Open Access Research Journal of
Multidisciplinary Studies
Journals home page: https://oarjpublication/journals/oarjms/
ISSN: 2783-0268 (Online)

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(REVIEW ARTICLE)

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The sanitary and forensic importance for the Piophilidae Family (Insecta: Diptera)

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Open Access Research Journal of Multidisciplinary Studies, 2021, 02(01), 127–138

Publication history: Received on 19 November 2021; revised on 22 December 2021; accepted on 24 December 2021

Article DOI: https://doi.org/10.53022/oarjms.2021.2.1.0069

Abstract

The objective of this paper is to describe the medical, veterinary, sanitary, and forensic importance for the Piophilidae family (Insecta: Diptera). The research describes studies related to quantitative taxonomic and conceptual aspects. A literature search was carried out containing articles published from 1957 to 2021. The mini review was prepared in Goiânia, Goiás, from September to October 2021, through the Online Scientific Library (Scielo), internet, Academia.edu, Frontiers, ResearchGate, Biological Abstract, Publons, Qeios, Pubmed, Dialnet, World, Wide Science, Springer, RefSeek, Microsoft Academic, Science, ERIC, Science Research.com, SEEK education, Periodicals CAPES, Google Academic, Bioline International, VADLO, Scopus, Web of Science, LILACS, Medline, LIS and Portal of Scientific Journals in Health Sciences.

Keywords: Literature; Search; Conceptual aspects; Taxonomic aspects; Medical importance

1. Introduction

Pompilidae is a family of Hymenoptera that hunt spiders. They are medium or large, usually black, or dark blue with metallic highlights. The characteristically coiled antennas. They usually fly close to the ground. They are spider predators, on which they lay an egg. Larval development occurs in the captured spider Many of these wasps (Pimpilidae) feed on various flower species that pursue generalist pollination strategies, but several plants from Africa, Central and South America and Australia have been documented to form specific pollination relationships with species of pompilid (Figure 1) [1,2,3,4,5,6].

Figure 1 Cheese fly Neottiophilinae Subfamilies Piophilinae. The cheese fly *Piophila casei* (Linnaeus, 1758) is a dipterous insect of the Piophilidae family, known for infesting human food. The group is cosmopolitan and the

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saprophagous larvae are commonly known as leaping, due to their ability to leap several inches into the air when alarmed. They have this name because they deposit their larvae on certain cheeses, and this is usually attributed to cases of human myiasis, given that the larvae can survive in the intestine. A strange example of this type of fly's culinary use is the presence of its larvae in the maturation process of casu marzu, a Sardinian cheese; (Source: Cheese skipper - *Piophila casei* (Linnaeus). University of Florida [Internet]. Gainesville: University of Florida; © 2009 [cited 2021 Nov 27]. Available from https://www.biodiversity4all.org/photos/34276092.)

The adult cheese fly's body is black, bluish-black or bronze, with some yellow on the head, antennae, and legs. The wings are slightly iridescent and lie flat on the fly's abdomen when at rest. At 4 mm (0.16 in.) long, the fly is one-third to one-half the length of the common housefly (Figures 2 and 3) [7,8,9].

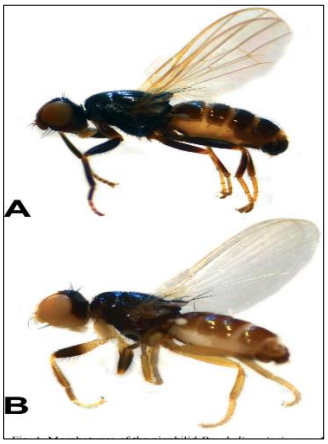

Figure 2 Morphotypes of the piophilid *Prochyliza nigrimanus* (Meigen, 1826). A– dark morph, male; B – pale morph, male; (Source: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/viewer.html?pdfurl=https%3A%2F%2Fpdfs.semanticscholar.or)

Figure 3 Anterior view of head of adult cheese skipper, *Piophila casei* (Linnaeus, 1758); (Source: Photograph by Susan Ellis, United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine)

A male woos a female by dancing side by side, forequarters raised, displaying her elongated antennae, and vibrating her elongated forelegs. A receptive female responds by opening her front legs to contact the male's long front legs. The male somersaults over his front quarters and turns to land on his back and lock onto his genitals. After several minutes of copulation, the female ejects most of the semen and swallows it. This behavior seems to be related to the successful production of fertile eggs. Given these elaborate morphological and behavioral adaptations, waltzes are of interest as a model system for studying the evolution of sexual dimorphism [8,9].

