



First occurrences of the host/parasitoid relationship in Brazil and Peru: Bibliographic summary

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Abstract

It is common for parasitoidism to modify the behavior of the host species, facilitating the development and propagation of the parasitoid and establishing a highly specific relationship. In this case, herbivores such as cattle, sheep, deer, and rabbits are the definitive host of the parasitoid. The objective of this review is to describe the first occurrence of the host/parasitoid relationship in Brazil and Peru. The mini review consists of a bibliographic summary of parasitoids of the Order Hymenoptera parasitoids collected in Brazil and Peru. The research was carried out in studies related to the theme with emphasis on the quantitative aspects of the Superfamily, Family, Subfamilies, Genera, and Species (taxonomic groups). A literature search was carried out containing articles published from 2000 to 2021. The mini review was prepared in Goiânia, Goiás, from July to September 2021, using the Electronic Scientific Library Online (SciELO) and internet. Since the relationship between parasitoids and their hosts is very specific, it is common for agricultural pests to be naturally controlled through parasitoidism. Wasps of the Ichneumonoidea and Braconidae family respectively parasitize caterpillars of butterflies and moths, and even aphids.

Keywords: Parasitism; Bibliographic summary; Agricultural pests; Biological control; Insect

1. Introduction

1.1. Host/parasitoid relationship

Parasitoids are characterized by having high fecundity, short life cycles and still interact in a very specific way with their hosts [1, 2, 3].

Most parasitoids belong to the insect group, mainly to the orders Diptera (flies) and Hymenoptera (wasps), and females usually lay their eggs on their hosts. Thus, when hatching from the eggs, the larvae consume the host individual that serves as a resource in the initial stage of development, killing it many times before it reproduces for the first time. Some parasitoid wasps belonging to the Apocrita suborder have an ovipositor used to insert the eggs into the host's body. The *Cotesia congregata* (Say 1836) (Hymenoptera: Braconidae) wasp, on the other hand, lays its eggs in the larvae of the tobacco insect, the *Manduca sexta* (Linnaeus, 1763) (Lepidoptera: Sphingidae) moth. Along with the eggs, this species injects a virus that knocks down the host's immune system, facilitating the invasion and hatching of eggs [1, 2, 3].

It is common for parasitoidism to modify the behavior of the host species, facilitating the development and propagation of the parasitoid and establishing a highly specific relationship. In this case, herbivores such as cattle, sheep, deer, and rabbits are the definitive host of the parasitoid [1, 2, 3].

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There are several ways to classify parasitoid organisms. Regarding the place of development, individuals can develop on the external surface of the host, also called ectoparasitoids, or inside the host's body, known as endoparasitoids. Regarding the host's life stage, the parasitoids can attack and develop in eggs, larvae, pupae, nymphs and in the adult host. In all these cases, the exploitation of the host can happen in two ways, classifying the parasitoids into idiobionts, which inhibit any activity and development of the host at the time of parasitization, and cenobionts, which allow the host to feed and develop, dying later by account of the hatching of the larvae [1, 2, 3].

When developing in non-parasitic hosts, the parasitoid can also be called the primary parasitoid. In some cases, the parasitoids called secondary or hyperparasitoids parasitize other parasitoids, and are usually ingested by organisms already parasitized previously. For example, female wasps of the Trigonalidae family lay their eggs on leaves that will serve as a food resource for caterpillars. Upon reaching the digestive system, they perforate the intestinal wall and look for other parasitoid larvae to feed on [1, 2, 3].

Since the relationship between parasitoids and their hosts is very specific, it is common for agricultural pests to be naturally controlled through parasitoidism. Wasps of the Ichneumonoidea and Braconidae family respectively parasitize caterpillars of butterflies and moths, and even aphids. In agrosystems, such as coffee, cotton, soybean, sorghum, beans and wheat, dozens of families of parasitoids responsible for the cultivation of pests are found. The most found superfamily is usually Chalcidoidea, as it has a high host diversity, such as aphids, flies, caterpillars and scale insects [1, 2, 3].

1.2. Group of parasitoids collected in this study



Figure1 *Brachymeria podagrica* (Fabricius, 1789) (Hymenoptera: Chalcididae); (Source: https://v3.boldsystems.org/index.php/Taxbrowser_Taxonpage?taxid=453340)



Figure 2 *Neralsia splendens* (Borgmeier, 1935) (Hymenoptera: Figitidae); (Source: <http://www.waspweb.org/Cynipoidea/Figitidae/Figitinae/Neralsia/index.htm>)

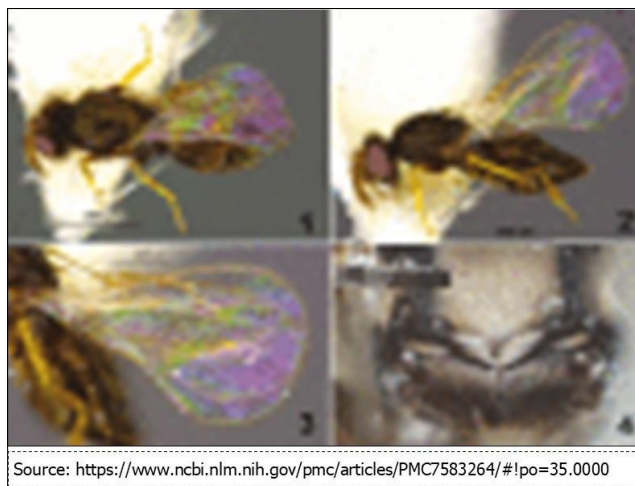


Figure 3 *Kleidotoma nigra* (Hartig, 1840) (Hymenoptera: Figitidae); (Source: <https://www.invasive.org/browse/detail.cfm?imgnum=5583873>)



Fig. 2. General appearance of the parasitoid *Hemencyrtus herbertii*.

Figure 4 *Hemencyrtus herbertii* Ashmead, 1900 (Hymenoptera: Encyrtidae); (Source: <https://www.semanticscholar.org/paper/First-report-of-the-parasitoid-Hemencyrtus-Ashmead-Marchiori/d21aad3cf7429b123ed774765d97cb7f0c6e77c>)



Source: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7583264/#!po=35.0000>

Figure 5 *Tachinobia repanda* Boucek, 1977 (Hymenoptera: Eulophidae); (Source: <https://openaccesspub.org/ijen/article/1625>)



Figure 6 *Nasonia vitripennis* (Walker, 1836) (Hymenoptera: Pteromalidae); (Source: <https://bugguide.net/node/view/1224218/bgpage>)

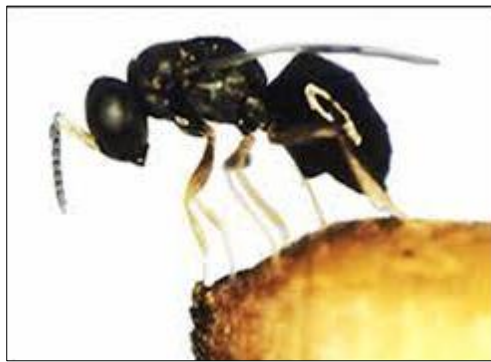


Figure 7 *Pachycrepoideus vindemmiae* (Rondani, 1875) (Hymenoptera: Pteromalidae); (Source: https://www.researchgate.net/figure/Pachycrepoideus-dubius-femelle-40_fig7_281565789)

