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(REVIEW ARTICLE)

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Biology of the Pergidae Family (Insecta: Hymenoptera)

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Abstract

The Pergidae family are insects with complete development, so they go through the egg, larva (in several stages), pupa (to undergo metamorphosis) and adult (the winged insect, ready to reproduce) phase. The developed larvae, as we received in the photo, are black in color and measure about 2.5 cm in length. They appear between June and September in groups, walking in the pasture, a habit that suggests the ability to seek more food and protection against predators. This mini-review aimed to inventory aspects of the biology of the Pergidae Family such as life cycle, mating behavior, damage in agriculture, poisoning in animals, thanatosis and management. The present work uses the reference of bibliographical research, understood as the act of inquiring and seeking information on a certain subject, through a survey carried out in national and foreign databases, with the objective of detecting what exists of consensus or controversy. The articles were published in indexed scientific research, book scientific chapters, theses banks, university dissertations, national and international scientific articles, scientific journals, documents and the academic and scientific journals available online ResearchGate, HAL SSRN, Scielo, Biological abstract, Qeios and Academia.edu.

Keywords: Mating Behavior; Damage; Agriculture; Poisoning; Thanatosis; Management

1. Introduction

Superfamily Tenthredinoidea is a large superfamily of Symphyta, containing more than 8400 species worldwide, mainly in the family Tenthredinidae. All known larvae are herbivores, and several are considered pests [1,2,3]. The existing families at present share certain distinctive characteristics: a narrowed pronotum in its middle zone, protibial paired spurs, and the lack of the mesonotal transverse groove. The superfamily also includes two extinct families. It was found that there are 66 tribes and 17 subfamilies with living members. (Figure 1) [1,2,3].

Sources: https://tasmanianinsectfieldguide.com/hexapoda/insectsoftasmaniahymenoptera2/superfamily-tenthredinoidea/ and https://www.inaturalist.org/taxa/201415-Pergidae

Figure 1 Superfamily Tenthredinoidea. Adult of Pergidae

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The Pergidae is a moderate-sized family of sawflies in the Western Hemisphere and Australasian regions. The Pergidae are, with almost 450 described species, the third-largest family of Symphyta after the Tenthredinidae and the Argidae. Morphologically, most pergids are typically sawfly-like, but the form of the antennae varies considerably in the number of segments and from simple to serrate and pectinate or even bipectinate (Figures 2-3B) [3,4,5].

Source: https://www.brisbaneinsects.com/brisbane_sawflies/BrambleSawfly.htm

Figure 2 *Philomastix xanthophilus* sp. nov. posterior position and oral position

Sources: Photo 175341999, (c) melc83f, some rights reserved (CC BY-NC) and https://www.flickriver.com/photos/tags/pergidae/

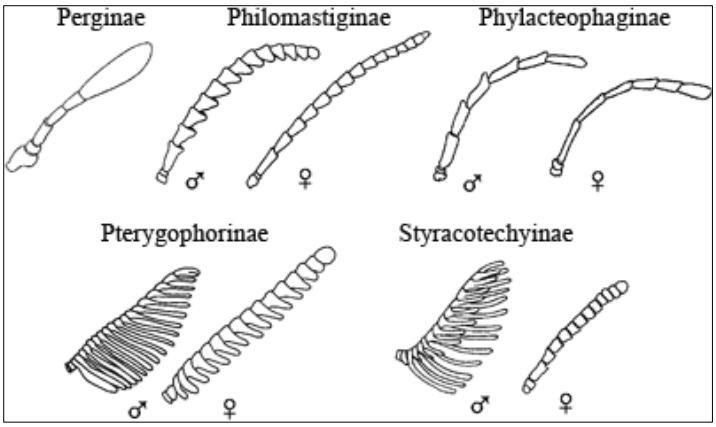
Figure 3A *Pterygophorus cinctus* Klug, 1814 and Pergidae sp. by dhobern

Sources: Photo 180454255, (c) Maureen Gubbels, all rights reserved, uploaded by Maureen Gubbels, https://www.inaturalist.org/photos/180454255 and https://anic.csiro.au/insectfamilies/image_details.aspx?OrderID=27447&BiotaID=27695&ImageID=5145&PageID=families

Figure 3B *Philomastix macleaii* (Westwood, 1880) and Pergidae sp.

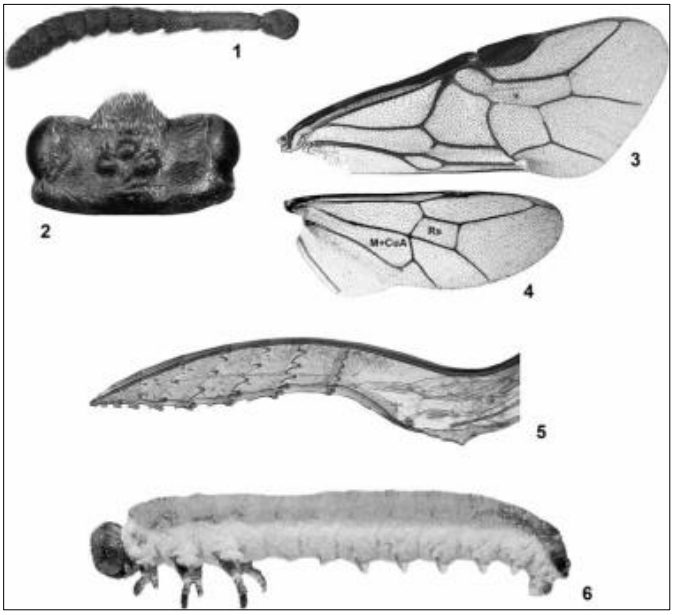
1.1. Description

Antenna with 4 to 25 antennomeres rarely with 9 antennomeres as in most Tenthredinidae, shape serrate, filiform, capitate, pectinate, bipectinate, or furcate. Labium 1-3 lobed, palpus 1-4 segmented. Macillary palpus 2-6-segmented. Fortibia apically with 1-2 spurs, midtibia with 0-2 preapical spines, and hind tibia with 0-1 subapical spine. Tarsal claws are simple. First abdominal tergite fused with metapleuron. Fore wing without radial crossvein (2r), anal cell present or absent. Hind wing with cell RS present, without medial (M) and anal cell (A) (Figures 4-6) [4,5,6].