Females lay eggs on carrion and larvae develop mainly on protected parts of the carcass; depending on the degree of decomposition, they often develop within the bone marrow. As in other pyophyllid species, the last instar larvae jump from the surface of the carcass where they feed and pupa in the soil (Figure 4) [9,10].

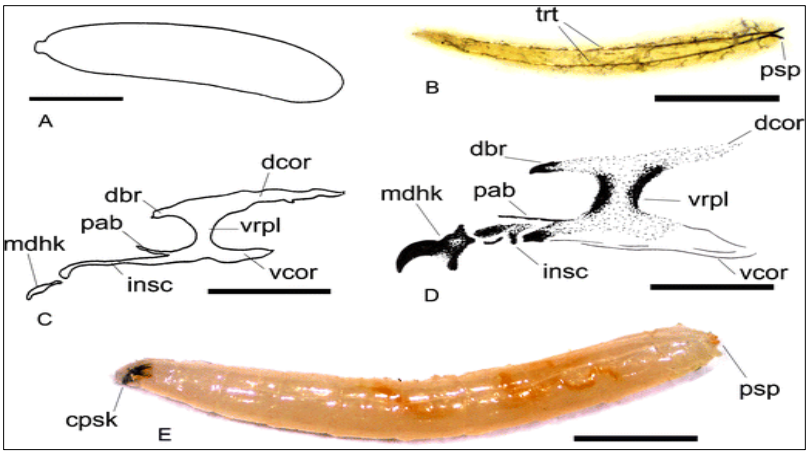

Figure 4 The contrary pattern is observed in egg (A) length. The number and arrangement of the lobes of anterior spiracles, which had been used as a distinctive character of *Piophila casei* (Linnaeus, 1758) some keys, are the same in both species. Morphological features of the cephaloskeleton (such as the general shape and the distance between the tips and the base of the mouth hooks/base of the mouth hooks ratio), the arrangement of anal segment in third-instar larvae and the appearance of the ventral creeping welts in the puparium are the main characters allowing for identification of both species (A, B and C). The third-instar larvae and puparium of *Prochyliza nigrimanus* (Meigen, 1826) are significantly shorter than those of *P. casei* (E); (Source: https://link.springer.com/article/10.1007/s00436-012-2943-5)

If ingested (accidentally or not), larvae sometimes survive in the gut and pass through the digestive system alive. This behavior is known as enteric or intestinal myiasis. In the intestine, larvae can cause serious damage when trying to pierce the intestinal walls. Symptoms include nausea, vomiting, pain in the abdomen and bloody diarrhea. Both live and dead larvae can pass through the feces. Some species are also known to cause naso-oral and urogenital myiasis (Figures 5 and 6) [11,12].

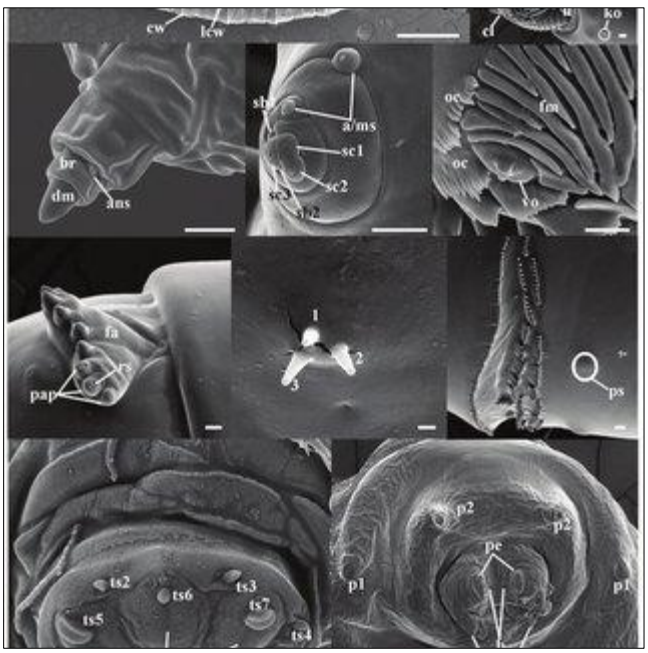

Figure 5 Micrographs of the third instar of *Piophila casei* (Linnaeus, 1758). (A) Larval body composed of twelve segments; (B) cephalic region; (C) antenna; (D) detail of sensilla in maxillary palpus; (E) detail of ventral organ, oral