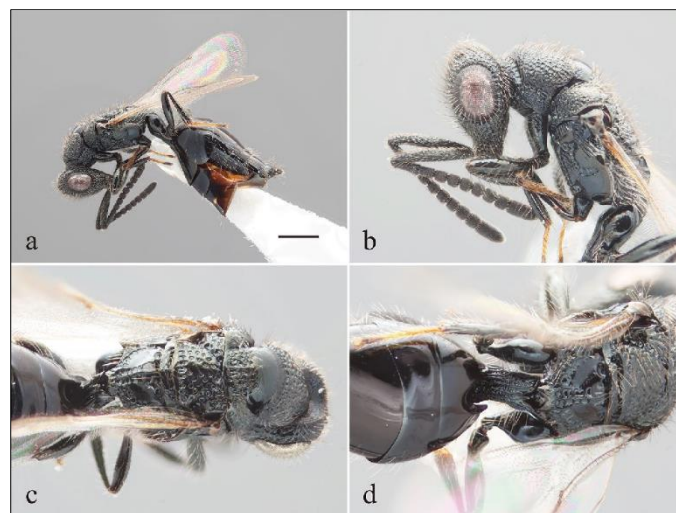


Figure 8 Species of *Spalangia* a, b, c and d (Hymenoptera: Pteromalidae); (Source: [https://www.semanticscholar.org/paper/Detection-of-Spalangia-\(Hymenoptera%3A-Pteromalidae\)](https://www.semanticscholar.org/paper/Detection-of-Spalangia-(Hymenoptera%3A-Pteromalidae)))

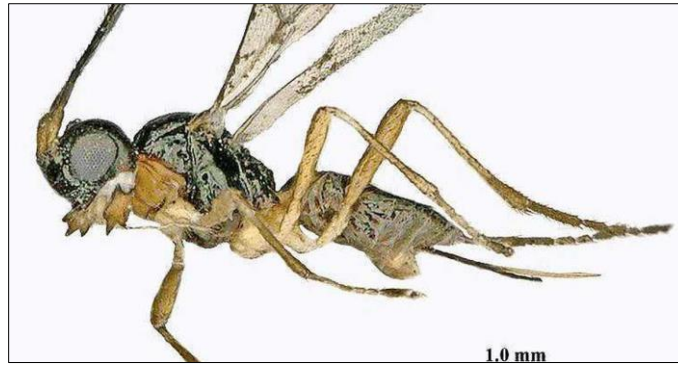


Figure 9 *Aphaereta* sp. (Hymenoptera: Braconidae); (Source: <https://www.world-today-news.com/new-wasp-discovered-in-vondelpark-interior/>)



Figure 10 *Trichopria* sp. (hymenoptera: Diapriidae); (Source: <https://bugguide.net/node/view/15884>)

Objective

The mini review aims to describe the host/parasitoid relationships in Brazil and Peru.

2. Methods

The methodology used in this study was that of Marchiori (2021) [4]. The collection was built from articles from 2000 to 2021 with the themes: Classification, study of the main Genus and Species and Families.

2.1. Methods used to collect parasitoids in this paper

2.1.1. Metal Container traps

Regarding the collection of parasitoids in animal feces (chicken, cattle and buffalo feces) we used the following methodology. Feces were removed from the farm sheds placed in 10 basins to be transported to the laboratory for removal of pupae. The pupae were removed and placed on absorbent paper for drying and later individualized in glass capsules for the emergence of adult flies or parasitoids [Figure 11].



Figure 11 Metal Container traps

2.1.2. *The pitfall trap (soil traps)*

It consists of a 15 cm diameter by 10 cm high plastic container. This container, containing one liter of water, 20 ml of detergent and 2 ml of formaldehyde, is buried until its opening is at ground level. A 150 ml beaker is used as a support for the bait and is attached to the container by a thin wire, pierced at its edge, which keeps it hanging and centered in the trap. The trap is protected from excessive sun and rain by placing a cardboard roof on a wire that is 10cm above the floor (Figure 12).



Figure 12 The pitfall trap

2.1.3. *Method with animal carcasses*

Method with animal carcasses in rural areas using two pig carcasses weighing approximately 10 kg each were used as bait. The pigs were mechanically killed with a blow to the head and immediately placed in metal frame cages to exclude large vertebrate scavengers. Under the cages, metal trays with sawdust were placed to collect pupae. The pupae were extracted by flotation in water. The pupae were placed individually in gelatin capsules for the emergence of adult flies or parasitoids (Figure 13).



Figure 13 Method with animal carcasses

2.1.4. Method for collecting feces

Method for collecting feces. Fresh animal feces collected from pastures, pens or poultry farms are placed in 10 round plastic supports 20 cm in diameter. The feces remained exposed for 15 days in the environments mentioned above. After this period, the feces are sent to the laboratory to extract the pupae using the flotation method. The pupae are removed with the aid of a sieve, placed on absorbent papers to dry, and later, individually stored in gelatin capsules (number 00) until the emergence of flies and / or parasitoids. The parasitoids and flies that have emerged are identified and stored in 70% alcohol (Figure 14).



Figure 14 Method for collecting feces

In this study, the parasitoids collected are from larvae and pupae. (Figures 15 and 16)

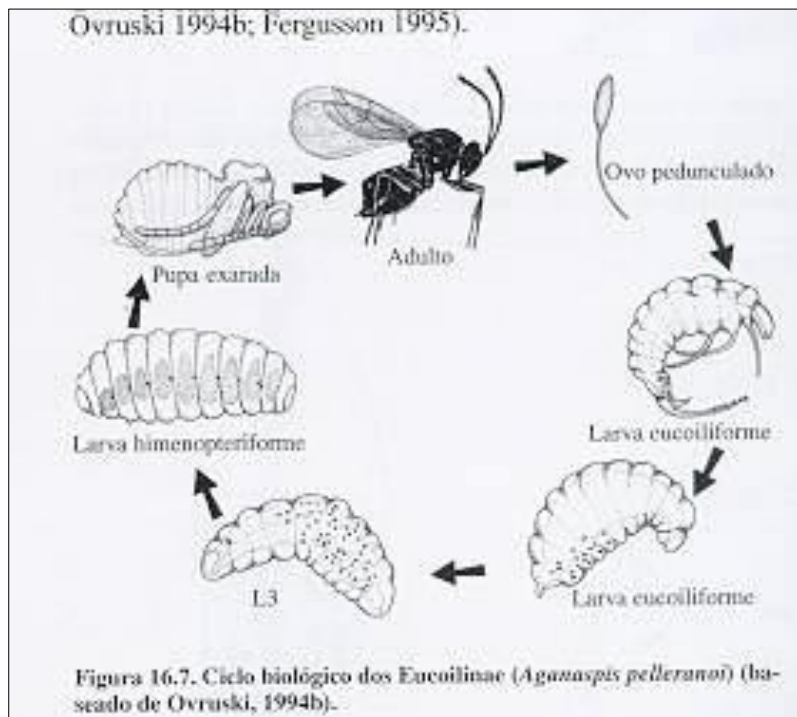


Figure 15 Life cycle of a larval parasitoid; (Source: Ferguson 1993)

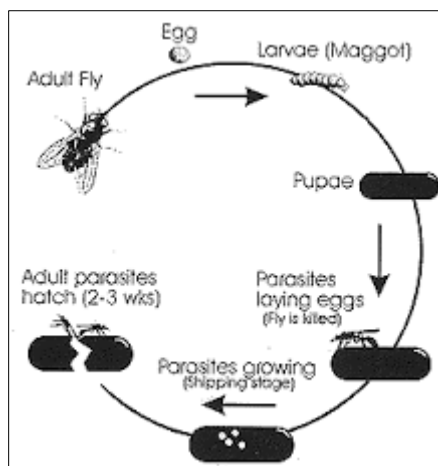


Figure 16 Life cycle of a pupal parasitoid (<https://biocontrol.entomology.cornell.edu/parasitoids>)

3. Study carried out

3.1. Study 1

This article reports the occurrence of the parasitoid *Leptopilina bouvardi* (Barbotin, Carton & Keltern Pillaut, 1979). (Hymenoptera: Figitidae: Eucoilinae) parasitizing *Zaprionus indianus* Gupta 1970 (Diptera: Drosophilidae).