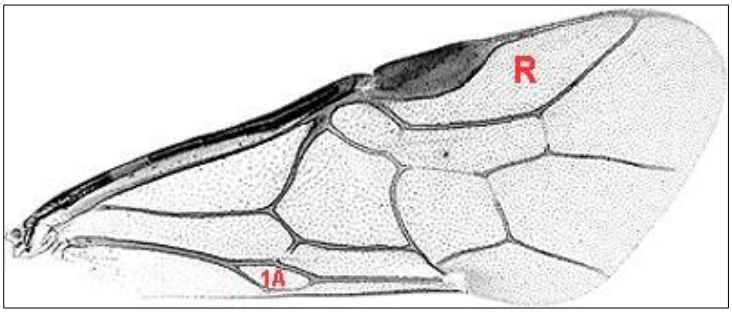
Source: cavaliniassessoria.com.br

Figure 4 Shapes of antenna in some Australian subfamilies of Pergidae. Sexual dimorphism is common and reflected in differences in type of antennae, colour, and size



Source: https://treatment.plazi.org/id/0A3B3701FFFFFFAFFEBEF9C9FC1BFE1F

Figure 5 *Dalia graminis* Schmidt in Schmidt & Brown, 2005: (1), Antenna in lateral view, (2), Head in dorsal view, (3), Fore wing, (4), Hind wing, (5), Lancet, (6), Full grown larva

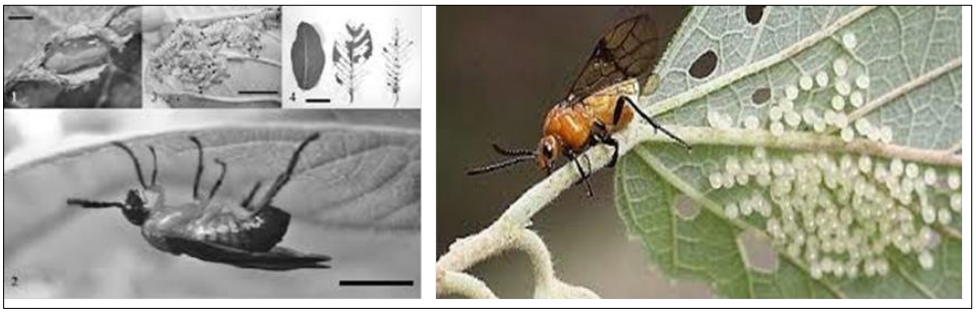


Source: https://pergidae.snsb-zsm.de/morphology

Figure 6 *Dalia graminis* Schmidt in Schmidt & Brown, 2005. (a) Radial cell (R) without crossvein, (b) Medial and anal cell of hind wing missing. (c) Anal cell of fore wing is usually not present (exception below)

1.2. Life Cycle

The Pergidae family are insects with complete development, so they go through the egg, larva (in several stages), pupa (to undergo metamorphosis) and adult (the winged insect, ready to reproduce) phase. The developed larvae, as we received in the photo, are black in color and measure about 2.5 cm in length. They appear between June and September in groups, walking in the pasture, a habit that suggests the ability to seek more food and protection against predators (Figure 7) [7,8,9].



Source: entomological-society-of-washington/volume-111/issue-4/0013-8797-111.4.795/Life-History-Notes-on-the-Sawfly-Haplostegus-nigricrus-Conde-Hymenoptera/10.4289/0013-8797-111.4.795.short

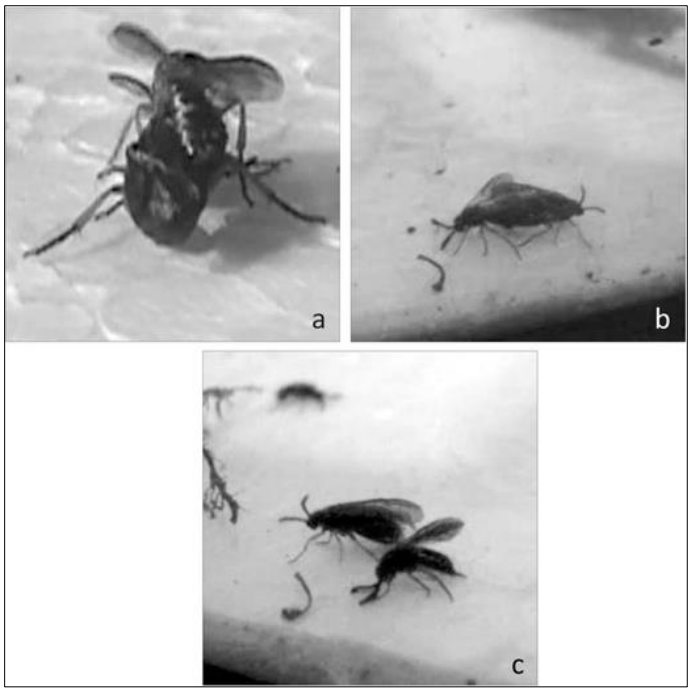
Figure 7 Life history Notes on the sawfly *Haplostegus nigricrus* Conde, 1936 Conde (Hymenoptera: Pergidae) on *Psidium* (Myrtaceae) (1) pupae, (2) larvae, (3) deflowering, (Adult), (4) eggs

Once growth is complete (which occurs through molting or ecdysis), the larva undergoes metamorphosis, passing to the pre-pupa stage, assuming a yellowish-white color and measuring 12.5 mm in length. Below the surface, the prepupa expels a clear and viscous substance that adheres to soil particles, forming a kind of black protective shell. This stage lasts approximately 6 months, when it turns into a pupa and, 15 days later, the adult insect emerges (November to April). The adult has a vasiform appearance and is rarely found [10,11,12].

1.3. Biology

Adults feed on several *Eucalyptus* species, others have such divergent food plants as dead or dying leaves, aquatic ferns, and fungi. Most feed externally on leaves, although some are bud borers or leaf miners and are also saprophagous. Sexual dimorphism is common and reflected in differences in the type of antennae, color, and size. Included are some of the few known apterous sawflies. Larvae of some travel in groups on the ground and eat dead or dying vegetation. They also travel as groups to find group pupation sites. These groups are a tight-knit mass of larvae crawling over each other looking like giant slugs (Figures 8-13) [13,14,15].

Figure 8 Adult of *Perga dorsalis* Leach, 1817 (Hymenoptera: Pergidae) and larvae feeding on leaves of *Eucalyptus citriodora* (HooK) (Myrtaceae)



Source: https://pergidae.snsb-zsm.de/

Figure 9 The larval natural history of *Perreyia flavipes* Konow, 1899; however, virtually nothing is known about the adult behavior, particularly because of its short lifespan. In this study, was report on the first extensive study on the adult behavior of *P. flavipes*, including movement, mating and thanatosis. The results show some unusual behavior adaptations presented by *P. flavipes*, such as irregular activity behavior, thanatosis behavior-like display, and primitive maternal care

Source: https://commons.wikimedia.org/wiki/File:Pergidae,_from_the_family_of_Sawflies.jpg

Figure 10 Pergidae, from the family of sawflies.jpg

Source: https://anic.csiro.au/insectfamilies/image_details.aspx?OrderID=27447&BiotaID=27695&ImageID=5149&PageID=families

Figure 11 Female *Perga* standing over young larva *Eucaliptus* leaf

Source; https://jhr.pensoft.net/article/24408/

Figure 12 Sexual dimorphism *Acordulecera* spp. (a) Female, body length 4.5 mm (b) female body length Lateral views

Source: https://www.flickr.com/photos/31031835@N08/8253051253

Figure 13 Sawfly larvae, family Pergidae. Wog Wog, Morton National Park, NSW Australia, November 2012

1.4. Veterinary Importance

The Larvae seem to be of the genus *Perreyia* or "false caterpillars", which in some places are veritable pests. Another known name for these larvae is "pig killer" because, when ingested by pigs and even cattle, they release a toxic substance secreted by the cutaneous glands that poison them. They present weakness, depression, muscle tremors, excitement, aggressiveness, and mortality within 2 days of the onset of symptoms. In animals that survive longer, jaundice and sensitivity to light are observed (Figure 14) [14,15,16].