comb, and face mask; (F) detail of anterior spiracle; (G) Keilin's organ; (H) spines of the thorax; (I) detail of posterior spiracle; (J) back view of the larva. Abbreviations: I-XII, body segments; 1-3, sensilla of Keilin's organ; an, antenna; a/ms, antennal or mandibular sensilla; ans, antenna of sensilla; b, button; br, basal ring; cl, cephalic lobe; cw, ventral creeping; dm, antennal dome; fa, fan-shaped structure; fm, face mask (=oral ridge); ft, folding tegument; ko, Keilin's organ; lcw, lateral creeping welt; ll, labial lobe; mp, maxillary palpus sensilla; ms, muscle scars; oc, oral comb; p1-4, posterior papillae; pap, papillae; pe, posterior spiracle; ps, placodea sensillum; rs, respiratory slit; sb1-2, basiconic sensilla of maxillary palpus; sc1-3, coeloconic sensilla of maxillary palpus; ts1-7, trichoid sensilla; vo, ventral organ. Scales: A, 1 mm; B, C, D, E, F, H, and I, 10 μm; G, 1 μm; J, 100 μm; (Source: https://www.researchgate.net/figure/SEM-micrographs-of-the-third-instar-of-Piophila-casei-A-Larval-body-composed-of-twelve_fig2_329853348)

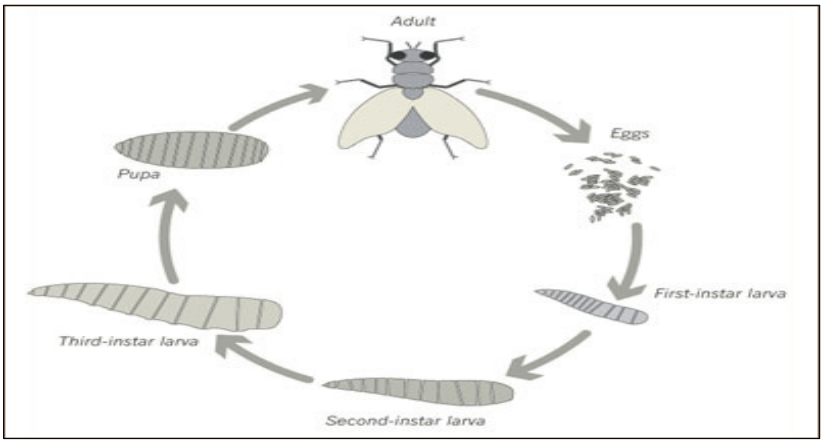

Figure 6 The complete life cycle of a cheese skipper in appropriate nourishment and temperature conditions can be as short as 12 days (1 day for egg development, 5-day larval maturation, 5 day pupal maturation, 1 day of adult feeding before reproduction). However, the typical life cycle is as follows (Mote 1914): Egg ~23 to 54 hours - Larva ~14 days - Pupa ~12 days - Adult ~3 to 7 days; (Source: https://entnemdept.ufl.edu/creatures/urban/flies/cheese_skipper.htm)

In Forensic Entomology, the presence of *P. casei* larvae can be useful to estimate the date of death of mortal remains because they do not take up residence in a corpse until three to six months after death. However, *P. casei* is not the only pyophyllid species to attack human cadavers, so care is appropriate in identifying the species found and interpreting their meaning. (Figures 7 and 8) [11,12,13].

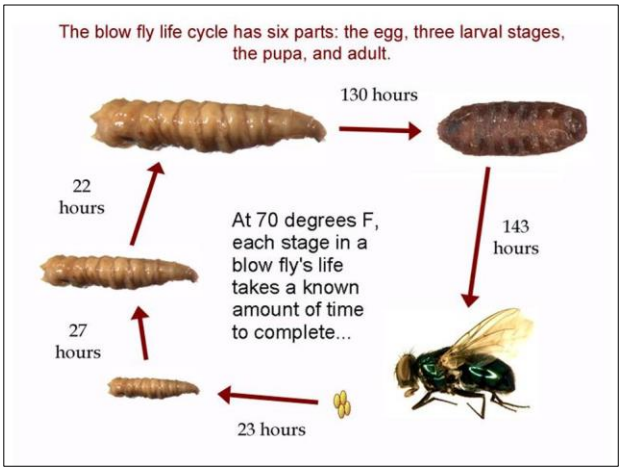

Figure 7 An Introduction to Forensic Entomology: Application of insects to legal issues. Insects associated with crimes; (Source: https://slideplayer.com/slide/3461042/)

Figure 8 Adult cheese skippers, *Piophila casei* (Linnaeus, 1758), on cheese; (Source: Photograph by Susan Ellis, United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant)

Waltz flies breed in early spring, usually on moose carcasses. In the mid-spring of a good year, they are one of the most abundant insect species in the local forests. Nubile females bask in the vegetation around the carcasses, and males flock to the sun to court and defend territory [12,13].

