.

[52] Edwards GB, Jackson RR. The role of experience in the development of predatory behaviour in *Phidippus regius*, a jumping spider (Araneae, Salticidae) from Florida. New Zealand Journal of Zoology. 1994; 21: 269 –277.

[53] Silva VC, Pollet M. The Sepsidae of the Mitaraka expedition, French Guiana (Diptera). Zoosystema. 2020; 42(14): 195-205.