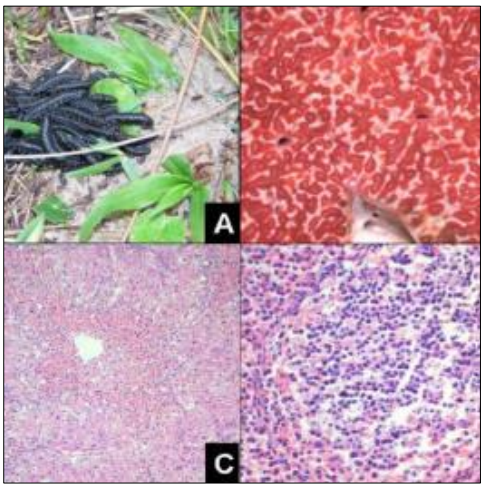


Figure 14 Beef, mixed. Poisoning by *Perreyia* larvae (A) Grouping of *Perreyia* larvae in the middle of the pasture. (B) Liver with increased lobular pattern on the cut surface. (C) Liver with centrilobular and midzonal coagulation necrosis, diffuse, accentuated with centrilobular congestion and hemorrhage and swollen and vacuolated hepatocytes in the periportal region. (D) Spleen, white pulp with lymphoid depletion and diffuse and marked necrosis of germinal centers

1.5. Damage

The Pergidae and call of the sawfly are found throughout the area occupied by these tree species, mainly from Malleco to Valdivia through the central valley. Pergidae produces two types of damage: The female makes small incisions in the leaf at the time of oviposition and defoliates in the larval stages, consuming the leaf as a skeletonizer. Population density is regulated by natural agents, which decreases the level of damage, but, in turn, natural agents are influenced by abiotic factors that have not been evaluated (Figures 15-16) [15,16].

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

Figure 15 Larvae on *Eucalyptus*

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

Figure 16 Larvae and protective female parent of *Pseudoperga* sp. (Perginae)

1.6. Distribution Geographic

The Pergidae show a Gondwanan distribution. Most species occur in South America and Australia, but no species is known from South Africa. They are the dominant sawfly family in Australia and, with the Tenthredinidae and Argidae, are one of the major families in the Neotropical region [17,18].

1.7. Management

The magnitude of damage caused has yet to be assessed but is estimated to be considerable. A small parasitoid hymenopteran was found, identified as *Classis* spp. (Hymenoptera: Ichneumonidae), highlighting its action in the pre-pupal state with laboratory-estimated mortality of 14.9% (Figure 17) [17,18].

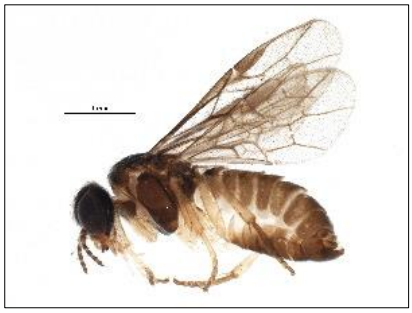
Source: https://bdj.pensoft.net/article/69867/

Figure 17 Hymenoptera Ichneumonidae

1.8. Taxonomy

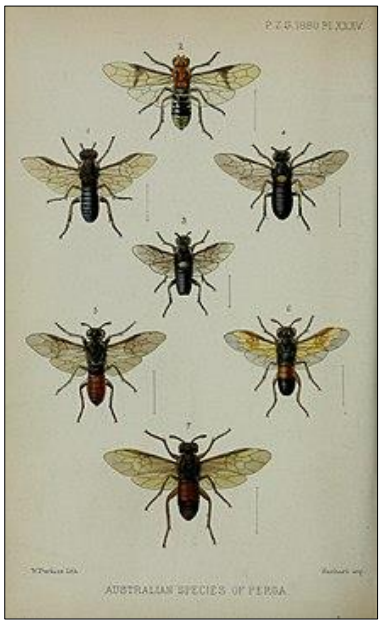
1.8.1. Subfamilies

Acordulecerinae, Conocoxinae, Euryinae, Loboceratinae, Parasyzygoniinae, Perginae, Pergulinae, Perreyiinae, Philomastiginae, Phylacteophaginae, Pterygophorinae, Pterygoperginae, Styracotechyinae and Syzygoniinae (Figure 18-26) [19,20].