Between March and November 2001, 03 specimens of *l. bouvardi* collected in the months of September (two specimens) and November (one specimen) of 2001 in the spring, were obtained from 139 pupae of *Z. indianus*, representing 2.2% of parasitism. This is the first report of *L. bouvardi* parasitizing pupae of *Z. indianus* in Brazil [5].

3.2. Study 2

This work reports the first occurrence of the parasitoid *Paraganapis egeria* Diaz & Gallardo Walsh & 1996 (Hymenoptera: Figitidae) parasitizing *Haematobia irritans* L. 1758 (Diptera: Muscidae) in the Neotropical region.

Two from 718 (0.26%) horn fly pupae collected at middle of April 1994, at the beginning of cold and dry season (19.8°C and rainfall of 62.5mm³) were parasite by an Eucoilinae (Figitidae) now confirmed as belonging to the specie *P. egeria*. This is the first record of *P. egeria* parasiting the horn fly in the Neotropical region [6].

3.3. Study 3

The aim of this note is to expand the knowledge of the host species of the parasitoid *Triplasta atrocoxalis* Ashmead, 1895 (Hymenoptera: Figitidae).

From 30 bovine fecal plaques 62 pupae of *Cyrtoneurina paraescita* Couri, 1995 (Diptera: Muscidae) were obtained, of which 11 emerged as adults, 50 produced neither flies nor parasitoids and from one pupa emerged a parasitoid of the species *T. atrocoxalis*. Parasitism of 1.6% was found [7].

3.4. Study 4

The aim of this study is to describe the first occurrence of *Kleidotoma nigra* (Hartig, 1840) (Hymenoptera: Figitidae) as a parasitoid of *Archiseopsis scabra* (Loew, 1891) (Diptera: Sepsidae) in Brazil.

After collecting 36 fecal plaques from March to June 2006, three specimens of the parasitoid *K. nigra* emerged from 47 puparia of *A. scabra*. The percentage of parasitism was 6.4% [8]. First occurrence of *K. nigra* as a parasitoid of *A. scabra* in Brazil [8].

3.5. Study 5

The main objective of the study was to describe the first report of *Tachinobia repanda* Boucek, 1977 (Hymenoptera: Eulophidae) in Brazil. In March 2009, 11 pupae were obtained from *Oxysarcodexia* sp. (Diptera: Sarcophagidae), and

emerged from a pupal of *T. repanda*, respectively. The percentage of parasitism was 9.1%. When a parasitoid species has its host as an insect considered a pest it becomes a potential biological control agent [9].

3.6. Study 6

The aim of this study is to describe the first occurrence of *Kleidotoma nigra* (Hartig, 1840) (Hymenoptera: Figitidae) parasitizing *Brontaea quadristigma* (Thomsom, 1899) (Diptera: Muscidae).

After collecting 40 fecal plaques from June to October 2003, two specimens of the parasitoid *K. nigra* of 21 pupae of *B. quadristigma*. The percentage of parasitism was 9.5% [10].

3.7. Study 7

The objectives of this study were to investigate the host of *Triplasta coxalis* (Ashmead, 1895) (Hymenoptera: Figitidae) the new occurrence of the parasitoid *Kleidotoma nigra* (Hartig, 1840) (Hymenoptera: Figitidae) and *T. coxalis* in Brazil.

After collecting 20 fecal plaques between January and February 2001, four specimens of *T. coxalis* and one specimen of *K. nigra* were obtained from 1163 puparia of *Palaeosepsis* sp. (Diptera: Sepsidae) in feces of 144 hours of exposure in pastures. The percentage of parasitism of *T. coxalis* and *K. nigra* was 0.34% and 0.08%, respectively. There was a total percentage of parasitism of 0.43% [11].

3.8. Study 8

The objective of this work is to inform about the first record of *Brachymeria podagratica* (Fabricius, 1789) (Hymenoptera: Chalcididae) in guinea pig carcasses in the Province of Castilla, Department of Piura, Peru.

In total, 91 specimens of *B. podagratica* were collected, in addition to 744 adult Calliphoridae and 493 adults Sarcophagidae associated with guinea pig carcasses. It was observed that *B. podagratica* appeared until the tenth day of the test, when the corpses began the skeletonization state, as the dipterans present were in the larval and pupal stages, states that lasted until the twelfth day. For this reason, the presence of *B. podagratica* in guinea pig carcasses is attributed as a parasitoid of Diptera larvae belonging to the Calliphoridae and Sarcophagidae families [12].

3.9. Study 9

The objective of this paper was to report a new host for the parasitoid *Pachycrepoideus vindemmiae* (Rondani, 1875) (Hymenoptera: Pteromalidae), which was collected in the urban region of Goiânia, in the central part of the state of Goiás, Brazil.

Between January and May 2014, two specimens of *P. vindemmiae* were collected from 26 pupae of *Synthesiomyia nudiseta* (Van der Wulp, 1883) (Diptera: Muscidae). The percentage parasitism observed was 7.7%. The percentage parasitism can also be correlated with the parasitoid's search capacity and with the availability of resources [13].

3.10. Study 10

The aim of the present study was to report on a new host for *Neralsia splendens* (Borgmeier, 1935) (Hymenoptera: Figitidae) in a rural area in Brazil.

Between March and July 2012, 26 pupae of *Cyrtoneurina paraescita* Couri, 1995 (Diptera: Muscidae) were collected from bovine feces, from which two specimens of *N. splendens* emerged. The parasitism rate was 0.35%. Forests and agricultural areas are places of refuge and emergence for these parasitoids [14].

3.11. Study 11

The objective of this work was to report the occurrence of the parasitoid *Nasonia vitripennis* (Walker, 1836) (Hymenoptera: Pteromalidae) parasitizing pupae of muscoid dipterans in different substrates in Itumbiara, southern Goiás, Brazil.

The liver was the substrate that attracted the greatest number of specimens of *N. vitripennis* with 45.9% of the individuals collected and presented the greatest diversity of parasitized muscoid dipteran species (50.0%). *Chrysomya megacephala* (Fabricius, 1794). (Diptera, Calliphoridae) was the species most parasitized by the parasitoid *N. vitripennis*, presenting a percentage of parasitism of 46.2%.

In bovine kidneys, *N. vitripennis* showed preference for *C. albiceps*. In the chicken substrate, *N. vitripennis* showed preference for *Peckia chrysostoma* (Wiedemann, 1830) (Diptera: Sarcophagidae) and *Musca domestica* L. 1758 (Diptera: Muscidae). In fish, *N. vitripennis* showed preference for *C. albiceps* and *P. chrysostoma*.