1.1. Cheese Skipper Fly: *Piophla casei* (Linnaeus, 1758)

Cheese Skipper Fly: biology, casu marzu, cheese skipper Fly, eggs, en, fly, insect, Italy, larva, life cycle (Figures 9, 10, 11 and 12).

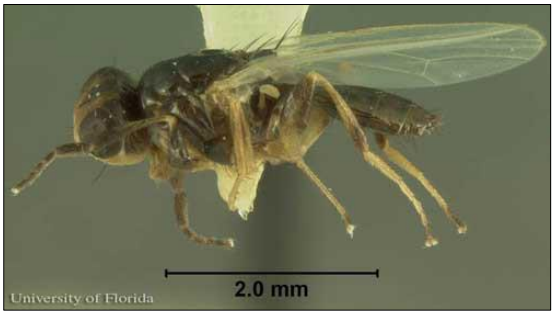

Figure 9 Males are 4.4-4.5 mm; (Source: https://entnemdept.ufl.edu/creatures/urban/flies/cheese_skipper.htm)

Figure 10 Females are 5.0-5.2 mm.

https://entnemdept.ufl.edu/creatures/urban/flies/cheese_skipper.htm

Figure 11 Eggs are laid in dead carcasses, smoked fish, moldy cheese, and salty substrates like ham, bacon, and beef. Life Cycle: 1)140-500 eggs are laid 10 hours after mating. 2) Eggs hatch between 1 to 4 days. 3) Develop into larva and stay in dark, dry locations near putrid meat and cheese (2 weeks) 5) Develop into pupa (12days) 6) Adults live up to 3 to 7 days; (Source: https://entnemdept.ufl.edu/creatures/urban/flies/cheese_skipper.htm)

Figure 12 Forensic Importance: Develop at constant rates, are not limited to a specific location, and are uneffected by weather or drugs. Cheese Skipper Flies originated from Italy. They were introduced to illegally produced pecorino cheese to promote a fermentation. This resulted in a burning flavor and white residue paste on the cheese. They are also known to cause humans and animals intestinal myiasis if accidentally consumed. This can lead to lesions, diarrhea, and nausea. Casu Marzu (Cheese with Worms); (Source: https://entnemdept.ufl.edu/creatures/urban/flies/cheese_skipper.htm)

Piophilidae are a small family with less than 100 species described in 23 genera, mostly Holarctic in distribution, although some species are cosmopolitan. The nomenclature is volatile, with two subfamily names (Neottiophilinae and Thyreophorinae) in use recently, having been included in the Piophilinae subfamily [14].

Objective

The medical, veterinary, sanitary, and forensic importance for the Piophilidae family (Insecta: Diptera).

2. Methods

The method used to prepare this mini review was Marchiori 2021 methodology [15].

3. Studies conducted and selected

3.1. Study 1

The objective is to analyze the diversity of the main families of Diptera in Serra Talhada – PE and Triunfo – PE, since they are close regions that have distinct climate and vegetation.

During the two collection periods, 1,215 were obtained. individuals of the order Diptera, of these, 950 (78.19%) were identified at the species level, distributed in eight species.

The family Calliphoridae presented the greatest richness, with three species – *Chrysomya albiceps* (Wiedemann, 1829), *Chrysomya megacephala* (Fabricius, 1794) and *Lucilia eximia* (Wiedemann, 1819), the latter being the most abundant species with 39 (78%) individuals collected; two from Muscidae – *Musca domestica* (Linnaeus, 1758) and *Ophyra chalcogaster* (Wiedemann, 1830); one from Fanniidae – *Fannia canicularis* (Linnaeus, 1758); one of Phoridae – *Megaselia scalaris* (Loew) and one from Piophilide – *Piophila casei* (Linnaeus, 1758); Stratiomyidae – *Hermetia illucens* (Linnaeus, 1758).