Source: http://v3.boldsystems.org/index.php/Taxbrowser_Taxonpage?taxid=333091

Figure 18 Subfamily Acordulecerinae



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

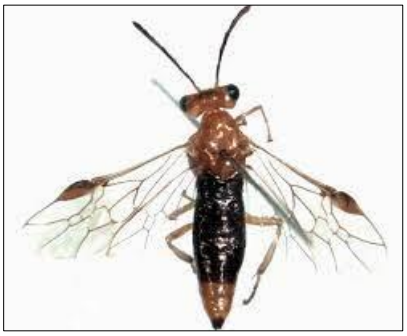
Figure 19 Subfamily Perginae

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

Figure 20 Subfamily Perreyiinae

Source: https://www.brisbaneinsects.com/brisbane_sawflies/Philomastiginae.htm

Figure 21 Subfamily Philomastiginae



Source: https://species.wikimedia.org/wiki/Phylacteophaginae

Figure 22 Subfamily Phylacteophaginae

Source: https://www.brisbaneinsects.com/brisbane_sawflies/Pterygophorinae.htm

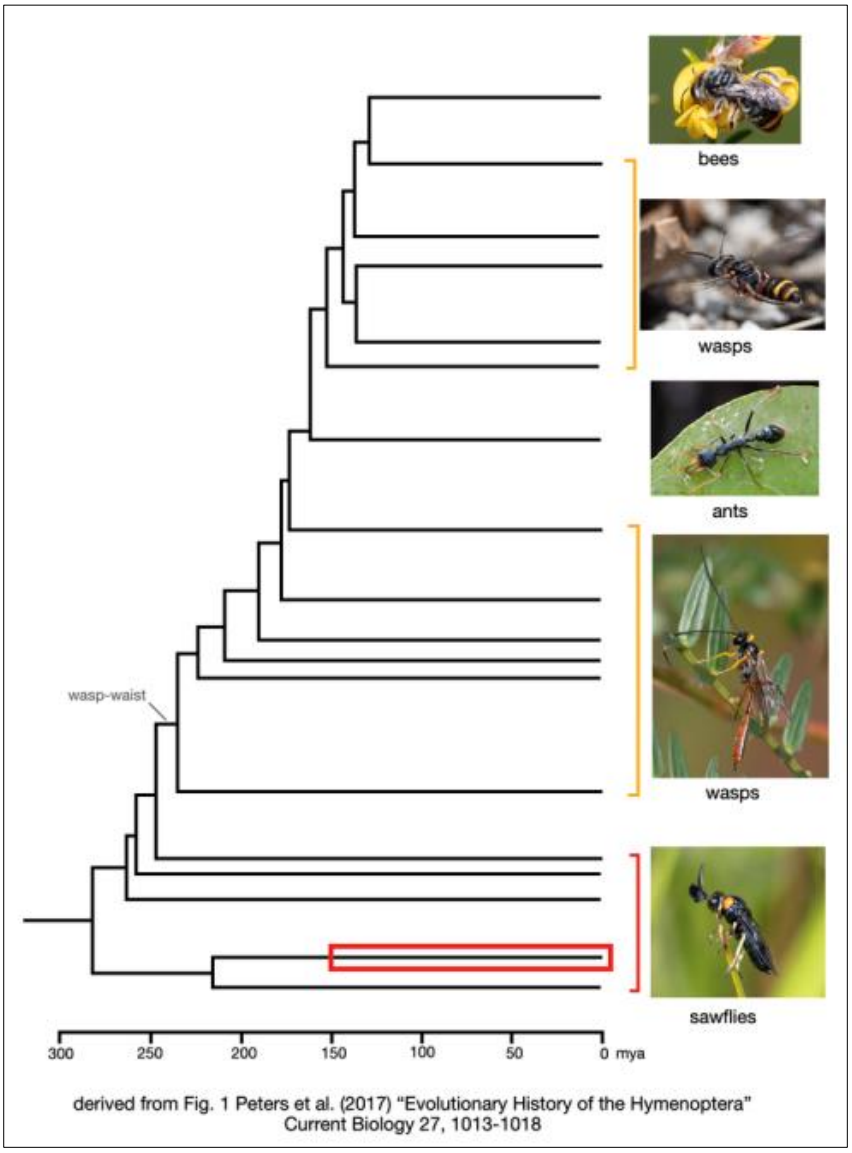
Figure 23 Subfamily Pterygophorinae

Sources: Photo 19585308, (c) Nick Lambert, some rights reserved (CC BY-NC-SA), uploaded by Nick Lambert and https://guatemala.inaturalist.org/photos/19585308

Figure 24 Subfamily Pteryperginae

Source: https://www.brisbaneinsects.com/brisbane_sawflies/Styracotechyinae.htm

Figure 25 Subfamily Styracotechyinae



Source: https://southernforestlife.net/happenings/2022/six-things-about-sawflies

Figure 26 This diagram summarizes our current understanding of the evolutionary history of the Hymenoptera - based on an analysis of gene sequences. The 153,000 species of hymenopterans known globally are the product of around 281 million years of evolution. Around 240 million years ago, one line evolved with a thin, flexible waist and gave rise to wasps, ants and bees. The remaining lines retained a thick waist and became sawflies. Australian sawflies evolved from one of these lineages, outlined in red in this diagram

Objective

This mini-review aimed to inventory aspects of the biology of the Pergidae Family such as life cycle, mating behavior, damage in agriculture, poisoning in animals, thanatosis and management.

2. Methods

The present work uses the reference of bibliographical research, understood as the act of inquiring and seeking information on a certain subject, through a survey carried out in national and foreign databases, with the objective of detecting what exists of consensus or controversy. The articles were published in indexed scientific research, book scientific chapters, theses banks, university dissertations, national and international scientific articles, scientific journals, documents and the academic and scientific journals available online ResearchGate, HAL SSRN, Scielo, Biological abstract, Qeios and Academia.edu.

3. Selection of papers

3.1. Study 1

This work aims to describe the clinical and pathological aspects of an outbreak of spontaneous poisoning by *Perreyia flavipes* Konow, 1899, larvae in pigs in the State of Santa Catarina (Figure 27).

Source: https://www.biodiversity4all.org/taxa/367930-Perreyia

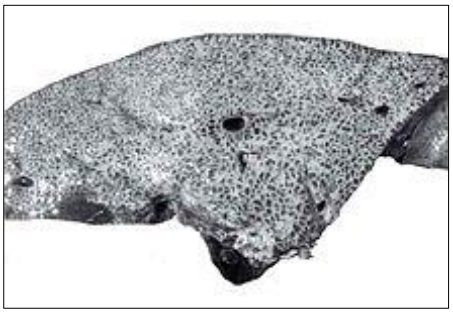
Figure 27 *Perreyia flavipes* Konow, 1899 (Hymenoptera Pergidae)

Ingestion of the larval stage of this species has been reported as a cause of acute hepatic necrosis in cattle and sheep in Australia, in sheep and goats in Denmark and in cattle in Uruguay. In Brazil, spontaneous poisoning by *P. flavipes* larvae has been reported in cattle (Figure 28) [21,22,23].

Figure 28 The liver was yellowish with petechial hemorrhages randomly distributed in the parenchyma and accentuation of the lobular pattern both on the capsular surface and on the cut, characterized by dark red centrilobular areas interspersed with lighter areas

In pigs, intoxication is described only experimentally. Although there are cases suggestive of natural poisoning *by P. flavipes* larvae, these have not been described or have not had a confirmed diagnosis. Intoxication occurs from May to July, which corresponds to the larval period of the insect. Animals ingest the larval form which is palatable. Columns

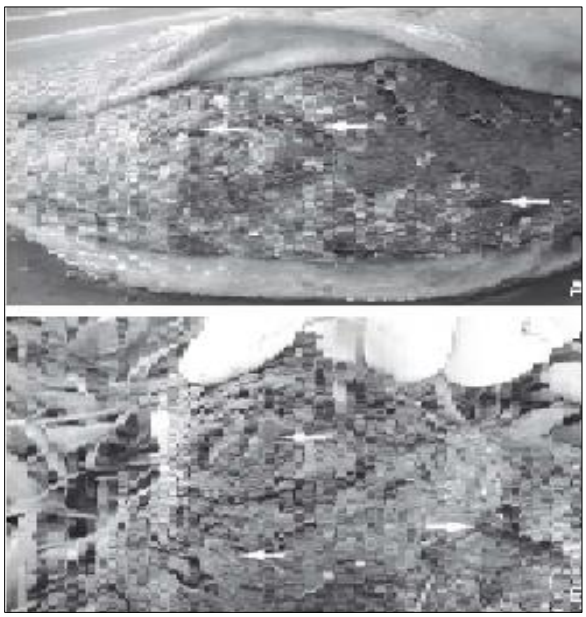
containing numerous larvae are observed that crawl over the pasture mainly in the early hours of the morning, or while there is moisture in the pasture (Figure 29) [21,22,23].



Source: https://pt.wikipedia.org/wiki/Perreyia

Figure 29 Cut surface of the liver with marked evidence of the lobular pattern, characterized by dark areas delimited by light lines in spontaneous poisoning by *Perreyia flavipes* Konow, 1899, in swine

Clinical signs were observed at the end of the day when the animals were collected and consisted of anorexia, apathy, constant head movement and ear flapping. They also had difficulty walking and staggering, teeth grinding and agitation of the ears and head, which were increased by nearby noises and movements. The period between the onset of clinical signs and death of the animals was 12-24 hours (Figure 30) [21,22,23].



Source: https://www.researchgate.net/figure/A-Estomago-contendo-fragmentos-e-larvas-de-Perreyia-flavipes-B-Evidenciacao-das_fig2_262614798

Figure 30 (A) stomach with fragments of larvae (B) Also showing fragments of presence of larvae in the feces

Three pigs that died with clinical signs of the disease and were in good nutritional status were necropsied. The liver showed an accentuation of the lobular pattern evident on the capsular and cut surface, which was characterized by dark red areas, slightly depressed and delimited by light lines. In the stomach there were numerous fragments of larvae and/or whole larvae of *P. flavipes* mixed with the stomach contents. Additionally, there were dried feces in the large intestine [21,22,23].