In human feces, *N. vitripennis*: showed preference for *P. chrysostoma* and *Sarcodexia lambens* (Wiedemann, 1830) (Diptera: Sarcophagidae). In liver, *N. vitripennis* showed preference for *C. albiceps*, *Oxysarcodexia thornax* (Walker, 1849) (Diptera: Sarcophagidae) and *Synthesiomyia nudiseta* (Wulp, 1883) (Diptera: Muscidae) (Chi square = 2764.2; GL=24; P<0, 0001). This paper reports the first occurrence of *N. vitripennis* parasitizing *S. lambens* pupae in Brazil [15].

3.12. Study 12

The objective of this work is to report the first occurrence of *Spalangia cameroni* Perkins, 1910 (Hymenoptera, Pteromalidae) parasitizing *Ornidia obesa* Fabricius, 1775 (Diptera: Syrphidae) in Brazil.

From August to December 2007, 21 specimens of *O. obesa* were collected from which two specimens of the parasitoid *S. cameroni* emerged. The percentage of parasitism was 9.5%. There are no reports of *S. cameroni* parasitizing *O. obesa* in Brazil and in the world. This work records the first occurrence of the parasitoid *S. cameroni* parasitizing *O. obesa* in Brazil [16].

3.13. Study 13

The objective of this work was to report the occurrence of *Muscidifurax raptorellus* (Kogan & Legner, 1970) (Hymenoptera: Pteromalidae) in Brazil.

In October 2007, 10 pupae of *Fannia pusio* (Wiedemann, 1830) were collected from which two specimens of *M. raptorellus* emerged, representing 5% of parasitism. *Muscidifurax* Girault & Sanders is a genus with only five species, of which only *M. raptorellus* was not found in the country *Muscidifurax raptor* Girault & Sanders 1910 (Hymenoptera: Pteromalidae) has been reported [17].

3.14. Study 14

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.

Fourty seven pupae of *A. scabra* were obtained, two of which yielded the parasitoid *T. coxalis*. The percentage of parasitism was 4.3%. *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 natural enemy of *A. scabra* [18].

3.15. Study 15

The objective of this work was to report the first occurrence of the parasitoid *Spalangia nigroaenea* Curtis, 1839 (Hymenoptera: Pteromalidae) in pupae of *Fannia pusio* (Wiedemann, 1830) (Diptera: Fanniidae) in Brazil.

Ten pupae of *F. pusio* collected on March and April 30 were obtained, from which two specimens of *S. nigroaenea* emerged, from those collected in April, verifying a percentage of parasitism of 20.0%. This work records the first occurrence of *S. nigroaenea* as a parasitoid of *F. pusio* in Brazil [19].

3.16. Study 16

The objective of this work was to report the first occurrence of the parasitoid *Eurytoma* sp. (Hymenoptera, Eurytomidae) parasitizing *Fannia pusio* (Wiedmann, 1830) in Brazil.

One hundred fifty-three (153) specimens of *F. pusio* were collected, from which emerged two specimens of the parasitoid *Eurytoma*. The percentage of parasitism was 1.3%. In Itumbiara, *F. pusio* was found parasitized by *Pachycrepoides vindemmiae* (Rondani, 1875) (Hymenoptera: Pteromalidae), *Spalangia nigra* Latrielle, 1805 (Hymenoptera: Pteromalidae) *Paraganaspis egeria* Díaz, Gallardo & Wash 1996 (Hymenoptera: Figitidae) and *Spalangia drosophilae* Ashmead, 1887 (Hymenoptera: Pteromalidae). This work records the first occurrence of *Eurytoma* sp. parasitizing *F. pusio* in Brazil [20].

3.17. Study 17

The aim of this note is to relate the new host for the *Gnathopleura quadridentata* Wharton, 1986 (Hymenoptera: Braconidae; Alysiinae) species in Brazil.

During the period from September to December 2003, 04 specimens of *G. quadridentata* were collected in 65 pupae of *Peckia chrysostoma* (Wiedemann, 1830) (Diptera: Sarcophagidae), showing 4.6% of parasitism. The results obtained with this research allow us to stretch the occurrence of *G. quadridentata* on a new host [21].

3.18. Study 18

The objective of this note is to report the new host for the parasitoid *Pachycrepoideus vindemmiae* (Rondani, 1875) (Hymenoptera, Pteromalidae) in Brazil.

From June to August 2004, two specimens of *P. vindemmiae* were collected in 16 pupae of *Cyrtoneurina pararescita* Couri 1995 (Diptera: Muscidae). The percentage of parasitism was 12.2%. The fact to attack several dipterous, favors *P. vindemmiae* permanence in the environment, improving its potential as biological agent. This paper registers the first occurrence of parasitoid *P. vindemmiae* in pupae of *C. pararescita* in Brazil [22].

3.19. Study 19

The aim of this note is to report the first occurrence of the parasitoid *Spalangia nigra* Latrielle 1805 (Hymenoptera: Pteromalidae) parasitizing pupae of *Cyrtoneurina pararescita* Couri 1995 (Diptera: Muscidae) in Brazil.

Forty pupae were collected from which 36 adults of *C. pararescita* and four parasitoids of the species *S. nigra* emerged. The percentage of parasitism was 10%. This is the first report of *S. nigra* as a natural enemy of *C. pararescita* in bovine feces [23].

3.20. Study 20

The objective of this note is to report on the first occurrence of the parasitoid *Pachycrepoideus vindemmiae* (Rondani, 1875) (Hymenoptera: Pteromalidae) on *Megaselia scalaris* (Loew, 1866) (Diptera: Phoridae) in Brazil.

In September and October 2004, six specimens of *P. vindemmiae* were collected from 46 pupae of *M. scalaris*. The percentage of parasitism observed was about 13.0%. The fact that *P. vindemmiae* makes use of species of several Diptera genera favors their continual presence within the environment. This paper registers the first occurrence of the parasitoid *P. vindemmiae* on pupae of *M. scalaris* in Brazil [24].

3.21. Study 21

The objective of this work is to report the first occurrence of *Pachycrepoideus vindemmiae* (Rondani, 1875) (Hymenoptera: Pteromalidae) parasitizing *Ornidia obesa* Fabricius, 1775 (Diptera: Syrphidae) in Brazil.

In April 2006, 18 specimens of *O. obesa* were collected from which two specimens of the parasitoid *P. vindemmiae* emerged. The percentage of parasitism was 9%. There are no reports of *P. vindemmiae* and other parasitoids in *O. obesa* in Brazil and in the world. This work records the first occurrence of the parasitoid *P. vindemmiae* parasitizing *O. obesa* in Brazil [25].

3.22. Study 22

The aim of this paper was to report the first occurrence for *Gnathopleura Quadridentata* (Wharton, 1986) (Hymenoptera: Braconidae) on pupae of *Sarcodexia lambens* (Wiedemann, 1830) (Diptera: Sarcophagidae) in Brazil.

During the period from April to May of 2004, 28 specimens of *G. quadridentata* were collected in 28 out of 50 pupae of *S. lambens* showing 56.0% of parasitism. The aim of this note is to report the first occurrence for *G. quadridentata* on pupae *S. Lambens* in Brazil [26].