Figure 13 *Piophila casei* Linnaeus, 1758 necrophagous dipterofauna associated with different decaying organic matter; (Source: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/viewer.html?pdfurl=https%3A%2F%2Fedis.ifas.ufl.edu%2Fpdf%2FIN%2FIN84300.pdf&clen=1549585&chunk=true Source: Susan Ellis, USDA APHIS PPQ, B)

Representatives of the Sarcophagidae family were identified at the genus level, *Peckia* with 253 (20.82%) specimens. At the family level, Tephritidae and Ulidiidae were identified, representing 0.99% of the total number of individuals [16].

3.2. Study 2

The cheese skipper, *Piophila casei* (Linnaeus, 1758), sometimes called the ham skipper, is a member of the "skipper fly" family (Piophilidae). These flies receive their name due to the unusual ability of the larvae to propel themselves through the air. The flies are detritivores, feeding on decaying matter, and even have been found on the exhumed remains of Egyptian mummies. Because of their delayed infestation of decaying remains, *P. casei* have been implicated as useful in the forensic investigation of postmortem remains and the determination of time since death (Figure 14).

Figure 14 Adult cheese skippers, *Piophila casei* Linnaeus; (Source: Photograph by Susan Ellis, United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine)

Often found as pests in meat and cheese, these small flies often are cited as a cause of accidental enteric (intestinal) myiasis, where the fly larvae invade the living tissue of animals including humans. Researchers have reported cases of myiasis in red foxes in Iowa.

Intentional introduction of *P. casei* larvae into pecorino cheese produces the famous, but illegally produced, Italian cheese known as "casu marzu," a delicacy desired for the famous pungent taste left behind when the larvae digest and ferment the cheese. Individuals eat the goo-like paste as well as the living maggots [17,18].

3.3. Study 3

The cheese fly (*Piophila casei*) is a dipterous insect of the Piophilidae family, known for infesting human food. The group is cosmopolitan and the saprophagous larvae are commonly known as leaping, due to their ability to leap several inches into the air when alarmed (Figures 15A and 15B).

Figure 15A Diptera larva causing urogenital myiasis; (Source: https://www.sciencedirect.com/science/article/pii/S2214442020301911)

They have this name because they deposit their larvae on certain cheeses, and this is usually attributed to cases of human myiasis, given that the larvae can survive in the intestine. A strange example of this type of fly's culinary use is the presence of its larvae in the maturation process of casu marzu, a Sardinian cheese.

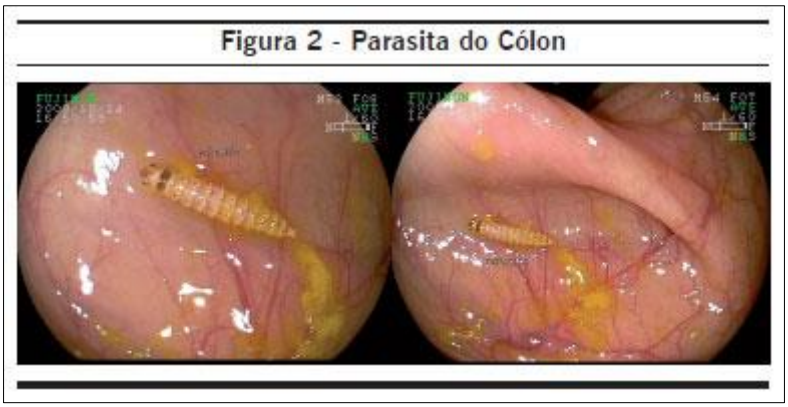

Figure 15B Myiasis caused by dipteran larvae. As to location, myiasis can be cutaneous (skin and subcutaneous tissue) or cavitary. Biologically, they can be classified as accidental (when the individual accidentally ingests eggs or fly larvae present in food - intestinal or urinary). In situations of accidental myiasis (intestinal or urinary), the diagnosis can be made through digestive endoscopy and cystoscopy; (Source: https://www.scielo.br/j/ramb/a/ZcGc4f8hwdqZdDmm663psxy/?lang=pt)

Some agents that fall outside the Calyptratae Subsection have also been reported to cause human myiasis. The species *Hermetia* sp. belonging to the Stratiomyidae family can cause furuncular and intestinal myiasis, *Scenopinus* sp. causes urogenital myiasis. Other diptera such as *Eristalis tenax* (Linnaeus, 1758) (Diptera: Syrphidae), *Megaselia scalaris* (Loew, 1866) (Diptera: Phoridae) and *Piophila casei,* L.1758 have been reported to cause urogenital myiasis [18,19,20].