The histological lesions were restricted to the liver and were characterized by coagulative necrosis of hepatocytes, with centrilobular to massive distribution that was accompanied by congestion and marked hemorrhage. These areas of necrosis, when centrilobular, were surrounded by one or two layers of hepatocytes with vacuolar degeneration [21,22,23].

3.2. Study 2

This paper describes a brief review of the literature on *Perreyia flavipes* Konow, 1899, which was found between the months of May and July (2000) near the rural campus of the university in the region of Bagé, Rio Grande do Sul, Brazil (Figure 31) [24,25].

Source: https://twitter.com/InsetoLand/status/1227266110766092289

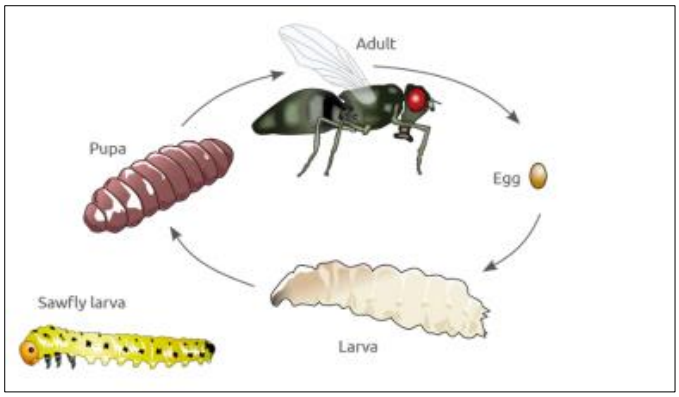
Figure 31 Adults of the *Perreyia flavipes* Konow, 1899

Larvae of the specie *P. flavipes* are toxic to animals such as cattle, sheep, pigs and rabbits, causing acute liver poisoning. The predominant toxic principle is pergidine which is a heptapeptide containing a phosphoseryl residue, these compounds are stable to enzymatic degradation due to their configuration and their strong chemical bond and lipophilic character (Figure 32) [24,25].

Source: https://www.shutterstock.com/pt/image-photo/perreyia-flavipes-konow-pergidae-perreyinae-species-2025217109

Figure 32 The "mata-porco" larvae of *Perreyia flavipes* Konow, 1899. Sawfly species with gregarious larvae. They feed on foliage and walk together to intimidate predators, causing cattle and pigs to die in two days when they eat them

Eggs *P. flavipes* were deposited on decomposing vegetation close to the ground, remaining in incubation for 26-33 days. With the hatching of the eggs, the larvae appear in the pastures from March and are about 1 mm long. In the last larval stage, they are black in color. shiny and measure 17-22 mm, being easily observed between the months of May and September (Figure 33) [24,25].



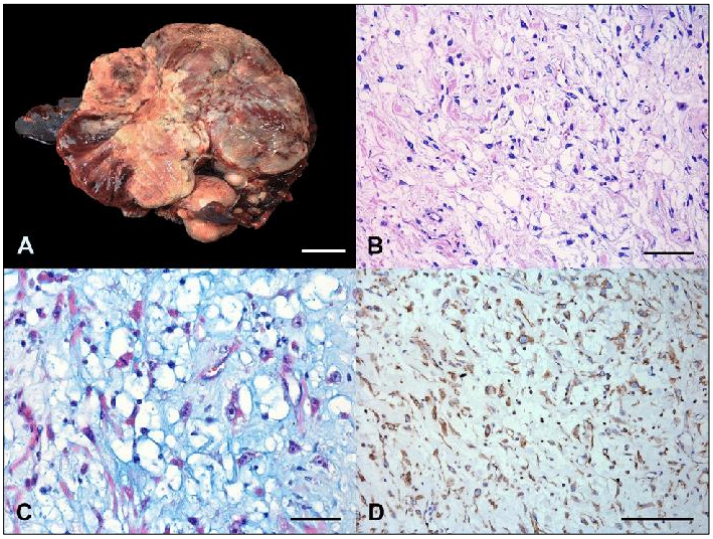
Source: https://ahdb.org.uk/knowledge-library/identification-and-management-of-flies-and-sawflies-in-field-crops

Figure 33 There are four stages to the fly life cycle – egg, larva (mostly legless maggots), pupa and adult

These larvae are seen with some frequency in the months of May to July (2000). This period has the highest incidence of rainfall in the region, favoring the cycle of insects that prefer humid, dark environments in the middle of the pasture, where the colony was found. The report of the appearance of these insects is of paramount importance due to the high toxicity for the animals since there is a high incidence of cases already described in the literature [24,25].

3.3. Study 3

Perreyia flavipes Konow, 1899, is a hymenopteran insect whose larvae can poison cattle, sheep and pigs. Spontaneous intoxication has been described in Uruguay. In Brazil there is a communication of intoxication in pigs by hymenopteran insect larvae has been described in cattle (Figure 34) [26,27].



Source: https://www.researchgate.net/figure/Figura-1-Mixossarcoma-esplenico-em-um-canino-A-Baco-com-uma-massa-multilobulada-medindo_fig1_321727795

Figure 34 Splenic myxosarcoma in a canine. (A) Spleen with a multilobed mass measuring 25 x 12 x 20 cm of soft consistency, with gray gelatinous areas interspersed with slightly firm yellowish areas. (B) Fusiform neoplastic cells, arranged in loose bundles interspersed with abundant myxoid material. (C) Evidence of myxoid material among neoplastic cells by Alcian blue staining. (D) Sharp immunostaining for vimentin in the cytoplasm of neoplastic cells

Sawflies are related to bees, wasps and ants. Although the adults look similar to wasps, they are distinguished by a broad connection between the abdomen and thorax. The larvae are also caterpillar-like, with six or more pairs of prolegs on the abdomen (Figure 35) [26,27].

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

Figure 35 Larva of Pergidae smooth head capsule with distinct

True caterpillars have five pairs or fewer, with the first two abdominal segments legless. Sawfly larvae also have a smooth head capsule with distinct, small black eyes [26,27].

3.3.1. Mating Behavior

The male then grabs the female using the hind pair of legs in response, the female stays immobile during the whole process, while the male approximates its abdominal apex to the female abdominal sternum. Male and female turn back-to-back 180° and join in copula While in copula, the male abdominal apex is placed below the female, sometimes its hind legs remain on the female's wings (Figure 36) [26,27].

Sources: Schmidt et al. 2006 and https://pergidae.snsb-zsm.de/biology

Figure 36 Mating left: Male aligns to female, middle: male attaches apex of abdomen to the female abdomen, right: mating position. Mating of *Lophyrotoma analis* Costa, 1864), left: Male aligns to female, middle: male attaches apex of abdomen to the female abdomen, right: mating position from Schmidt et al. 2006

The end of the copulation is initiated either by the female or the male, with one of them rotating its body and completely losing contact with the genitalia of the other individual and then walking away. The immobile female starts to move a few seconds after the male stopped copulating [26,27].