3.23. Study 23

This work reports the new host and habitat of *Neralsia splendens* (Borgmeier, 1935) (Hymenoptera: Figitidae) collected in *Oxysarcodexy thornax* (Walker, 1849) (Diptera: Sarcophagidae), using traps with human feces baits at Farm the Agronomy Course, in Itumbiara, Goiás, Brazil, in February 2005.

Nine specimens of the parasitoid *N. splendens* that emerged from 50 pupae of *O. thornax* were collected. The parasitism rate obtained was 18.0% [27].

3.24. Study 24

This work reports the first record of *Spalangia drosophilae* Ashmead, 1885 (Hymenoptera: Pteromalidae) in pupae of *Oxysarcodexia thornax* (Walker, 1849) (Diptera: Sarcophagidae) and the superparasitism of this species in Brazil.

From August to December 2003, 43 specimens of *S. drosophilae* were collected from 27 pupae of *O. thornax*, obtaining up to 26 individuals from the same pupae. The percentage of parasitism observed (11.1%) (3 parasitized pupae/27 total pupae collected). This work reports the first record of *S. drosophilae* in *O. thornax* pupae and the superparasitism of this species in Brazil [28].

3.25. Study 25

The aim of the present work was to report the first occurrence of the parasitoid *Triplasta coxalis* (Ashmead, 1865) (Hymenoptera: Figitidae: Eucoilinae) as a natural enemy of *Archisepsis scabra* (Loew, 1861) (Diptera: Sepsidae) in cattle feces in Brazil.

Fourty seven pupae of *A. scabra* were obtained, two of which yielded the parasitoid *T. coxalis*. The percentage of parasitism was 4.3% [29].

3.26. Study 26

The aim of this study is to describe the occurrence of *Tachinobia* sp. (Hymenoptera: Eulophidae) in immature stages of *Chrysomya albiceps* (Wiedemann, 1819) in Brazil.

In September 2002, 43 puparia of *C. albiceps* were obtained from one of which emerged 30 specimens of *Tachinobia* sp. It is probably one of the three described species of *Tachinobia*. The percentage of parasitism was 2.3% (1/43). This work reports the first occurrence of *Tachinobia* sp. parasitizing *C. albiceps* in Brazil [30].

3.27. Study 27

The aim of this study is to report the new host and habitat for the parasitoid *Trybliographa* sp. (Hymenoptera: Figitidae) in Brazil.

In February 2005, 50 pupae of *Oxysarcodexy thornax* (Walker, 1849) (Diptera: Sarcophagidae) were collected in human feces, from which 5 specimens of *Trybliographa* sp. The percentage of parasitism was 10%. This work records the first occurrence of *Trybliographa* sp. parasitizing *O. thornax* using human feces and pitfall trap in Brazil [31].

3.28. Study 28

In the present work we report the first occurrence in Brazil of *Brachymeria podagrica* (Fabricius, 1789) (Hymenoptera: Chalcididae) collected from pupae of *Squamatoides trivittatus* Curran, 1927 (Diptera: Sarcophagidae) obtained from bovine kidney. The percentage of parasitism was 4%.

This is the first report of *B. podagrica* using *S. trivittatus* as a host in Brazil [32].

3.29. Study 29

The aim of the present study is to report the first occurrence of the parasitoid *Spalangia drosophilae* Ashmead, 1887 (Hymenoptera: Pteromalidae) in *Fannia pusio* pupae (Wiedemann, 1830) (Diptera: Fanniidae).

To collect the insects, bovine liver was used as bait. 265 pupae of *F. pusio* were obtained, from which 4 emerged parasitoids belonging to the species *S. drosophilae*. The percentage of parasitism was 1.5%. This paper reports the first occurrence of *S. drosophilae* parasitizing *F. pusio* in Brazil [33].

3.30. Study 30

The aim of this study is to describe the first occurrence of *Paraganaspis egeria* Diaz, Gallardo & Walsh, 1996 (Hymenoptera: Figitidae: Eucoilinae) as a parasitoid of *Archisepsis scabra* (Loew, 1861) (Diptera: Sepsidae) in Brazil.

From May to June 2003, 116 puparia of *A. scabra* were obtained from which four specimens of the parasitoid *P. egeria* emerged. The percentage of parasitism was 3.4%. This paper describes the first occurrence of *P. egeria* as a parasitoid of *A. scabra* in Brazil [34].

3.31. Study 31

This study reports, for the first time, the occurrence of *Triplasta coxalis* (Ashmead, 1865) (Hymenoptera: Figitidae: Eucoilinae) as a parasitoid of *Palaeosepsis* spp. (Diptera: Sepsidae).

From May to June 2003 and for the fifteen days of exposition of feces, 347 pupae of *Palaeosepsis* spp. from which four specimens of the parasitoid *T. coxalis* emerged. The percentage of parasitism obtained was 1.2%. This work describes for the first time in Brazil the occurrence of *T. coxalis* in buffalo feces [35].

3.32. Study 32

This article reports the first occurrence of the parasitoid *Aphaereta* sp. (Hymenoptera: Braconidae) on pupae of *Sarcodexia lambens* (Wiedemann, 1830) (Diptera: Sarcophagidae). Bovine liver was used as bait to collect the insects.

In the study, 37 pupae of *S. lambens* were obtained, three of which yielded the parasitoid *Aphaereta* sp. The percentage of parasitism was 8.1% [36].

3.33. Study 33

This study reports, for the first time, the occurrence of *Triplasta coxalis* (Ashmead, 1865) (Hymenoptera: Figitidae: Eucoilinae) as a parasitoid of *Palaeosepsis* spp. (Diptera: Sepsidae) found in buffalo dung at Itumbiara, Goiás, Brazil.

From May to June 2003 and for the fifteen days of exposition of feces, 347 pupae of *Palaeosepsis* spp. from which four specimens of the parasitoid *T. coxalis* emerged. The percentage of parasitism obtained was 1.2%. This work describes for the first time in Brazil the occurrence of *T. coxalis* in buffalo feces [37].

3.34. Study 34

This paper reports the first occurrence of the parasitoid *Leptopilina bouvardi* Barbotin et al., 1979 (Hymenoptera: Figitidae: Eucoilinae) collected in pupae of *Zaprionus indianus* Gupta, 1970 (Diptera: Drosophilidae).

March and November 2001, 03 specimens were obtained from 139 *Z. indianus* pupae. The overall percentage of parasitism was 2.2%, obtained using traps containing fruit-based bait (pear, apple, and banana) [38].

3.35. Study 35

The purpose of this study is to report a new habitat and host for *Trichopria* sp. (Hymenoptera: Diapriidae) in Brazil.

In December 2003, 155 pupae of *Peckia chrysostoma* (Wiedemann, 1830) (Diptera: Sarcophagidae) were obtained from which 41 specimens of the parasitoid *Trichopria* sp. from a single puparium. This study reports the first occurrence of *Trichopria* sp. parasitizing *P. chrysostoma* in bovine kidneys in Brazil and superparasitism in *Trichopria* sp. in Minas Gerais [39].

3.36. Study 36

The objective of this work was to report the first record of *Spalangia drosophilae* (Ashmead, 1885) (Hymenoptera: Pteromalidae) in *Oxysarcodexia thornax* (Walker, 1849) (Diptera: Sarcophagidae) pupae and the superparasitism of this species in Brazil.