3.4. Study 4

The objective is to describe the dipterofauna associated with carcass decomposition in Cerrado regions, where the characteristics of humidity and temperature are quite peculiar.

The study was carried out between the months of July and August 2003 in a cerrado area of Fazenda Água Limpa of Universidade de Brasília, in Brasília, DF. Three pigs *Sus scrofa* (L, 1758) (Mammalia: Suidae) placed in metal cages and covered by a Shanom-type insect trap. About 8 thousand specimens of flies were collected in the period belonging to the families Stratiomyidae, Calliphoridae, Muscidae, Piophilidae, Sarcophagidae, Cuterebridae, Syrphidae, Drosophilidae, Asilidae, Tachynidae, Bombyliidae, Phoridae (Figures 16 and 17).

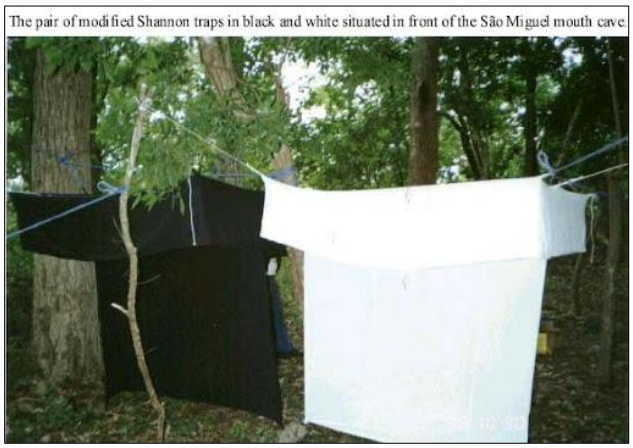

Figure 16 Shanom-type insect trap; (Source: http://www.bioline.org.br/request?oc01097)

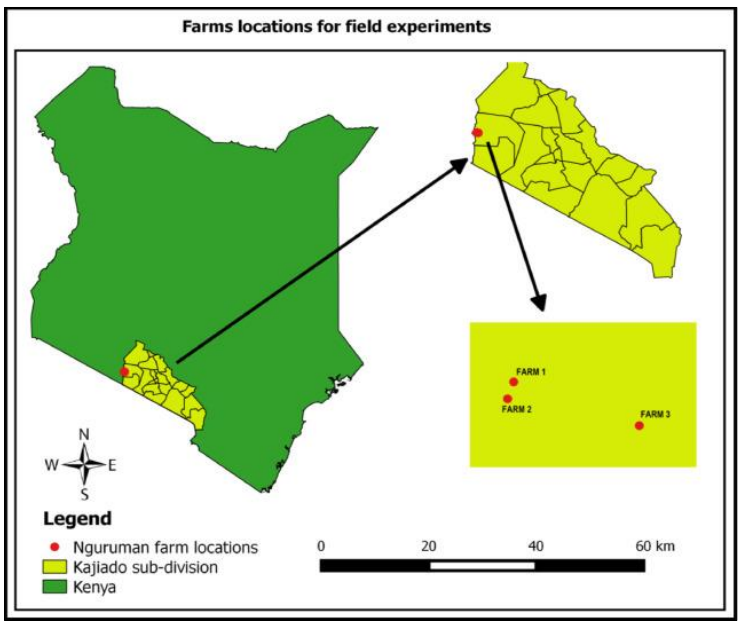

Figure 17 A strategy for using traps (Shanom-type insect trap) that attract arthropods to the center of fungal-based entomopathogens. Trapped pests are infected with the entomopathogen, which can spread it among its co-specifics after being released. Estimate based on model of ideal traps density and distribution per unit of space (ha, km2). The

research revealed that nine pheromone traps per ha. are needed with a spacing of 37.45 m between the traps; (Source: https://www.sciencedirect.com/science/article/abs/pii/S1476945X19300923)

Other insects collected in the trap belong to the orders Lepidoptera, Hymenoptera, Coleoptera, Heteroptera and Orthoptera. The main species of flies of importance for Forensic Entomology collected were the following: *Hermetia illucens* (l., 1758) (Stratiomyidae); *Cochliomyia macelaria* (Fabricius, 1775), *Chrysomya megacephala* (Fabricius, 1974), *Lucilia* sp., *Chrysomya albiceps* (Wiedmann, 1819), (Calliphoridae); *Piophila casei* L, 1758 (Piophilidae), *Pechia* sp. (Sarcophagidae), *Musca domestica* L, 1758 (Muscidae) [21].