3.3.2. Thanatosis

Thanatosis behavior in *P. flavipes* is characterized by the complete immobility and retracting of body appendages for a few seconds. The behavior was observed during mechanical stimulation and social interactions. The duration of thanatosis by mechanical stimulation is longer in males (Figure 37) [26,27].

Source: https://link.springer.com/article/10.1007/s13744-017-0509-z

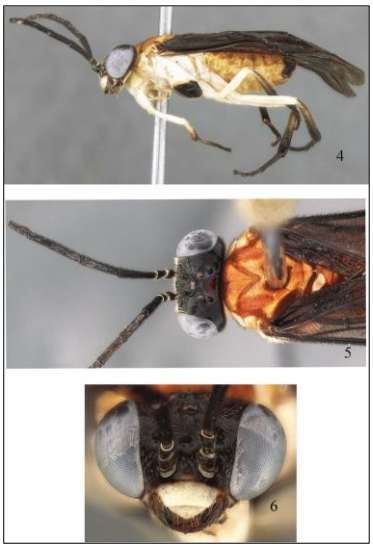
Figure 37 (a) On the adult behavioral repertoire of the sawfly *Perreyia flavipes* Konow, 1899 (Hymenoptera: Pergidae): Movement, mating, and thanatosis (b)

Spontaneous thanatosis happens when one individual meets another and touches it first during walking behavior, only when the first to touch it walked away, the other one started to walk again. The immobility behavior of some females during the mating also could be considered thanatosis-like females became immobile after the first contact of the male, remaining in this same state until the end of the copulation [26,27].

3.4. Study 4

3.4.1. Management/ Natural enemies and Sesquiterpenes.

Natural enemies, such as parasitoid species, are an important element in agricultural pest management. When considering the approach to shelter, alternative prey, flower-rich habitat, environment). Natural enemies require appropriate resources to help keep pests under control. Hedges, associated banks and other shrubby areas are protected from insecticides and intensive cultivation (Figure 38) [27,28].

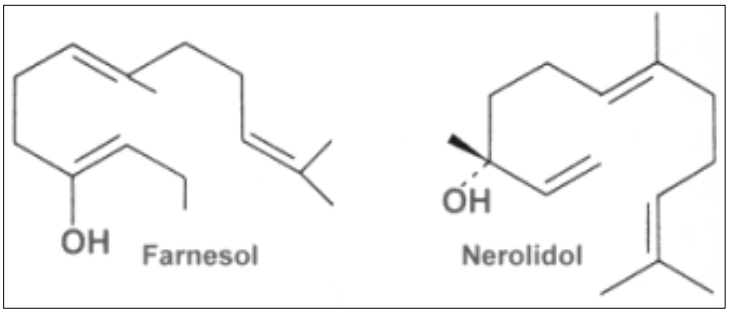


Source: https://www.researchgate.net/figure/Figures-4-6-Dochmioglene-crassa-4-Lateral-5-Dorsum-of-head-and-thorax-6-Face-front_fig2_271182398

Figure 38 *Dochmioglene crassa* (Cameron) Smith & Janzen & Hallwachs, 2013 (Hymenoptera: Tenthredinidae) (4) Lateral (5) Dorsum of head and thorax (6) Face, front

Grass bands and flower-rich pastures support high densities of some species. Natural enemies that live only part of the year within a crop need other habitats to forage, breed, or survive periods of dormancy. Protect natural vegetation along the bases of hedges and fences against the spread of insecticides and herbicides Plow two furrows together to form a

raised [beetle bank] to create drier conditions favored by insects and divide larger fields - sow with clump-forming grasses (Figure 39) [27,28].



Source: http://cyberlipid.gerli.com/description/simple-lipids/terpenoids-2/sesquiterpenes/

Figure 39 The acyclic representative is also called farnesans, term derived from the basic structure, farnesol. Farnesol and nerolidol are very common and are isolated from essential oils of various sources *Eucalyptus* 'feeders' plants in the family Myrtaceae, in particular species of *Eucalyptus*, have high leaf concentrations of essential oils, mainly mono- and sesquiterpenes. Monoterpenes are generally toxic to insects without specific defence against them

Pests usually occur sporadically during the growing season, with shorter life cycles than natural enemies. Other food sources and alternative prey inside and outside fields are needed to maintain natural enemy populations. Minimal tillage and application of organic fertilizers are especially valuable in providing suitable conditions for invertebrates that feed on detritus and serve as alternative prey for predators. Pollen and nectar are essential for some groups of natural enemies, especially parasitic wasps and flower flies. They are important foods for many other natural enemies (Figure 40) [2 7,28].

Sources: Photo 2908499, (c) Edithvale-Australia Insects and Spiders, some rights reserved (CC BY-NC), uploaded by Edithvale-Australia Insects and Spiders and https://www.biodiversity4all.org/photos/2908499

Figure 40 An parasitoid (family Encyrtidae)

Woodlands, hedgerows, banks, plantations and agro-environmental habitats containing wildflowers, annual arable plants, or flowering wild bird seed plants can provide pollen and nectar. These flower-rich areas are also home to alternative prey. Areas rich in flowers can be created using a mix of wildflowers and grasses or legumes. Mixtures that provide both complex and simple flowers are the most beneficial because they support both short and long-cycle insects [27,28].

3.4.2. Management/ Cultural.

To avoid intoxication, the animals must be removed from the paddocks where the outbreak is occurring. It is recommended to inspect the paddocks early in the morning when there is still moisture on the vegetation before introducing the animals into new areas, as at this time the larvae are more easily observed in groups and moving around [27,28].

Winter pastures made by plowing the soil can be a safe place for animals when there are outbreaks of poisoning. Plowing the soil restricts the availability of food for the first-stage larvae, which need dry vegetation in decomposition, and plowing the soil makes it possible for these pastures to be free of larvae during the outbreaks [27,28].

3.5. Study 5

The objectives of this study were to describe the epidemiology and pathology of three outbreaks of poisoning by *Perreyia flavipes* Konow, 1899 in cattle that occurred in the area of influence of the Regional Diagnostic Laboratory.

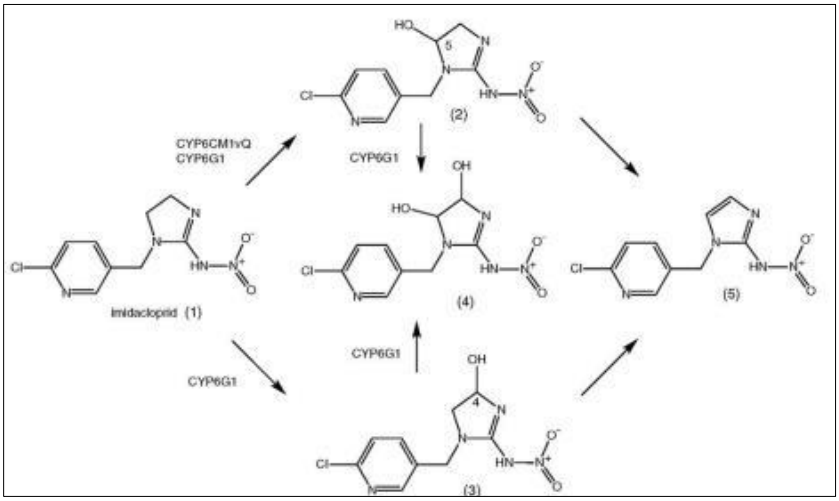
This is the first report of poisoning by *P. flavipes* in cattle in Brazil. Intoxication was observed in the municipalities of Candiota, Canguçu and São Lourenço between July and August 2006. Morbidity in the three outbreaks was 6.2%, 0.8% and 33.5% respectively, and lethality was 100%. Maximum and minimum average temperature data and average and normal rainfall for the region between October 2005 and March 2006 (Figure 41) [27,28]