From August to December 2003, 43 specimens of *S. drosophilae* were collected from 27 pupae of *O. thornax*, obtaining up to 26 individuals from the same pupae. The percentage of parasitism observed (11.1%) (3 parasitized pupae/27 total pupae collected). This work reports the first record of *S. drosophilae* in *O. thornax* pupae and the superparasitism of this species in Brazil [40].

3.37. Study 37

The purpose of this note is to report the first occurrence in Brazil of the parasitoid *Zaeucoila triangulifera* Kieffer, 1907 (Hymenoptera: Figitidae: Eucoilinae).

During the sampling period, 4 specimens of *Z. triangulifera* were collected (2 specimens in March and 2 in April 2002). Therefore, this is the first record of *Z. triangulifera* for Brazil [41].

3.38. Study 38

The aim of this paper is to relate the new host for the *Aphaereta* sp. (Hymenoptera: Pteromalidae) species in Brazil.

During the period from March to September 2001, 374 specimens of *Aphaereta* sp. were collected in 26 pupae of *Peckia chrysostoma* (Wiedemann, 1830) (Diptera: Sarcophagidae). From the first to twelfth pupae were found 8, 10, 22, 27, 28, 29, 31, 31, 40, 42, 47, and 60 specimens, respectively. The results obtained from this research allow us to stretch the occurrence of *Aphaereta* sp. on a new host [42].

3.39. Study 39

This paper reports a new host for *Brachymeria podagrica* (Fabricius, 1789) (Hymenoptera: Chalcididae) in Brazil.

During March 2001 to March 2002, three specimens of *B. podagrica* were collected from 30 pupae of *Hemilucilia flavifacies* Enderlein, 1933 (Diptera: Calliphoridae) showing 10.0% of parasitism. The high percentage of parasitism can also be related to capacity of search of the parasitoid and to the availability of recourses. This is the first report of *B. podagrica* in pupae of *H. flavifacies* in Brazil [43].

3.40. Study 40

This study report first occurrence of parasitoid *Hemencyrtus herbertii* Ashmead, 1900 (Hymenoptera: Encyrtidae) in pupae of *Hemilucilia flavifacies* Enderlein, 1931 (Diptera: Calliphoridae) in Brazil.

From March of 2001 to January of 2002, 16 specimens of *H. herbertii* were collected from 81 pupae *H. flavifacies*. The percentage of parasitism was 19.8%. The *H. herbertii* presented himself as gregarious, emerging several specimens from the same pupary [44].

3.41. Study 41

This article reports the occurrence of the parasitoid *Spalangia endius* (Walker, 1839) (Hymenoptera: Pteromalidae) parasitizing *Zaprionus indianus* Gupta, 1970 (Diptera: Drosophilidae).

Between November and December 2001, 4 specimens of *S. endius* were obtained from 105 pupae of *Z. indianus*, representing 3.8% of parasitism. The use of chemical substances to control this fly and benefit fruit exportation may result in high production costs, while causing environmental and human health damage. Thus, the search for effective natural enemies may result in an alternative capable of providing the basis for a long-term control program. In conclusion, this is the first report of *S. endius* parasitizing pupae of *Z. indianus* in Brazil [45].

3.42. Study 42

The objective of this paper was to report a new host for the parasitoid *Pachycrepoideus vindemmiae* (Rondani, 1875), which was collected in the urban region of Goiânia, in the central part of the state of Goiás, Brazil.

Between January and May 2014, two specimens of *P. vindemmiae* were collected from 26 pupae of *Synthesiomyia nudiseta* (Van der Wulp, 1883) (Diptera: Muscidae). The percentage parasitism observed was 7.7%. The percentage parasitism can also be correlated with the parasitoid's search capacity and with the availability of resources [46].

3.43. Study 43

The objective of this article is reporting the first occurrence of the parasitoid *Pachycrepoideus vindemmiae* (Rondani, 1875) (Hymenoptera: Pteromalidae) parasitizing pupae *Zaprionus indianus* Gupta, 1970 (Diptera: Drosophilidae) in Brazil.

Between March to November of 2001, 285 specimens of *P. vindemmiae* were obtained from 963 pupae of *Z. indianus*, representing 13.8% of parasitism. This percentage was considered high and was probably due to the availability of recourses, to the density of hosts and to the capacity of search of parasitoids. This is the first report of *P. vindemmiae* parasitizing pupae of *Z. indianus* in Brazil [47].

3.44. Study 44

The objective of this scientific study was to report, for the first time in Brazil, the occurrence of the parasitoid *Anastatus* sp. parasitizing eggs of *Leptoglossus zonatus* Dallas, 1852 (Hemiptera: Coreidae).

Seventy-two eggs of *L. zonatus* were collected in January 15 of 2002, from which five parasitoids of the *Anastatus* sp. (Hymenoptera: Eupelmidae) emerged. The percentage of parasitism observed was 6.9%. The use of chemicals in controlling crop pests may result in increased production costs as well as in damages to the environment and to human health.

These results contribute to the knowledge of the parasitoids occurring in the State of Goiás. This is the first report of the occurrence of *Anastatus* sp. parasitizing immature stages of *L. zonatus* in Brazil [48].

3.45. Study 45

The aim of this study was to verify the occurrence of *Conura* sp. (Hymenoptera: Chalcididae) in immature stages of *Tuta absoluta* (Meyrick, 1917) (Lepidoptera: Gelechiidae) in tomato crop in Lavras, Minas Gerais.

From August 2001 to February 2002, 500 pupae of *T. Absolute* were obtained from which 13 specimens of *Conura* sp. The percentage of parasitism was 2.6%. The infestation of tomato plants inside the greenhouse was due to openings in the greenhouse that allowed the entry of both the pest insect and the parasitoids. This work reports the first occurrence of the parasitoid *Conura* sp. in immature stages of *T. absoluta* in Lavras, Minas Gerais [49].

3.46. Study 46

The objective of this work is to report the first occurrence of the parasitoid *Pachycrepoideus vindemmiae* (Rondani, 1875) (Hymenoptera: Pteromalidae) parasitizing *Sarcodexia lambens* (Wiedemann, 1830) (Diptera: Sarcophagidae) in Brazil.

From May to September 2001, 22 pupae of *S. lambens* were collected in human feces, from which parasitoids of the species *P. vindemmiae* emerged, in four with a parasitism percentage of 18.2%. In Brazil, this work represents the first report of the parasitoid *P. vindemmiae* using as host *S. lambens* [50].

3.47. Study 47

The aim of this note is to report a new host for *Brachymeria podagrica* Fabricius, 1787 (Hymenoptera: Chalcididae) species in Brazil.

From March to August 2001 four specimens of *B. podagrica* were collected in 29 pupae of *Chrysomya albiceps* (Wiedemann, 1819) (Diptera: Calliphoridae) showing 13.8% of parasitism. This is the first report of *B. podagrica* in pupae of *C. albiceps* in Brazil [51].

3.48. Study 48

The aim of this paper was to report the first occurrence of *Brachymeria podagrica* Fabricius, 1787 (Hymenoptera: Chalcididae) on pupae of *Sarcodexia lambens* (Wiedemann, 1830) (Diptera: Sarcophagidae) in Brazil.

During the period from March 2001 to March 2002, three specimens of *B. podagrica* were collected in 33 pupae of *S. lambens* showing 9.0% of parasitism. The aim of this note is to report the first occurrence of *B. podagrica* on pupae of *S. lambens* in Brazil [52].