3.5. Study 5

Sanitation is considered the most important aspect of management of cheese skippers. Light infestations of *Piophila casei* L., 1758, larvae can be removed individually, but the judicious use of fumigation techniques if often required for more severe infestations

Pachycrepoideus dubius Ashmead, 1904 (Hymenoptera: Pteromalidae) a small pteromalid wasp, is the primary parasite of the cheese skipper. The wasp attacks the pupal stage of *P. casei*, as well as other cyclorrhaphan flies. It attacks the host in the pupal stage and is the only parasite. However, other research conducted at Ohio State University states that *P. dubius* does not act as an economically viable method for natural control of the cheese skipper (Figures 18, 19 and 20) [22].

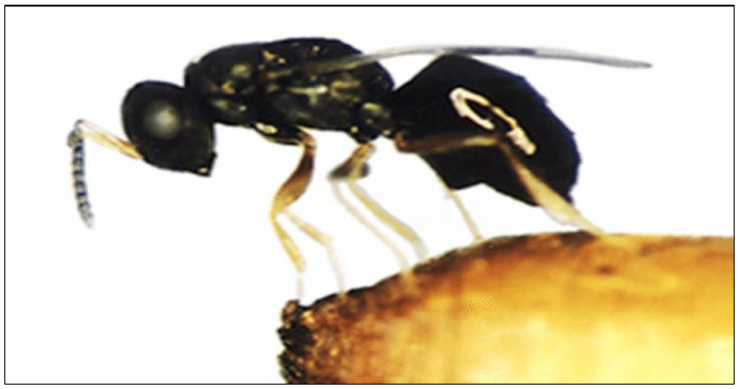

Figure 18 *Pachycrepoideus dubius* Ashmead, 1904 (Hymenoptera: Pteromalidae) female; (Source: https://www.researchgate.net/figure/Pachycrepoideus-dubius-femelle-40_fig7_281565789)

The small beetle *Necrobia rufipes* 1775 (De Geer) (Coleoptera: Cleridae) is also reported as a predator of cheese skipper larvae.

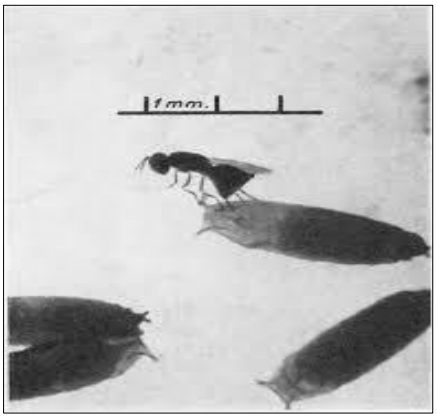

Figure 19 *Pachycrepoideus dubius* Ashmead, 1904 (Hymenoptera: Pteromalidae); (Source: https://www.jstor.org/stable/3565161)

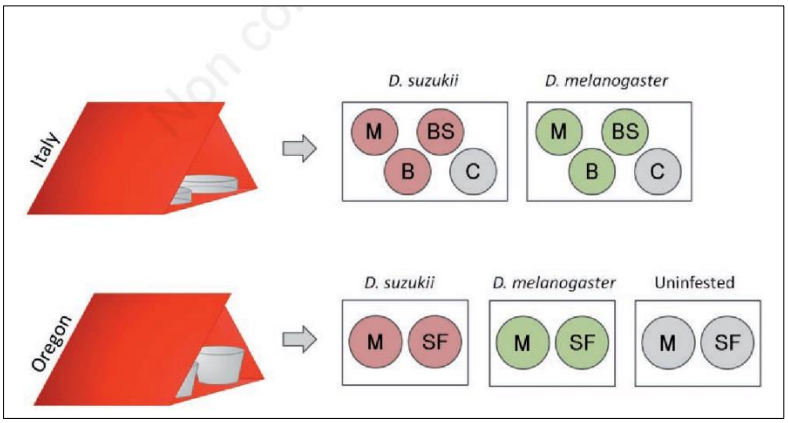

Figure 20 Schematic drawing of the sentinel traps: In Italy, two trap types were prepared, while in Oregon three trap types were placed in each site. M: food medium; BS: banana slices; B: blueberries; C: control (uninfested); SF: seasonal fruit. *Wolbachia* endosymbiont of *Pachycrepoideus dubius* Ashmead, 1904 (Hymenoptera: Pteromalidae); (Source: https://www.semanticscholar.org/topic/Wolbachia-endosymbiont-of-Pachycrepoideus-dubius/4982351)

4. Conclusion

The so-called cheese flies are the best-known members, but most Piophilidae species are scavengers of animal products, carrion and fungi. They may therefore be important in forensic Entomology and in Medical Entomology. For a fly larva, larvae of many species have an unusually well developed ability to jump when alarmed or when they abandon their larval food to pupate; they can therefore be known as cheese skippers or other types of skippers depending on their food source.