Source: https://pergidae.snsb-zsm.de/eucalyptus-feeders

Figure 41 Defense reaction of *Pergagrapta polita* (Leach, 1817). When disturbed, larvae exudate fluid from their mouth trying to apply it to their enemy

Clinical signs were characterized by prostration, staggering gait, hindquarter incoordination, aggressiveness, jaundice and death within 24-48 hours. At necropsy, an enlarged liver with a dark or yellowish color was observed, with an accentuated lobular pattern, and an enlarged, edematous gallbladder with hemorrhages in the serosa. There was also intestinal congestion and petechial hemorrhages in the serosa and dry feces in the cecum [27,28].

Histologically in the liver, there was hemorrhagic necrosis accentuated centrilobular to mid zonal necrosis and necrosis of the germinal centers of the lymph nodes and spleen, and also the presence of hemosiderin in macrophages. In the white matter of the brain, status spongiosis (hepatic encephalopathy) was observed, a lesion frequently observed in toxic diseases that affect the liver (Figure 42) [27,28].



Source: http://what-when-how.com/insect-molecular-biology-and-biochemistry/insect-cyp-genes-and-p450-enzymes-part-8/

Figure 42 Aldrin epoxidase activity and cytochrome P-450 content of sawfly larvae, *Pergagrapta polita* (Leach, 1817) (Hymenoptera: Pergidae) feeding on two *Eucalyptus* species metabolism of imidacloprid by insect P450 enzymes: (1) imidacloprid; (2) 5-hydroxyimidacloprid; (3) 4-hydroxyimidacloprid; (4) dihydroxyimidacloprid; (5) non-enzymatically derived dehydroimidacloprid

Intoxication probably occurred due to the intense drought that occurred in the region, which favored the presence of dead plant matter that serves as food for the larvae, associated with the lack of forage that led the animals to ingest them. [27,28].

It has been shown that the greater number of larvae in certain years is associated with greater emergence of adult insects due to the prolonged drought in spring and summer, when the insect is in the pupal stage in the soil. Later, if there is good availability of food, that is, accumulation of dry and decomposing vegetation in early autumn and winter [27,28].

3.6. Study 6

Thus, the present work describes the defense behavior of the larvae of the Neotropical Symphyta *Haplostegus nigricrus* Conde, 1936 Conde (Hymenoptera: Pergidae) through field and laboratory observations submitted to the predators, *Podisus nigrispinus* (Dallas, 1851) (Hemiptera: Pentatomidae), *Supputius cincticeps* Stal, 1860 (Heteroptera, Pentatomidae) and *Brontocoris tabidus* (Signoret, 1852) (Heteroptera: Pentatomidae) (Figures 43-44) [29,30].

Figure 43 Natural mortality agents of *Haplostegus nigricrus* Conde (Hymenoptera: Pergidae): (A) An parasitoid (family Encyrtidae); (B) unknown symptom of aggression by natural enemy; (C) *Csymptom* of virus infection and (D) pupa of *H. nigricrus* colonized by *Aspergillus* sp. under laboratory conditions

Sources: Torres et al., 2006) and http://www.tarimkutuphanesi.com/Domates_guvesi-Tuta_absoluta_(Meyrick 1917)_00987.html

Figure 44 Adult and nymph of *Podisus nigrispinus* (Dallas, 1851) (Hemiptera: Pentatomidae) preying on a caterpillar. The females lay eggs in small masses, reaching up to 40 eggs per mass. During the entire life cycle, each female lays eggs from 81 to 300 eggs. This predator can be found in soybeans throughout the crop cycle, feeding on caterpillars and other smaller insects, presenting a high potential for use in pest control

Source: EcoRegistros. 2023. *Supputius cincticeps* - Species sheet. Accessed from http://www.ecoregistros.org on 04/11/2023

Figure 45 *Supputius cincticeps* Stal, 1860 (Heteroptera: Pentatomidae)

Haplostegus nigricrus larvae showed defensive behaviors such as maintaining distance and immobility, escaping attacks, aggressive movements to detach the predator's stylet and retaliating, which, in general, does not differ from that presented in other prey. However, the elimination of hemolymph droplets, through the mouthparts, seems to be the main defensive strategy of *H. nigricrus* larvae, which is standard in Symphyta that use plants of the Myrtaceae family as hosts (Figure 46) [27,28].

Source: https://www.researchgate.net/figure/Figura-1-Larva-de-ultimo-estadio-de-Haplostegus-nigricrus-Conde-Hymenoptera-Pergidae_fig1_277075116

Figure 46 Last-stage larva of *Haplostegus nigricrus* Conde, 1936 Conde (Hymenoptera: Pergidae) under *Psidium leafguajava* (Myrtaceae) in a typical defense position

All these predators showed similar attack strategies, mainly by ambush, which can define the success of predation The final region of the abdomen and head of the larva of *H. nigricrus* were initially chosen by predators for insertion of the stylus. The other attacks were concentrated at the end of the abdomen, as this is a less sclerotized region and, therefore, easier for the predator's stylet to penetrate. This preference may also have been manifested to avoid direct contact with the frontal region of the head of *H. nigricrus* larvae, which is the region of the body with a large amount of regurgitated toxic compounds (Figure 47) [29,30].

Source: Photos at https://www.naturalista.mx/taxa/737513-Brontocoris-tabidus

Figure 47 *Brontocoris tabidus* (Signoret, 1852) (Heteroptera: Pentatomidae)

4. Conclusion

The Larvae seem to be of the genus *Perreyia* (Family Pergidae), which in some places are veritable pests. Another known name for these larvae is pig killer because, when ingested by pigs and even cattle, they release a toxic substance secreted by the cutaneous glands that poison them. They present weakness, depression, muscle tremors, excitement, aggressiveness, and mortality within 2 days of the onset of symptoms. In animals that survive longer, jaundice and sensitivity to light are observed. The results show some unusual behavioral adaptations presented by *P. flavipes*, such as irregular activity behavior, thanatosis behavior-like display, and primitive maternal care.

References

[1] Blank SM, et al. Studies toward a world Catalog of Symphyta (Hymenoptera). Zootaxa. 2009: 2254: 1–96.

[2] Macedo A. Hymenoptera [Internet]. São Paulo: MZUSP-Hymenoptera; © 2001 [cited 2023 Apr 12]. Available from https://sites.google.com/site/hymenopteramzsp/mzusp/pesquisa-1.

[3] Boevé J-L, Diego F, Domínguez D, Smith R. Sawflies from northern Ecuador and a checklist for the country (Hymenoptera: Argidae, Orussidae, Pergidae, Tenthredinidae, Xiphydriidae). Journal of Hymenoptera Research. 2018: 64: 1-24.