3.49. Study 49

The aim of this note is to report the first occurrence of the parasitoid *Hemencyrtus herbertii* Ashmead, 1900 (Hymenoptera: Encyrtidae) as a natural enemy of *Musca domestica* L. 1758 (Diptera: Muscidae) in Brazil.

After four collections carried out from May to June 2001, a total of 115 pupae were obtained, being 13 pupae of *M. domestica* collected in human feces, of which five emerged adults, seven did not emerge nor adults and neither parasitoid, probably due to natural host mortality, and from a pupa five gregarious parasitoids emerged belonging to the species *H. herbertii*. The total percentage of parasitism was 11.3%, and in pupae of *M. domestica* with 38.4% [53].

3.50. Study 50

The aim of this paper was to report a new host for *Spalangia endius* (Walker, 1839) (Hymenoptera: Pteromalidae) in Brazil.

During the period from March to December 2001, six specimens of *S. endius* were collected in 76 pupae of *Peckia chrysostoma* (Wiedemann, 1830) (Diptera: Sarcophagidae) showing 7.9% of parasitism. The high percentage of parasitism can be related to the period or the number of the collections, which were performed [54].

3.51. Study 51

The objective of this work was to report the first occurrence of *Gryon gallardoi* (Brethes, 1914) (Hymenoptera: Scelionidae) as a parasitoid of the species *Leptoglossus zonatus* (Dallas, 1852) (Hemiptera: Coreidae), in Goiás.

A total of 41 eggs of *L. zonatus* were obtained, of which 30 nymphs (orange and brown spots) and 11 of *G. gallardoi* parasitoids hatched. The percentage of parasitism (parasitized eggs/total eggs) of the species was 26.8%, indicating a potential for use in biological control programs [55].

3.52. Study 52

The objective of this work was to survey the parasitoids in eggs of hemiptera in corn. A total of 41 eggs of *Leptoglossus zonatus* (Dallas, 1852) (Hemiptera: Coreidae) were collected from which 30 nymphs hatched and 9 parasitoids of the genus *Gryon gallardoi* (Brethes, 1914) (Hymenoptera: Scelionidae) and two of the genus *Brasema* (Hymenoptera: Eupelmidae) emerged.

The total parasitism was 26.8%, being 4.8% caused by *Brasema* sp. These results contribute to the knowledge of the parasitoids that occur in Goiás [56].

3.53. Study 53

The objective of this work is to report the occurrence of the parasitoid *Paraganaspis egeria* Díaz, Gallardo & Wash, 1996 (Hymenoptera: Figitidae) parasitizing *Fannia pusio* (Wiedemann, 1830) (Diptera: Muscidae) in Brazil.

From May to July 2001 in human feces, 99 pupae of *F. pusio* were collected, of which three emerged parasitoids of the species *P. egeria* with a p of parasitism of 3.0%. In Brazil, this work represents the first report of this parasitoid species using *F. pusio* as host [57].

3.54. Study 54

The objectives of this study were to investigate the host of *Triplasta coxalis* (Ashmead, 1865) Hymenoptera: Figitidae) the new occurrence of the parasitoid *Kleidotoma nigra* (Hartig, 1840) (Hymenoptera: Figitidae) and *T. coxalis* in Brazil.

After collecting 20 fecal plaques between January and February 2001, four specimens of *T. coxalis* and one specimen of *K. nigra* were obtained from 1163 puparia of *Palaeosepsis* sp. (Diptera: Sepsidae) in feces of 144 hours of exposure in pastures. The percentage of parasitism of *T. coxalis* and *K. nigra* was 0.34% and 0.08%, respectively. There was a total prevalence of parasitism of 0.43%. Therefore, this work reports the new occurrence of these two species in the State of Goiás [58].

3.55. Study 55

The aim of this study was to investigate the occurrence of parasitoids in pupae of *Allograpta obliqua* (Say, 1893) (Diptera: Syrphidae) in maize.

Six pupae of *A. obliqua* were collected from which two emerged *Conura* sp. (Hymenoptera: Chalcididae) and four they did not emerge, neither syrphids nor parasitoids. The cause of mortality of pupae of this dipteran in the field may be due to the natural mortality of the host. The percentage of parasitism observed was 33.3%. These results are important because they contribute to the knowledge of hosts and species of Chalcididae occurring in the State of Goiás [59].

3.56. Study 56

The aim of this work is, therefore, to report the parasitism of *Nasonia vitripennis* (Walker, 1836) (Hymenoptera: Pteromalidae) in puparia of *Peckia chrysostoma* (Wiedemann 1830) (Diptera: Sarcophagidae) collected in human feces.

After 06 collections of human feces, a pupa of the muscoid *P. chrysostoma* was collected from 63 individuals of the parasitoid *N. vitripennis*. This study reports the first occurrence of the parasitoid *N. vitripennis* in *P. chrysostoma* pupae [60].

3.57. Study 57

This work presents the first occurrence of the parasitoid *Spalangia drosophilae* Ashmead, 1885 (Hymenoptera: Pteromalidae) in pupary of *Archiseptis scabra* (Loew 1861) (Diptera: Sepsidae) in bovine feces collected in the city of Cachoeira Dourada, GO.

One hundred and five puparia of *A. scabra* were obtained from which six specimens of the parasitoid *S. drosophilae* emerged. The percentage of parasitism was 5.7% [61].

3.58. Study 58

This paper aims to record the first occurrence of the parasitoid *Pachycrepoides vindemmiae* (Rondani, 1830) (Hymenoptera: Pteromalidae) as a natural enemy of *Ophyra aenescens* (Wiedemann, 1830) (Diptera: Muscidae), in Brazil.

Three hundred and two pupae of *O. aenescens* were obtained, from which 6 emerged parasitoids belonging to the species *P. vindemmiae*, presenting a parasitism incidence of 1.98% [62].

3.59. Study 59

The objective of this research was to extend the knowledge of the geographic distribution of the parasitoid *Hemencyrtus herbertii* Ashmead, 1900 (Hymenoptera: Encyrtidae).

Between November 2013 and January 2014, six pupae were obtained from *Sarcodexia lambens* (Wiedemann, 1830) (Diptera: Sarcophagidae) of which were collected two specimens *H. herbertii* in two pupae. The overall percentage of parasitism was observed in 33.3% [63].

4. Main species of Diptera, Hemiptera and Lepidoptera associated with parasitoids in this study: host relationship host/parasitoid

In the order Diptera (from the Greek di = two and pteron = wings, because the hind wings are modified in the shape of dumbbells and function only as flight stabilizers), flies, mosquitoes, blowflies, mosquitoes, black flies, and horseflies are included. Approximately 153,000 species are known, distributed in 160 families around the world. In Brazil, there are about 8,700 species, with estimates of 60,000. It is a group that is present in most habitats. They are holometabolites, occupy several food niches, and may be parasites, hematophagous, predators, in addition to feeding on leaves, fruits, flowers, nectar and other sugary substances. Many Diptera play an important ecological role, especially as natural enemies of various organisms. Certain species are of great economic, forensic, medical, and veterinary importance (Figures 16, 17, 18, 19, 20, 21, 22, 23, 24, and 25) [64, 65, 66].

The Diptera (Muscomorpha) is one of the largest orders of insects, comprising abundant number of species as well as of individuals. Besides, these flies are of great medical and veterinarian importance since they may produce myiasis and may be vectors of microorganisms pathogenic to men and animals. The flies have been found to carry diseases causing organisms such as: bacteria, protozoa and helminths (Figures 26, 27, 28, 29, 30, 31 and 32) [67, 68, 69, 70].