References

[1] Cheese skipper - *Piophila casei* (Linnaeus). University of Florida [Internet]. Gainesville: University of Florida; © 2009 [cited 2021 Nov 27].

[2] Papp L, Darvas A. Contributions to a Manual of Palaearctic Diptera. 1th ed. Budapest: Science Herald. 1985.

[3] Gennard D. Forensic Entomology. An Introduction. 1th ed. London: Ed. Wiley. 2012.

[4] Pinheiro SD, et al. Variables in the estimation of the after-death interval by Forensic Entomology methods. Biosphere Encyclopedia 2012; 8(14): 1442-1443.

[5] Gary R, Lance M, Durden A. Entomologia Médica e Veterinária. 1th ed. São Paulo: Academic Press; 2013.

[6] Gomes L. Entomologia Forense: novas tendências e tecnologias nas ciências criminais. 1th ed. Rio de Janeiro: Ed. Technical Books. 2010.

[7] Bonduriansky R, Brooks RJ. Why do male horn flies (*Protopiophila litigata*) fight? Ethology Ecology & Evolution. 1999; 11(3): 287–301.

[8] Bonduriansky R, Wheeler J, Rowe L. Ejaculate feeding and female fitness in the sexually dimorphic fly *Prochyliza xanthostoma* (Diptera: Piophilidae). Animal behavior. 2005; 69(2): 489–497.

[9] Bonduriansky R, Rowe L. Interactions between sexual selection mechanisms on male body size and head shape in a sexually dimorphic fly. Evolution. 2003; 57(9): 2046-2053.

[10] Bonduriansky R. Layered sexual selection: a comparative analysis of sexual behavior within a pyophilid fly assemblage. Canadian Journal of Zoology. 2003; 8(3): 479–491.

[11] Bonduriansky R, Brasil CE. Fast and expensive aging in male wild flies. Nature. 2002; 420(6914): 377.

[12] Berenbaum MR. Noventa e nove mais larvas, ácaros e mastigadores. 1th ed. Illinois: University of Illinois Press. 1993.

[13] Robinson WH. Diptera, Ephemeroptera: Piophilidae: Comandante do queijo (*Piophila casei*). Handbook of urban insects and arachnids: A handbook of urban Entomology. 1th ed. Cambridge: Cambridge University Press. 2005.

[14] McAlpine JF. A revised classification of Piophilidae, including Neottiophilidae and Thyreophoridae (Diptera: Schizophora). Memories of the Entomological Society of Canada. 1977; 103: 1–66.

[15] 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.

[16] Cruz DLV, Spíndola AF, Lima FLS, Gomes Junior PP. Diversidade da dipterofauna necrófaga associada a diferentes matérias orgânicas em decomposição em dois tipos vegetacionais do semiárido Pernambucano. EntomoBrasilis. 2017; 10(3): 155-161.

[17] Benecke M. Six Forensic Entomology cases: Description and commentary. Journal of Forensic Science. 1998; 43: 797-80.

[18] Lui D, Greenberg B. Immature stages of some flies of forensic importance. Annals of the Entomological Society of America. 1989; 82: 80-93.

[19] Scott HG. Human myiasis in North America (1952-1962 Inclusive). 1th ed. Hayslip: Florida Entomologist. 2013: 47.

[20] Smith EH, Whitman RC. Ham/Cheese Skipper. 1th ed. Fairfax: Stored Product Pests. 2013.

[21] Koeppen RL, Tadros N. Case report: Urogenital myiasis in an adult male. Urology Case Reports. 2020; 33(101303): 1-3.

[22] Pujol-Luz JR, Arantes LC, Santana FHA, Higgins BF, Almeida PHM, Antonietto LS, Ururahy-Rodrigues A. Diptera (Insecta) de importância para a Entomologia Forense: Decomposição de carcaças de suínos no Distrito Federal. XXV Congresso Brasileiro de Zoologia: Brasília, Sociedade Brasileira de Zoologia. 2004.