[4] Iberfauna. Familia Pergidae. The Iberian fauna data bank [Internet]. Madrid: National Museum of Natural Sciences (CSIC); @ 2055 Available from ttp://iberfauna.mncn.csic.es/showficha.aspx?rank=J&idtax=3444.

[5] Moreno AM, Sobestiansky J, Mores N. Nutritional deficiencies. In: Sobestiansky J, Barcellos D, eds. Swine Diseases. 1st ed. Goiânia: Canon Editorial; 2088. p. 510-524.

[6] Smith DR, Janzen DH. Food plants and life histories of sawflies of the family Argidae (Hymenoptera) in Costa Rica, with descriptions of two new species. Journal of Hymenoptera Research. 2003; 12(1): 193–208.

[7] Smith DR. Chapter 11. Introduction to the basal Hymenoptera ("Symphyta"). / Chapter 12. Superfamily Xyeloidea and family Xyelidae. / Chapter 13. Superfamily Tenthredinoidea. / Chapter 14. Family Argidae. / Chapter 15. Family Cimbicidae. / Chapter 16. Family Diprionidae. / Chapter 17. Family Pergidae. / Chapter 18. Family Tenthredinidae. / Chapter 19. Superfamily Pamphilioidea and family Pamphiliidae. / Chapter 20. Superfamily Cephoidea and family Cephidae. / Chapter 21. Superfamily Siricoidea and family Siricidae. / Chapter 22. Superfamily Xiphydrioidea and family Xiphydriidae. / Chapter 23. Superfamily Orussoidea and family Orussidae. In: Fernández F, Sharkey MJ, eds. Introduction to the Hymenoptera of the Neotropical Region. 1st ed: Bogota: Colombian Society of Entomology and National University of Colombia; 2007. 203–271.

[8] Radostits OM, Gay CC, Blood DC, Hinchcliff KW. Clinic Veterinary: A treatise on diseases of cattle, sheep, pigs, goats and horses. 9st ed. Rio de Janeiro: Guanabara Koogan. 2002.

[9] Azevedo CO, et al. Checklist of the genera of Hymenoptera (Insecta) from Espírito Santo state, Brazil. Boletim do Museu de Biologia Mello Leitão. 2015; 37(3): 313-343.

[10] Raymundo DL, et al. Spontaneous poisoning by larvae of *Perreyia flavipes* (Pergidae) in sheep. Veterinary Research. 2008; 28(1):19-22.

[11] Flores C, Ugalde J, Hanson P, Gauld I. The biology of perreyiine sawflies (Hymenoptera: Pergidae) of the *Perreyia* genus group. In: Austin AD, Dowton M, eds. Hymenoptera Evolution, Biodiversity and Biological Control. 1st ed. Collingwood: CSIRO Publishing. 2000. p. 258-266.

[12] Raymundo DL. Spontaneous poisoning by *Perreyia flavipes* larvae in cattle in the State of Santa Catarina, Brazil. Ciência Rural. 2009; 39(1): 163-166.

[13] Djeison LR. Spontaneous poisoning by larvae of *Perreyia flavipes* (Pergidae) in sheep and cattle and experimental poisoning in sheep and rabbits [Ph.D. doctoral]. Rio de Janeiro: Federal University of Rio Grande do Sul; 2008.

[14] Smith DR. A synopsis of the sawflies (Hymenoptera, Symphyta) of America south of the United States: Pergidae. Revista Brasileira de Entomologia. 1990; 34(1): 7–200.

[15] Taeger A, et al. Electronic world catalog of Symphyta (Insecta, Hymenoptera) [Internet]. Nuremberg: German Entomological Institute (SDEI); @ 2018 [2023 Apr 09]. Available from https://www.sdei.de/ecatsym/.

[16] Schmidt S, Smith DR. An annotated systematic world catalogue of the Pergidae (Hymenoptera). Contributions of the American Entomological Institute. 2006; 34(3): 1-207.

[17] Costa JT. The other insect societies. 1st ed. Cambridge: Harvard University Press. 2006.

[18] Smith DR. A synopsis of the sawflies (Hymenoptera: Symphyta) of America South of the United States: Tenthredinidae (Nematinae, Heterarthrinae, Tenthredininae). Transactions of the American Entomological Society. 2003; 129(1): 1-45.

[19] Jervis M, Vilhelmsen L. Mouthpart evolution in adults of the basal, 'symphylans', hymenopteran lineages. Biological Journal of the Linnean Society. 2000. 70(1): 121–146.

[20] Schmidt S, Smith DR. An annotated systematic world catalogue of the Pergidae (Hymenoptera). Contributions of the American Entomological Institute. 2006; 34: 1–207.

[21] Jonck F, et al. Spontaneous poisoning by larvae of *Perreyia flavipes* (Pergidae) in pigs in the state of Santa Catarina. Brazilian Veterinary Research. 2013; 30(12): 1017-1020.

[22] Soares MP, Riet-Correa F, Smith DR, Soares P, Mendez MC, Brandolt AL. Experimental intoxication by larvae of *Perreyia flavipes* Know, 1899 (Hymenoptera: Pergidae) in pigs and some aspects on its biology. Toxicon. 2001; 39(5): 669-678.

[23] Djeison LR, et al. Spontaneous poisoning by *Perreyia flavipes* larvae in cattle in the state of Santa Catarina, Brazil. Ciência Rural. 2009; 39(1): 163-166.

[24] Pereira RS, et al. Larvae and *Perreyia flavipes* found in the Campaign region [Internet]. Unijui: Hall of Knowledge; @ 2013 [2023 April 10]. Available from file:///C:/Users/Lenovo/Downloads/2000-Texto%20do%20artigo-8112-1-10-20130809%20(1).pdf.

[25] Neves FM. Complex behavior of individual insect activity in delimited environments [Ph.D doctoral]. Curitiba: Universidade Federal do Paraná; 2016.

[26] Agriculture and Horticulture Development [Internet]. Kenilworth: Agriculture and Horticulture Development Board; @ 2023 [2023 April 10] Available from https://ahdb.org.uk/contact-us.

[27] Riet-Correa B, et al. Poisoning by *Perreyia flavipes* larvae in cattle [Internet]. Pelotas: Congresso de Iniciação Científica and Pós-graduação; @ 2016 [2023 Apr 10]. Available from http://www2.ufpel.edu.br/cic/2006/resumo_expandido/CA/CA_00234.pdf.

[28] Pereira AIA, et al. Larval defensive behavior of the Neotropical Symphyta *Haplostegus nigricrus* (Hymenoptera: Pergidae) exposed to the stink bug predators Podisus nigrispinus, *Supputius cincticeps* and *Brontocoris tabidus* (Heteroptera: Pentatomidae). Caatinga. 2008; 21(4): 167-171.

[29] Schmidt S, Walter GH, Moore CJ. Host plant relationships in myrtaceous-feeding pergid sawflies: Essential oils and the morphology and behavior of *Pergagrapta* larvae (Hymenoptera, Symphyta, Pergidae). Biological Journal of the Linnean Society of London. 2000; 70: 15-26.

[30] Zanuncio JC. Agedependent fecundity and fertility of the predator *Brontocoris tabidus* (Heteroptera: Pentatomidae) under field conditions. Journal of Economic Entomology. 2006; 99: 401-407.