Among the Coreidae (Insecta: Hemiptera) known to cause economic damage to crop plants, much attention has been directed to the species *Leptoglossus zonatus* (Dallas, 1852) (Hemiptera: Coreidae) that is abundant on maize and is considered a serious insect pest (Figure 33).

The caterpillars of the genus *Lonomia* (Lepidoptera: Saturniidae), which were collected in this experiment, are important causative agents of skin problems in humans, especially for individuals who work in rural areas. These insects can be found associated with economically important crops, which often feed and/or perform your posture. Among these pests, the tomato leaf miner *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) stands out (Figure 34).

5. Conclusion

Parasitoids, which mainly include taxa belonging to Hymenoptera, play an important role in the maintenance of other arthropod populations, acting as regulators of host densities. However, the large-scale patterns of these insects and the factors that shape them are still not well established. In this review, we focus on several aspects of the biology and macroecological patterns of parasitoids that have received some attention in the past, including recent studies on parasitoid faunas on islands.



Figure 17 *Chrysomya albiceps* (Wiedemann) (Diptera: Calliphoridae); (Source: <https://zookeys.pensoft.net/article/9262/>)

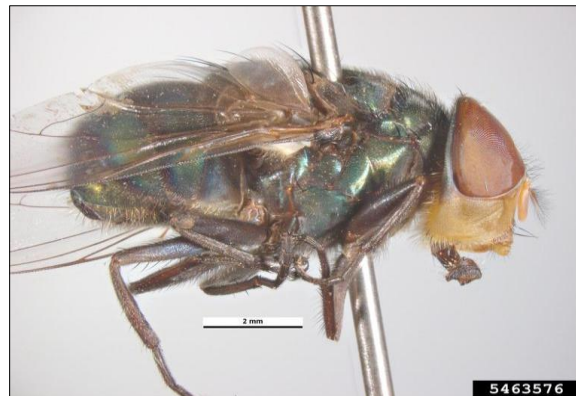


Figure 18 *Chrysomya megacephala* (Fabricius) (Diptera: Calliphoridae); (Source: <https://www.insectimages.org/browse/detail.cfm?imgnum=5463576>)



Figure 19 *Cyrtoneurina pararescita* Couri (Diptera: Muscidae); (Source: <https://pt.wikipedia.org/wiki/Muscidae>)



Figure 20 *Fannia pusio* (Wiedemann) (Diptera: Fanniidae); (Source: <https://bugguide.net/node/view/1483243/bgpage>)



Figure 21 *Hemilucilia flavifacies* (Engel) (Diptera: Calliphoridae); (Source: researchgate.net)



Figure 22 *Musca domestica* L. (Diptera: Muscidae); (Source: <https://pt.wikipedia.org/wiki/Muscidae>)



Figure 23 *Oxysarcodexia thornax* (Walker, 1849) (Diptera: Sarcophagidae); (Source: <https://biodar.unlp.edu.ar/sarcophagidae/en/info/20439.html>)



Figure 24 *Palaeosepsis* sp. (Diptera: Sepsidae); (Source: https://www.ecoregistros.org/site_br/imagen.php?id=325466)



Figure 25 *Peckia chrysostoma* (Wiedemann 1830) (Diptera: Sarcophagidae); (Source: <http://sarcophagidae.myspecies.info/taxonomy/term/1873/media>)



Figure 26 *Ravinia belforti* Prado & Fonseca (Diptera: Sarcophagidae); (Source: <https://biodar.unlp.edu.ar/sarcophagidae/en/info/20456.html>)



Figure 27 *Sarcodexia lambens* (Wiedemann) (Diptera: Sarcophagidae); (Source: <https://biodar.unlp.edu.ar/sarcophagidae/en/info/20451.html>)

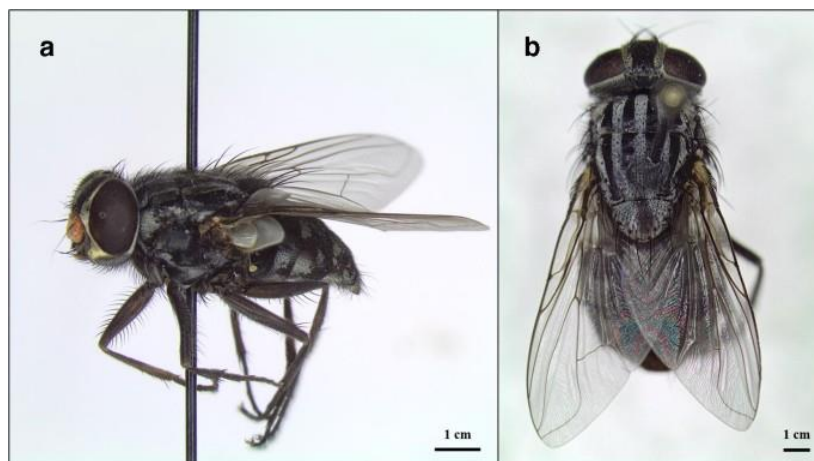


Figure 28 *Synthesiomyia nudiseta* (Wulp) (Diptera: Muscidae); (Source: <https://link.springer.com/article/10.1007/s00414-021-02543-w>)



Figure 29 *Sarcophagula occidua* Fabricius (Diptera: Sarcophagidae); (Source: <http://cookislands.bishopmuseum.org/species.asp?id=13976>)



Figure 30 *Brontaea* sp. (Diptera: Muscidae); (Source: <https://bugguide.net/node/view/815965>)



Figure 31 *Zaprionus indianus* Gupta (Diptera: Drosophilidae); (Source: <https://www.flickr.com/photos/mgaiani/2780315715>)



Figure 32 *Ornidia obesa* Fabricius (Diptera: Syrphidae); (Source: <http://gilwizen.com/ornidia/>)



Figure 33 *Leptoglossus zonatus* (Dallas, 1852) (Hemiptera: Coreidae); Source: <https://extension.usu.edu/pests/schoolipm/structural-pest-id-guide/western-leaf-footed-bug>

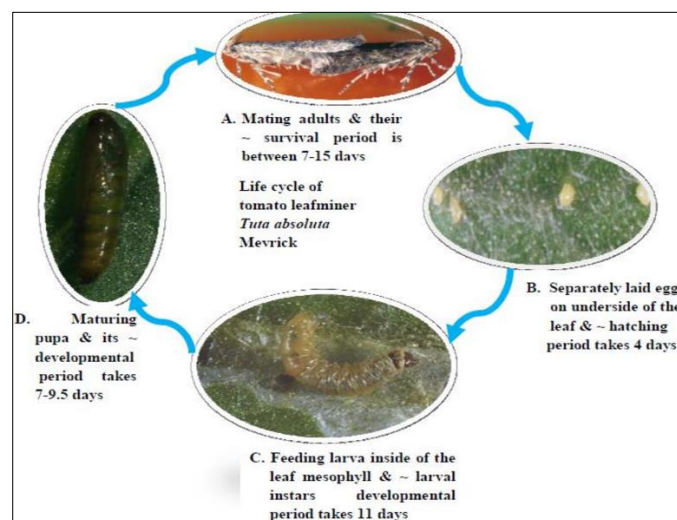


Figure 34 *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae)

Compliance with ethical standards

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